Uncompahgre Valley Reclamation Project

AB Lateral Hydropower Facility

Final Environmental Impact Statement
Volume I

United States Department of the Interior

Bureau of Reclamation

U.S. DEPARTMENT OF THE INTERIOR

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FINAL
ENVIRONMENTAL IMPACT STATEMENT

AB LATERAL HYDROPOWER FACILITY
UNCOMPAHGRE VALLEY RECLAMATION PROJECT
MONTROSE AND DELTA COUNTIES, COLORADO

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION

AS LEAD AGENCY IN COOPERATION WITH
U.S. DEPARTMENT OF THE INTERIOR--NATIONAL PARK
SERVICE AND BUREAU OF LAND MANAGEMENT

This final environmental impact statement describes four alternatives for the proposed construction and operation of a hydropower project using features of Bureau of Reclamation's Uncompahgre Valley Reclamation Project. The Bureau of Reclamation is considering executing a lease of power privilege (contract) with a private company to use Federal facilities for this project.

The alternatives described provide for additional water diversions from the Gunnison River through the existing Gunnison Tunnel to a penstock and powerplant near Montrose, Colorado. A no-action alternative is also described. The significant issues addressed in this final environmental impact statement include the impacts of reduced flows in the Gunnison River, increased flows in the Uncompahgre River, economic impacts in local counties, and impacts on endangered species and wetlands.

For further information regarding this final environmental impact statement, please contact the Regional Environmental Officer, Upper Colorado Region, U.S. Bureau of Reclamation, P.O. Box 11568, Salt Lake City, Utah 84147 (801) 524-5580 or FTS 588-5580.

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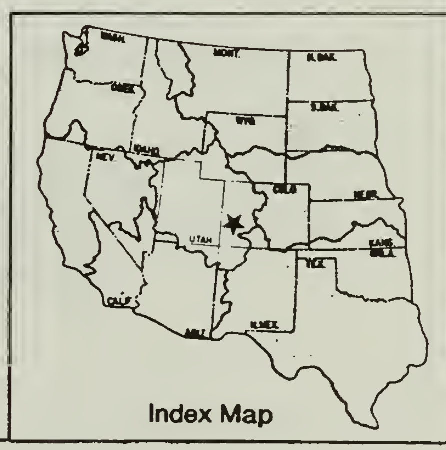
General map of AB lateral area.



SUMMARY

The purpose of this final environmental impact statement (FEIS) is to present the environmental impacts that would occur if any of the alternatives of the AB Lateral Hydropower Facility (facility) were constructed and operated. The facility would be funded, built, and operated by the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners (jointly referred to as the "Sponsors"). These groups plan to construct the facility using existing features of the Uncompahgre Valley Reclamation Project (UVRP), a U.S. Department of the Interior (USDI) Bureau of Reclamation (Reclamation) irrigation project. They are seeking a lease of power privilege (contract) with Reclamation that would permit using facilities of the UVRP.

The Uncompahgre Valley Reclamation Project (originally called the Gunnison Project) was authorized by the Secretary of the Interior on March 14, 1903, under the provisions of the Reclamation Act. Rehabilitation of the project and construction of the Taylor Park Dam was approved by the President on November 6, 1935. Hydropower development in association with the UVRP was authorized by the Act of June 22, 1938 (Public Law 75-698, Stat. 941).

The purpose of the facility, located in Montrose County, Colorado, is to economically develop the energy potential of water flows from the Gunnison River through the Gunnison Tunnel (Tunnel) to the Uncompahgre River (see figures S-1 through S-3). The large difference in elevations between the Tunnel and the Uncompahgre River creates the potential for hydropower production. Power from the proposed facility would be sold to local utilities. For the first 15 years of project operation, capacity and energy would be sold to the Public Service Company of Colorado. After that period, a different power sales agreement would be arranged.

During the winter, the Tunnel is currently used to meet only small water supply needs. The AB Lateral Project would, subject to guaranteed minimum flows in the Gunnison and other senior water rights, divert between 950 and 1,135 cubic feet per second (ft^3/s) of flows for power purposes; this water would then be returned to the Gunnison River at Delta. During the summer, the AB Lateral Facility would use water already being diverted from the Gunnison River for irrigation purposes. Water would flow through the powerplant, would fill canals downstream of Montrose, and then would be returned to the Gunnison River at Delta. Additional diversions would be made for power operations when irrigation demands were low (e.g., wet, high flow periods).

The developers cite the following needs for the proposed hydropower facility: (1) generating electrical power; (2) developing a renewable resource; (3) improving the existing irrigation system of the UVRP; and (4) enhancing the UVWUA's revenues for debt retirement and system improvement.

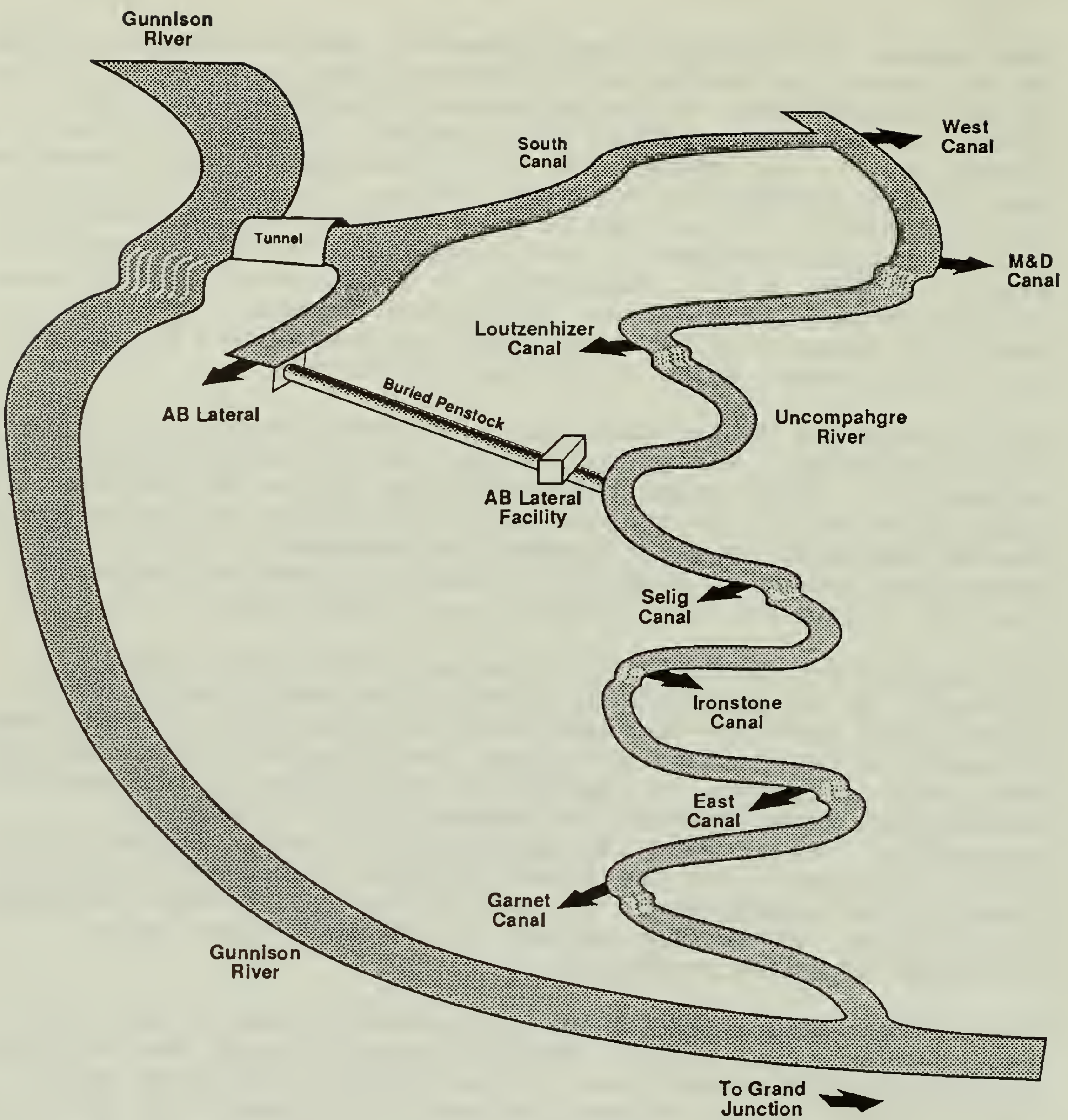


Figure S-1. Schematic of AB Lateral Project (looking south towards San Juan Mountains).

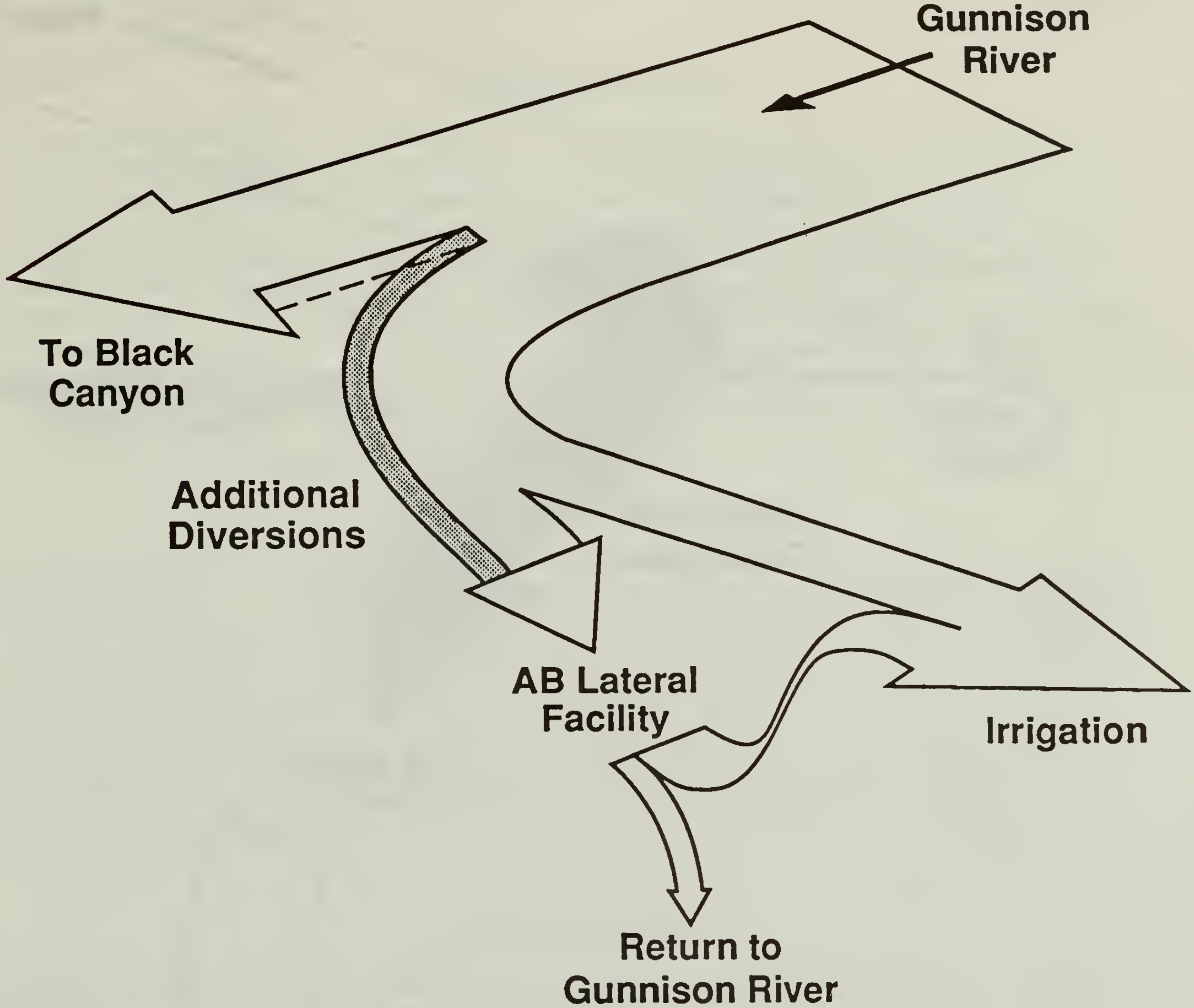


Figure S-2. Summer operation of AB Lateral Project (looking south).

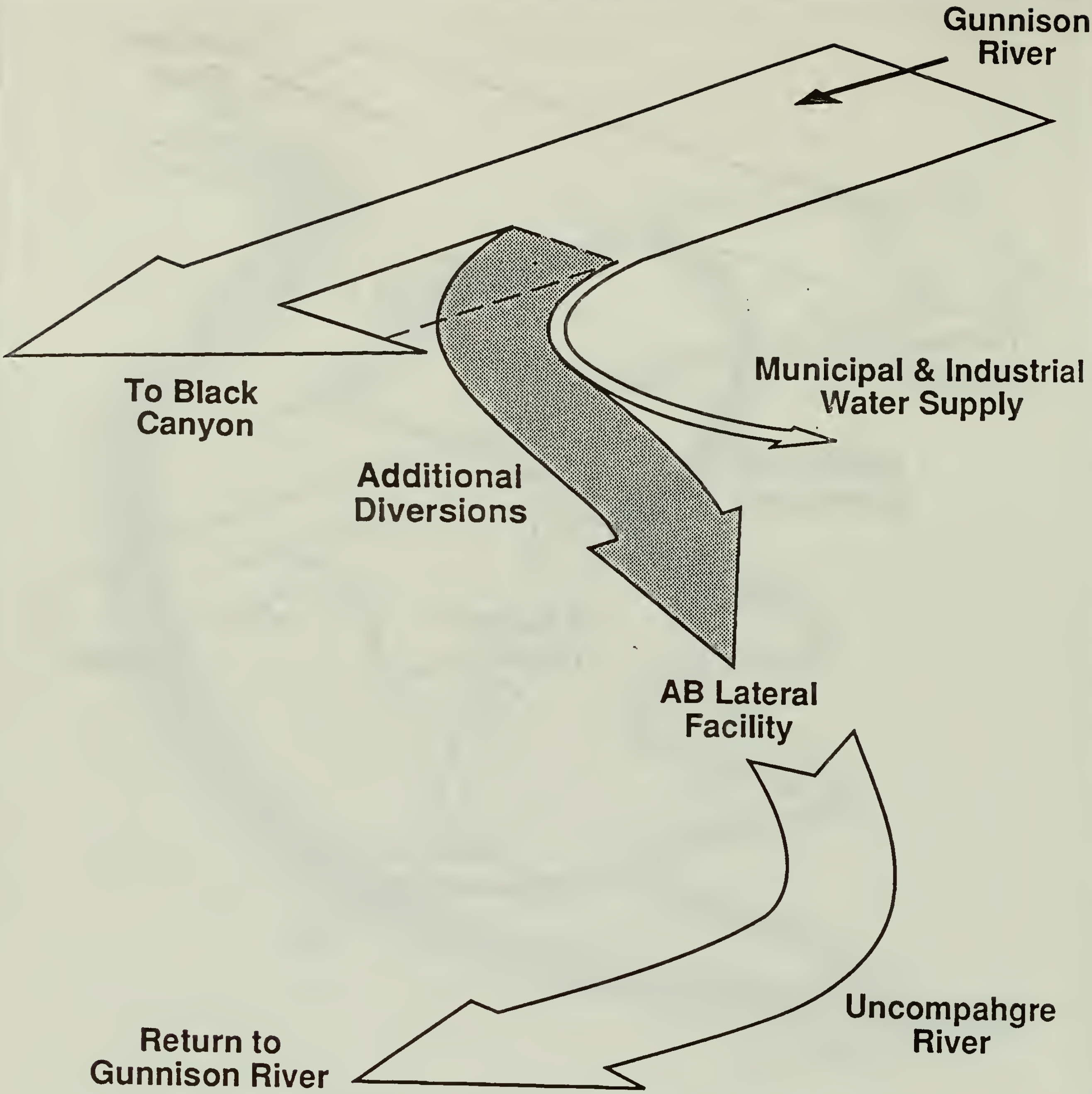


Figure S-3. Winter operation of AB Lateral Project (looking south).

ALTERNATIVES

The alternatives in the FEIS involve generating hydroelectric power using flows diverted from the Gunnison River and the elevation difference between the West Portal of the Tunnel and the Uncompahgre River in Montrose. A portion of the flows that would be diverted would also be used to meet UVRP irrigation needs; the remaining flows would be diverted for power generation. Four financially feasible alternatives, designated alternatives B, C, E, and F, are presented in the FEIS along with descriptions of plans that were studied but were found infeasible. Alternative A is the no-action alternative.

ALTERNATIVE A

Existing UVRP operating conditions would continue under alternative A. Water would continue to be diverted between March and November from the Gunnison and Uncompahgre Rivers to irrigate lands in Delta and Montrose Counties. Water diverted from the Gunnison River through the Tunnel is delivered to the Uncompahgre River through the South Canal and Cedar Creek. After entering the Uncompahgre River, Gunnison River flows are combined with Uncompahgre River flows and diverted into six major canal systems. Mean annual diversions from the Gunnison River are 336,411 acre-feet.

ALTERNATIVE B

Alternative B would divert water from the existing South Canal and AB Lateral into a penstock leading to a new powerhouse near Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace. New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. Modifications of existing facilities would include a portion of the existing AB Lateral, South Canal, and access roads.

The AB Lateral would be enlarged to a capacity of 1,235 ft^3/s and concrete-lined for 7,100 feet of its length. A penstock with a 1,135-ft^3/s capacity would be constructed to carry water from the lateral to a powerplant to be constructed north of Montrose. The other 100 ft^3/s would be used for irrigation purposes. The 38,380-foot penstock would be approximately 10 to 11 feet in diameter and would be buried. The powerplant would contain two Pelton turbines and generators designed to safely pass a maximum flow of 1,135 ft^3/s. Power would be transmitted through a new 115,000-volt (115 kilovolt [kV]) transmission line that would run north-south for approximately 3 miles between existing substations.

Water for the powerplant would be diverted from the Gunnison River using a priority system for allocating flows for needs including irrigation, instream flow, and power production. Senior irrigation demands and instream flow agreements would be given priority over hydropower needs. Mean annual diversions from the Gunnison River would be 691,013 acre-feet. A minimum instream flow level of 300 ft^3/s would be met in the Gunnison River, except in dry years when water is needed to satisfy senior irrigation rights, as in existing operations.

Environmental commitments under alternative B include protection of instream flows and irrigation supplies, acquisition and development of lands for wetland replacement, acquisition of lands to preserve an endangered plant species, development of deer escapes in the enlarged AB Lateral, protection and monitoring of riverbanks along the Uncompahgre River downstream from the powerplant, monitoring of the endangered bald eagle, and restoration of areas disturbed during construction.

ALTERNATIVE C

Alternative C, like alternative B, would divert water from the South Canal and AB Lateral into a penstock that would convey water to the powerplant near Montrose. To increase water supplies for hydropower production, alternative C includes enlarging the Tunnel from its present capacity of 1,135 ft^3/s to 1,300 ft^3/s. However, the penstock and turbine capacity would still be limited to 1,135 ft^3/s. Mean annual diversions from the Gunnison River would be 726,896 acre-feet. Other features and operational and environmental considerations are similar to alternative B.

ALTERNATIVE E

The physical features of alternative E are similar to alternative B. The penstock and powerplant would be designed to a maximum capacity of 950 ft^3/s, rather than 1,135 ft^3/s. The penstock and enlarged AB Lateral would be scaled down from alternative B. The plan would include the bypass of flushing flows in the Gunnison River to reduce siltation, and it would deliver additional water to the Uncompahgre River upstream from Montrose during the summer. Mean annual diversions from the Gunnison River would be 661,090 acre-feet. Other features and operational and environmental considerations are similar to alternative B. Alternative E is Reclamation's recommended plan.

ALTERNATIVE F

The location, dimensions, and physical features of alternative F would be the same as alternative B, including the flow capacity of 1,135 ft^3/s for the powerplant. This alternative would reduce diversions from the Gunnison River during periods of ice buildup and would deliver additional water to the Uncompahgre River upstream from Montrose during the summer. Mean annual diversions from the Gunnison River would be 686,840 acre-feet.

SUMMARY OF EXISTING ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

GENERAL

The Uncompahgre Valley lies along the western flank of the Rocky Mountains with elevations ranging from 4,950 feet above sea level near Delta to 6,500 feet near Montrose. The Gunnison River flows east of the valley through the Black Canyon of the Gunnison National Monument (Monument) and the Gunnison Gorge Recreation Area. The climate is typified by low precipitation and a wide range of daily and average annual temperatures. Native vegetation consists mostly of semidesert shrubs. Wetlands occur along the Gunnison and Uncompahgre Rivers.

About 505,000 acre-feet of water flow into the Uncompahgre Valley annually. Nearly two-thirds of this volume is imported for irrigation from the Gunnison River via the Tunnel, and the remaining volume is derived from the Uncompahgre River and its tributaries.

The Uncompahgre River fishery is limited due to water quality and flow problems. However, the Gunnison River supports an excellent trout fishery between Crystal Reservoir and several miles downstream from the river's confluence with the North Fork of the Gunnison.

The total population in Montrose and Delta Counties is approximately 50,000 people. In addition to agriculture, tourism and recreation are important local industries.

Any of the four development alternatives would result in short-term, construction-related impacts and long-term operational impacts. Short-term impacts include vegetation clearing, erosion, and construction disturbance, as well as short-term increases to the local economy. Long-term impacts would be related to the decreased flows in the Gunnison River and the increased flows in the Uncompahgre River and the long-term additions to the local economy resulting from power production.

STREAMFLOWS

Under the no-action alternative (alternative A), streamflows within the study area would continue to be affected by the operations of upstream reservoirs of the Aspinall Unit and Dallas Creek Project. The Gunnison River would be operated to maintain at least a minimum flow of 300 ft^3/s except during extremely dry periods.

With alternatives B, C, E, and F, the Gunnison River would continue to be operated to maintain at least a minimum flow of 300 ft^3/s except during extremely dry periods. However, diversions from the river would increase, with the greatest increase occurring during the nonirrigation season. Annually, the volume of water in the Gunnison River downstream from the Tunnel would be decreased by 45 percent for alternative B, 49 percent for alternative C, 41 percent for alternative E, and 44 percent for alternative F.

Average December through February flows entering the Black Canyon would be 1,392 ft^3/s for alternative A, 476 ft^3/s for B, 471 ft^3/s for C, 581 ft^3/s for E, and 499 ft^3/s for F. Average July through September flows would be 897 ft^3/s for alternative A, 730 ft^3/s for B, 637 ft^3/s for C, 730 ft^3/s for E, and 730 ft^3/s for F. Minimum streamflows would be 300 ft^3/s for all alternatives, but the frequency of 300-ft^3/s flows would increase significantly with development alternatives.

A monitoring system would be operated to assure that instream flows are maintained and irrigation supplies are protected. As described under alternative F, additional flows would be bypassed to the Gunnison River during winter operations if adverse icing conditions develop. Alternatives E and F also would release up to 1,000 acre-feet of additional flow to the Uncompahgre River via the South Canal during the summer.

The operation of the facility would result in a decrease in Uncompahgre River flows in some reaches and increases in other reaches. Streamflows in the Uncompahgre River entering Montrose would be reduced by 75 percent for all of the development alternatives. Streamflows in the Uncompahgre River downstream from the proposed tailrace would be increased by 339 percent for alternative B, 364 percent for alternative C, 318 percent for alternative E, and 336 percent for alternative F.

Diversions from the Gunnison River would be curtailed under all alternatives, including no-action, during flooding periods along the Uncompahgre River. Under the development alternatives, local flooding and severe local erosion would occur in case of catastrophic penstock failure (an extremely remote occurrence).

IRRIGATION

Operation of the development alternatives would not affect the amount of water diverted for irrigation use within the study area, including private irrigation diversions as well as the UVRP. The Montrose and Delta Canal (M&D) and the Loutzenhizer Canal would receive the majority of their water supply from the Uncompahgre River with development. Under the no-action alternative, about 59 percent of the water supplies delivered to these canals would be derived from the Gunnison River. Under any of the development alternatives, about 35 percent would be derived from the Gunnison. Conversely, the Selig, East, Ironstone, and Garnet canals would receive higher percentages of Gunnison River water. Senior water rights for private irrigation diversions along the Gunnison and Uncompahgre Rivers would continue to be honored.

RIVER MORPHOLOGY

Without development, the Gunnison River between the North Fork confluence and Delta would be expected to become narrower and more stable due to the effects of existing upstream water storage projects. Changes being caused by the Aspinall Unit on the Gunnison River upstream from the North Fork would continue.

With development, more of the riverbed would be exposed. The principal time that this would occur is in the nongrowing season. This would limit encroachment of riparian vegetation and wetlands during periods of low and intermediate flows. Scouring during high flow periods would maintain the channel.

Without development, the Uncompahgre River upstream of the study area would become a narrower and more stable river under the influence of Ridgway Reservoir. Within the study area (downstream from the South Canal), the bank erosion that now occurs would continue, and bank stabilization by individuals and local governments would continue.

With development, bank erosion in the Uncompahgre River between the South Canal and the proposed tailrace would decrease together with the river's potential to scour encroaching vegetation. Between the proposed tailrace and Delta, the river would become more unstable and significant additional bank erosion would occur unless bank protection was initiated. To reduce this erosion, bank stabilization would be performed by the Sponsors before development in areas found to be most susceptible to erosion. Changes in erosion would be monitored during operations, and further bank stabilization would be completed where necessary.

WATER QUALITY AND TEMPERATURE

Under the no-action alternative, water quality in the Gunnison River would not change significantly. Water quality in the Uncompahgre River has historically been poor but may improve as Ridgway Reservoir will settle out sediment and other pollutants.

Under the development alternatives, additional diversion from the Gunnison River would reduce the volume of high quality water available to dilute lesser quality tributary inflows. This reduction in water quality would occur primarily downstream from the North Fork. Temperatures in the Gunnison River would be slightly colder in the winter and warmer in the summer. The conditions under which ice forms in the Gunnison River would occur more frequently under the development alternatives. Ice accumulation would be most extensive below the North Fork confluence but would also increase above this tributary. Alternative F provides operational changes to decrease diversions and, therefore, increase flows if ice conditions would create environmental problems. The Gunnison River's capacity to remove sediments would be reduced, particularly in the winter. Alternative E would provide for bypassing flushing flows when needed.

Water supplies in the Uncompahgre River in the 12-mile reach between the South Canal and Montrose would receive less high quality water from the Gunnison River during the irrigation season and, thus, less dilution capability would exist. Downstream from Montrose, additional Gunnison River water would be present to dilute sediments and other pollutants. Salt loading to the river would be reduced by the hydropower project through lining the AB Lateral and reducing flow in the South Canal.

SOILS AND VEGETATION

No significant changes in soils or vegetation are projected under the no-action alternative. Under the development alternatives, vegetation and soil disturbance would occur in construction areas. Disturbed areas would be restored and reseeded. A total of approximately 11 acres of wetlands would be lost directly. This acreage would be replaced by creating a wetland area near the powerplant and also by vegetation planting along the Uncompahgre River. Indirect effects are also discussed in the FEIS.

Lower flows in the Gunnison River would allow the establishment of additional riparian and wetland vegetation. However, the scouring of vegetation would occur during high flow periods as now occurs under the no-action alternative. Along the Uncompahgre River, bank stabilization efforts would be required to protect riparian areas.

Less than one percent of the total known population of the endangered clay-loving wild buckwheat (Erigonum pelinophilum) would be eliminated during construction of the penstock. Special construction techniques in this area would be imposed to reduce impacts, and off-site conservation measures to protect other populations would be implemented.

FISHERIES

Without development, the Gunnison River would be expected to keep its status as a Gold Medal fishery maintained by natural reproduction. This fishery has been maintained under a large range of flows during the 1980's, and no significant, long-term habitat or water quality changes would be expected.

Development alternatives would divert additional flows from the river, with the largest change occurring during the nonirrigation season. Studies on the fish populations and fish habitat during the 1980's indicate that the fishery would be maintained under development conditions. Additional fishing pressure would occur. Additional diversions through the Tunnel may increase the loss of fish from the Gunnison River to the South Canal.

Under the no-action alternative, the fishery in the Uncompahgre River between Ridgway Dam and the M&D Canal would be expected to improve due to better flow patterns and water quality. With development, habitat conditions may improve between the South Canal and the Loutzenhizer Diversion (approximately 7 miles) and decline between the Loutzenhizer Diversion and Montrose (approximately 4 miles). Flow conditions and water quality should improve downstream from Montrose, but other habitat conditions may prevent development of a significant fishery. River flows downstream from Delta would not be affected; therefore, the endangered fishes that inhabit the lower Gunnison and Colorado Rivers would not be affected.

WILDLIFE

Significant changes are not projected under the no-action alternative. Land use changes in the Uncompahgre Valley may gradually reduce wildlife habitat and numbers. Land management plans for lands along the Gunnison River, however, provide for long-term habitat preservation. Possible impacts to wildlife under development alternatives include loss of habitat in construction areas and the direct loss of 11 acres of wetland. These losses would be offset by a wetland replacement plan and restoration and revegetation plans. Increased flows in the Uncompahgre River would probably cause changes in the distribution of wintering waterfowl along that river. Reduced flows in the Gunnison River should not significantly affect wildlife resources. Increased hike-in fishing could, however, lead to wildlife disturbance during the spring and fall. Features of development alternatives include deer escape ramps along the AB Lateral and raptor-proofing of transmission lines to reduce impacts to wildlife.

Endangered bald eagles are common winter residents along rivers in the area, with the greatest concentrations occurring along the Gunnison River. Changes in river flows and accompanying ice conditions could affect use by eagles. A monitoring program has been recommended by the Fish and Wildlife Service (FWS) and adopted by the Sponsors.

LAND USE AND RECREATION

Significant land use changes are not projected under the no-action alternative. Construction of development alternatives would disturb approximately 234 acres of land, the majority of which is now used for livestock grazing or irrigated agriculture. Approximately 127 acres of land would be needed for operation of the facility. However, permanent land use changes would occur on only about 30 acres; this amount includes 24 acres of grazing land between the powerplant and the Uncompahgre River. The remaining 6 acres would be used for the operation and maintenance of the enlarged AB Lateral and its associated structures.

Under the no-action alternative, recreational use along the Gunnison River would be affected by management plans of the Bureau of Land Management (BLM) and the National Park Service (NPS). With development, river flows would decline, leading to a decrease in private and commercial rafting and an increase in hikers and anglers. The existing wilderness area in the Black Canyon of the Gunnison National Monument would have reduced river flows, particularly during the winter; this FEIS addresses the impacts of this reduction on resources within the Monument. The recreational value of the Uncompahgre River would continue to be limited from a public standpoint because of scarce public land along the river. However, various groups have recently developed trails and other public use areas along the river, and this trend is expected to continue. River flow changes in the Uncompahgre River would not deter from such developments except in the 4-mile reach between the Loutzenhizer Diversion and Montrose, where flows would be significantly reduced by the development alternatives. As indicated previously, alternatives E and F would provide additional flows to this reach as compared to other development alternatives.

WILD RIVER - WILDERNESS STUDY AREA

A portion of the Gunnison River downstream from the Tunnel has been determined to be eligible as a wild river under the Wild and Scenic Rivers System. A BLM wilderness study area borders the river downstream from the Black Canyon of the Gunnison National Monument. Under the no-action alternative, these areas may be designated by Congress as both a wild river and a wilderness area; they would remain eligible under development conditions according to NPS and BLM, although some resources would be adversely affected, according to these agencies.

SOCIAL AND ECONOMIC CONDITIONS

Without development, the economy of the Montrose-Delta area would continue to be dependent upon agriculture, tourism, and light industry. With the development alternatives, local employment opportunities would increase during construction. Operation of the facility would be expected to produce annual tax revenues to Montrose County of $400,000. Operating revenues to the UVWUA would be expected to range between $150,000 and $300,000 in the first year of operation, escalating each year thereafter to more than $1 million in the year 2008.

Without development, rafting use along the Gunnison River would be expected to average approximately $311,000 annually of direct expenditures. With development of alternatives B, E, or F, these expenditures would be reduced to about $274,000 annually, or to $237,000 with development of alternative C.

Without development, the estimated expenditures attributed to hike-in fishing to the Gunnison River would be about $446,000. This value would increase to about $507,000 with development of alternatives B, E, or F and to about $541,000 with development of alternative C.

AIR QUALITY AND NOISE

Operation of the facility would have little, if any, adverse impact on the air quality of the region. Activities during construction would generate fugitive dust emissions and mobile source air emissions. Dust may be generated during certain phases of construction. Motor vehicles and other construction equipment would emit exhaust pollutants.

Operation of the facility would offset emissions of SO_2, NO_x, and CO_2. For alternative E, these offsets are anticipated to average 740, 1,235, and 234,000 tons per year, respectively. For other alternatives, the offsets would be slightly higher.

Within the operational areas of the powerplant, the noise levels would conform to safe levels as established by Occupation Safety and Health Administration (OSHA) regulations. Outside the plant, the only constant and appreciable noise source would be the transformers. Vehicular traffic would be infrequent. Construction noise would result but would be short term and restricted to between 7 a.m. and 7 p.m. in residential areas.

CUMULATIVE IMPACTS

To more accurately describe impacts of the development alternatives, future river operations have been projected under the no-action alternative. The effects of upstream reservoirs of the Aspinall Unit and the Dallas Creek Project have been estimated so that total impacts of the AB Lateral Facility on the river systems can be seen.

Cumulatively, the impacts of reduced flows in the Gunnison River and the resultant increase of hike-in human use would affect wilderness and river values and would also reduce solitude and primitive recreational opportunities. Extensive publicity (both recent and ongoing) about the river and efforts to acquire additional access to the river will also contribute to an increase in hike-in human use. To preserve wilderness values, it will likely be necessary for the NPS and the BLM to institute more restrictive management practices on lands they administer along the Gunnison River.

A number of other projects upstream from the Aspinall Unit are being considered, including transmountain diversions to the eastern slope of Colorado. The feasibility of these proposals is directly affected by Colorado water law. If any of the development alternatives proposed in this FEIS are implemented, the available water supply for those projects could be reduced if their water rights are junior to those of the AB Lateral Facility. The water rights granted to the AB Lateral Facility would reserve more water in the Gunnison River Basin.

PUBLIC INVOLVEMENT

Public involvement activities are described in this FEIS. Various proposals for hydropower development on the UVRP have been considered since the mid-1930's. In 1986, Reclamation began issuing news releases and consulting with various agencies on the AB Lateral proposal; in 1987, it began preparing an environmental assessment and conducted environmental scoping meetings. Following public review of the assessment, Reclamation determined that an EIS should be prepared. Significant issues were determined throughout the public involvement process, and studies were completed to answer issues and concerns. A draft EIS was released for public review in April 1989. A record of decision will be issued following the 30-day waiting period after this FEIS is released.

SUMMARY

The following tables (S-1 through S-4) summarize information on the facility, including alternative costs, benefits, energy production, river flows, irreversible and irretrievable impacts and other environmental parameters. A financial feasibility ratio has been computed for each of the development alternatives. Only the sale of power generation has been included in the benefits calculation. Costs include the cost of constructing and operating the alternatives, environmental mitigation costs, and property taxes. Reclamation's recommended alternative is alternative E.

Summary Table S-1.--Short- and long-term impacts resulting from alternatives--AB Lateral Project

Resource	Irre-versible impact[1]	Irre-trievable impact[2]	Relationship of short-term use of environmental and long-term productivity
Streamflows	No	No	Streamflows in the Gunnison River would be reduced by diversions to proposed development. Streamflows in the Uncompahgre River would be increased. Largest decreases and increases would occur during the winter months.
Irrigation	No	No	Water supplies to irrigated lands would not be affected. Development would be operated to provide required demands to irrigation system before meeting hydropower demands.
River mechanics	Yes	No	Without mitigation, development would increase bank erosion along the Uncompahgre River downstream from the proposed tailrace. However, mitigation would help control the erosion. Gunnison River channel impacts would be less than would occur in the Uncompahgre River; however, changes presented in this FEIS to the Uncompahgre would be considered irreversible.
Water temperature	No	No	Periodic ice accumulation would occur during severely cold periods. During summer months, water temperatures in the Gunnison River below the North Fork confluence would increase during low flow periods. Temperatures in the Uncompahgre River would decrease in the summer below the powerplant and increase in the summer through the city of Montrose.
Water quality	No	No	Water quality in the Uncompahgre River would improve below the proposed tailrace. Water quality would degrade in the Uncompahgre River between the South Canal and the tailrace. Water quality in the Gunnison River would degrade downstream of the Smith Fork confluence.

[1] An irreversible impact to a resource is one that cannot be changed once it occurs.

[2] An irretrievable impact means that the resource cannot be recovered or reused.

Summary Table S-1.--Short- and long-term impacts resulting from alternatives--AB Lateral Project (continued)

Resource	Irreversible impact[1]	Irretrievable impact[2]	Relationship of short-term use of environmental and long-term productivity
Fisheries	No	No	Significant impacts to the Gunnison River fishery would not occur. The Uncompahgre River fishery below the tailrace would improve as a result of increased flows but would decline through Montrose.
Soils & vegetation	Yes	Yes	Less than one percent of the populations of clay-loving wild buckwheat and adobe penstemon would be eliminated during construction of the penstock. Widening and lining of the AB Lateral would result in the loss of 4 acres of wetland. Bank stabilization along the Uncompahgre River would result in the direct loss of 11 acres of wetland and an indirect loss of 11 to 29 acres.
Terrestrial wildlife	No	No	Significant impacts to terrestrial wildlife would not occur.
Land use & recreation	No	No	Significant land use changes are not expected with development. Recreational rafting usage of the Gunnison River would decrease. Hike-in angler use of the Gunnison River Gorge would increase.
Social and economic	No	No	Short-term employment opportunities would increase as a result of construction. Minor, long-term employment could also change due to increased revenues to Montrose County and the UVWUA. Development would decrease employment in the rafting industry and increase employment related to fishing.
Cultural resources	No	No	No impacts would occur to cultural resources except under alternative C, which includes enlarging the Gunnison Tunnel.
Air quality	No	No	Short-term degradation of air quality resulting from construction equipment would occur. Development would reduce emissions of air pollutants from fossil-fueled powerplants.

Summary Table S-2.--Summary comparison of alternatives--AB Lateral Project

Item	Alternative				
	A	B	C	E	F
Water flow data (in ft^3/s)					
Gunnison River					
Entering Black Canyon (average annual)	1,103	613	563	654	618
Average December through February flows	1,392	476	471	581	499
Average July through September flows	897	730	637	730	730
Minimum flows	300	300	300	300	300[1]
Below Delta (all periods)	No change	No change	No change	No change	No change
Uncompahgre River					
Below South Canal (average annual)	540	342	342	342	343
Average December through February flows	88	88	88	88	88
Average July through September flows	910	579	579	579	585
Below Montrose & Delta Canal (average annual)	312	113	113	113	115
Average December through February flows	60	60	60	60	60
Average July through September flows	471	140	140	140	145
Entering Montrose (average annual)	269	65	65	65	67
Average December through February flows	48	48	48	48	48
Average July through September flows	392	58	58	63	63
Below Cedar Creek (average annual)	202	684	735	643	679
Average December through February flows	38	956	960	850	932
Average July through September flows	279	442	536	442	442
Through turbines (average annual)	- NA -	702	751	661	695
Average December through February flows	- NA -	918	922	812	894
Average July through September flows	- NA -	527	621	527	522
Production data					
Rated capacity (HP)	- NA -	66,240	66,240	57,267	66,240
Rated capacity (kW)	- NA -	49,415	49,415	42,721	49,415
Average annual energy production (MWh)	- NA -	261,006	274,911	247,264	258,619
Design flow capacity (ft^3/s)	- NA -	1,135	1,135	950	1,135
Net head at maximum capacity (feet)	- NA -	580	580	603	580
Physical data					
Pipeline diameter (in.)[2]	- NA -	120	120	114	120
Tunnel modifications	None	None	Enlarged	None	None

[1] The minimum flow for alternative F would be increased as necessary during winter months for eliminating ice buildup in the Gunnison River downstream of the Tunnel.

[2] Penstock diameters are preliminary and subject to change.

Summary Table S-3.--Alternative cost data and financial feasibility analysis--AB Lateral Project ($1,000)

Item	Alternative				
	A	B	C	E	F
Alternative cost data (in 1990 dollars)					
Construction costs[1]	- NA -	$52,959	$53,709	$48,454	$52,959
Development costs[2]	- NA -	9,155	9,245	8,614	9,155
Total capital costs	- NA -	$62,114	$62,954	$57,068	$62,114
Annual operation and maintenance costs	- NA -	$1,050	$1,050	$950	$1,050
Financial analysis (in 1992 dollars)[3]					
Discount rate = 13 percent					
Present value, fixed costs	- NA -	$68,870	$69,797	$63,269	$68,870
Present value, variable costs	- NA -	$8,551	$8,551	$7,737	$8,551
Present value, revenues from sale of power	- NA -	$78,549	$82,733	$74,405	$77,848
Financial feasibility ratio	- NA -	1.015	1.056	1.048	1.006
Discount rate = 14 percent					
Present value, fixed costs	- NA -	$66,037	$66,926	$60,666	$66,037
Present value, variable costs	- NA -	$8,174	$8,174	$7,396	$8,174
Present value, revenues from sale of power	- NA -	$75,106	$79,107	$71,144	$74,436
Financial feasibility ratio	- NA -	1.012	1.053	1.045	1.003
Discount rate = 15 percent					
Present value, fixed costs	- NA -	$63,419	$64,273	$58,261	$63,419
Present value, variable costs	- NA -	$7,827	$7,827	$7,081	$7,827
Present value, revenues from sale of power	- NA -	$71,933	$75,764	$68,138	$71,290
Financial feasibility ratio	- NA -	1.010	1.051	1.043	1.001

1 Includes design and building, land acquisition, and environmental mitigation costs.
2 Includes financing, engineering design, licensing and legal fees, interest during construction, and administrative costs.
3 Discount rates evaluated represent the rate at which future costs and revenues are returned to 1992 dollars.

Summary Table S-4.--Impacts of alternatives--AB Lateral Project

Item	Alternative A	B	C	E	F
Water quality and quantity					
Salt-loading reduction (tons)	0	3,044	3,256	2,866	3,014
Average annual flow entering Black Canyon (Gunnison R.; ft^3/s)	1,103	613	563	654	618
Average annual flow entering Montrose (Uncompahgre R.; ft^3/s)	269	65	65	67	67
Average annual flow below Cedar Creek (Uncompahgre R.; ft^3/s)	202	684	735	643	679
Endangered species					
Clay-loving wild buckwheat affected by construction (acres)	0	<5	<5	<5	<5
Mitigation acreage provided by Sponsors (acres)	0	60	60	60	60
Endangered fisheries affected	None	None	None	None	None
Endangered wildlife affected	None	Bald eagle	Bald eagle	Bald eagle	Bald eagle
Wetlands (acres)					
Acreage directly affected	0	11	11	11	11
Acreage indirectly affected	0	29	29	11	29
Constructed wetland acreage provided	0	12	12	12	12
Additional riparian acreage planted	0	20	20	20	20
Land use (acres)					
Permanent easement requirements	0	127	127	127	127
Temporary easement requirements	0	249	249	249	249
Recreation					
Wilderness eligibility retained[3]	Yes	Yes[3]	Yes[3]	Yes[3]	Yes[3]
Gunnison River Wild & Scenic eligibility retained	Yes	Yes[3]	Yes[3]	Yes[3]	Yes[3]
Rafting, user days	4,673	4,066	3,440	4,066	4,066
Present value, direct expenditures ($1,000)[1]	$4,454	$3,924	$3,480	$3,924	$3,924
Economic impacts ($1,000)	$0	-$530	-$974	-$530	-$530
Fishing, user days	17,680	20,078	21,414	20,063	20,078
Present value, direct expenditures ($1,000)[1]	$6,387	$7,261	$7,748	$7,261	$7,261
Economic impacts ($1,000)	$0	$874	$1,361	$874	$874
Cultural resources					
Cultural resources sites affected	0	0	1	0	0
Air quality					
Air pollutant emissions offset: SO_2 (tons/yr)	0	800	825	740	800
NO_x (tons/yr)	0	1,300	1,375	1,235	1,300
CO_2 (tons/yr)	0	234,000	247,000	223,000	234,000
Present value, emission offset[2] SO_2 ($000's)	0	$4,799	$4,938	$4,444	$4,799
NO_x ($000's)	0	$6,715	$7,090	$6,360	$6,715
CO_2 ($000's)	0	$74,993	$76,790	$66,698	$74,993

[1] Direct expenditures for rafting and fishing shown as net present value, 1988 values inflated at 5 percent per year and discounted to 1992 dollars at 8.875 percent. Annual expenditures (in 1988 dollars) are shown in chapter 3.

[2] Present value of emission offset is calculated using technology involving cost of alternative reductions (see chapter 3); 1988 values are inflated at 5 percent per year and discounted to 1992 at 8.875 percent.

[3] Although eligibility is retained, values would be affected as discussed in chapter 3 of the FEIS.

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CHAPTER 1

PURPOSE AND NEED

INTRODUCTION

The purpose of this report is to present the environmental impacts that would occur if the alternatives of the AB Lateral Hydropower Facility were constructed and operated. The facility would be funded, built, and operated by the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners, jointly referred to as the "Sponsors" in this document.

The Sponsors plan to construct the AB Lateral Hydropower Facility using existing features of the Uncompahgre Valley Reclamation Project (referred to throughout this report as the UVRP), a Bureau of Reclamation (Reclamation) irrigation project. The Sponsors are seeking a contract (lease of power privilege) with Reclamation that would permit using UVRP features for generating hydroelectric power.

In 1987 and 1988, Reclamation prepared an environmental assessment (EA) to address project-related impacts. Public scoping meetings were held in November 1987 in Denver and Montrose, Colorado. Approximately 200 copies of the draft EA were distributed to agencies and interested members of the public in March and April 1988. Based largely on comments received in response to the EA, Reclamation determined that an environmental impact statement (EIS) for the facility needed to be prepared. Reclamation released the draft EIS in April 1989.

LOCATION

The facility would be located in west-central Colorado near the city of Montrose (see frontispiece map). The AB Lateral Project would use the existing Gunnison Diversion Dam, Gunnison Tunnel (Tunnel), part of the South Canal, and an enlarged AB Lateral near Montrose to deliver water to a proposed penstock and powerplant.

AUTHORIZATION

The Uncompahgre Valley Reclamation Project (originally called the Gunnison Project) was authorized by the Secretary of the Interior on March 14, 1903, under the provisions of the Reclamation Act. Rehabilitation of the project and construction of the Taylor Park Dam was approved by the President on November 6, 1935.

Hydropower development in association with the UVRP was authorized by the Act of June 22, 1938 (Public Law 75-698, Stat. 941) (the Act). Reclamation published a notice of intent to contract for hydropower development on the UVRP in the December 9, 1985, issue of the Federal Register (50 FR 50238).

Reclamation received one proposal in response to the Federal Register notice, the proposal submitted by the Sponsors. Reclamation and the Sponsors subsequently signed an agreement on June 6, 1986, to study the feasibility of developing hydroelectric power on the UVRP.

Under the Act, the hydropower facility would be constructed and operated under a lease of power privilege with Reclamation. The lease would provide for cost reimbursement fees, Reclamation's role as overseer, and the Sponsor's obligations, including environmental commitments. Funding for the hydropower studies is provided by the Sponsors. Reclamation serves as the lead Federal agency responsible for ensuring compliance with the National Environmental Policy Act (NEPA) of 1969.

PARTICIPATING ORGANIZATIONS

The UVWUA, a Colorado nonprofit corporation formed under the Colorado Non-Profit Corporations Act (Act), was formed in part to repay the debt incurred to the Government during construction of the UVRP and in part to operate and maintain the UVRP. The construction repayment contract was renegotiated in 1948, and final payment is scheduled for the year 2048. In 1988, approximately $7 million of these loans were repurchased by the UVWUA and refinanced with $2 million of debt supplied by the State of Colorado.

The Act also allows a nonprofit corporation to carry out any lawful purpose for which it was established. According to the UVWUA's Articles of Incorporation, as amended in 1927, the UVWUA's lawful purposes include developing hydroelectric power facilities.

The UVWUA's involvement in the AB Lateral Facility would include assistance in acquiring title to and/or the right to use lands necessary for construction and operation of the facility and in acquisition of the necessary water rights to operate the facility. The UVWUA would review and approve any plans that could affect the UVRP's operation including operation guidelines and canal and lateral modification designs. The UVWUA would operate and maintain the facility as part of normal operation and maintenance of the UVRP. The UVWUA would share the revenue from power sales but would not be at financial risk or liability for financing or constructing the facility for at least the first 25 years of operation. The UVWUA, at its option, could then acquire the project with any attendant obligations or liabilities. However, construction costs would be repaid before then. Revenues would be used for early debt retirement, for upgrading the irrigation system, or for reducing annual water users' assessments.

Montrose Partners is a partnership formed under the Massachusetts Limited Partnership Act (limited partners consist of a group of private investors). Mitex, Inc., of Boston, Massachusetts, the general partner, is a developer, owner, and operator of small hydropower facilities and has developed a number of hydroelectric projects.

Montrose Partners and the UVWUA would acquire all lands necessary for constructing and operating the facility. They would contract with engineering firms and others for studies and designs required to complete the facility, contract with equipment manufacturers to provide turbines and other electrical and mechanical equipment, and negotiate agreements for the sale of power. Montrose Partners would raise all funds needed to pay for the above activities and would be responsible for any financial risk for construction, operation, and maintenance of the facility. Revenues from power sales would be distributed among investors in the facility, the UVWUA, and the United States. The Sponsors are also required to comply with applicable city, county, and State rules and regulations regarding land use, water quality protection, and construction.

In addition to Reclamation's involvement in the facility, other Federal agencies are involved in various development stages. Approximately 1.7 acres of Federal land administered by the Bureau of Land Management (BLM) would be needed for enlarging the AB Lateral (described later); a Section 404 Permit would be needed from the U.S. Army Corps of Engineers (COE); a Section 402 Permit would be needed from the Colorado Department of Health; a Biological Opinion has been prepared by the Fish and Wildlife Service (FWS) under the Endangered Species Act; and coordination is ongoing with the FWS under the Fish and Wildlife Coordination Act. BLM and the National Park Service (NPS) are cooperating agencies with Reclamation in the NEPA process.

PURPOSE OF PROJECT

The purpose of the AB Lateral Hydropower Facility is to economically develop the energy potential of water flows from the Tunnel to the Uncompahgre River. The large difference in elevation between the West Portal of the Tunnel and the Uncompahgre River creates the potential for hydropower production.

NEED FOR PROJECT

The Sponsors cite the following needs for the proposed hydropower facility: (1) generating electrical power, (2) developing a renewable resource, (3) improving the existing irrigation system, and (4) enhancing the UVWUA's revenues for debt repayment and system improvement.

ELECTRICAL POWER

Power from the proposed facility would be sold to local utilities. For the first 15 years of project operation, capacity and energy would be sold to the Public Service Company of Colorado (Public Service) for resale to its customers. The 15-year power sales contract signed in 1988 would coincide with the financing term for project-related debt. Beginning in year 16, the Sponsors would be free to select a different power purchaser for the balance of the lease term with Reclamation.

Under the Public Utilities Regulatory Policies Act of 1978 (PURPA), Sponsors are assured a market for project power at rates not to exceed the purchasing utility's "avoided cost." Avoided cost is generally defined as the cost a utility would incur to provide an equivalent amount of generation. The avoided cost standard was developed to ensure that electric rate payers would be indifferent to such purchases. Power sales from the project at rates less than or equal to avoided costs would thus be economical when compared to other alternatives.

Electrical power needs within specific service territories are forecast by individual utilities. Currently, some utilities have surplus generating capacity, others are meeting current demands, and some have immediate needs. Public Service, which has contracted to purchase project electricity, has indicated a need for new capacity and energy in both the short and the long term. In the short term, Public Service has planned its resource acquisition process assuming that the AB Lateral project will be available to serve load[1] beginning in 1993. If AB Lateral is not completed by then, alternative arrangements would be necessary or the utility would be deficit by approximately 40 megawatts (MW).

Public Service Company's December 1989 Electric Demand and Supply Plan (Public Service Company, 1989) predicts that peak demand will increase an average of 1.6 percent annually, after allowances for demand management, through the end of its 20-year planning horizon. Including new reserve requirements, there will be a predicted increase over the next 20 years of 1,513 MW over 1989 loads. In addition, approximately 750 MW of existing power contracts will expire in that time period, leaving a need for 2,263 MW of new capacity by 2009.

Public Service Company proposes to meet that need with approximately 110 MW of unit re-ratings and upgrades, 1,330 MW of new on-system generating resources, and 800 MW of new power purchases, timed to meet demand as the demand for power grows. Public Service Company's projections include AB Lateral as an already committed resource from at least 1993 through 2008. If AB Lateral is not constructed, then the need for additional

[1] Load is the electric demand placed on a utility by its customers.

resources would increase accordingly. Evaluating the predicted needs of Public Service Company, the project's power sales agreement was approved by the Colorado Public Utilities Commission in June 1988 (Colorado Public Utilities Commission, 1988).

Demand forecasts for the larger Rocky Mountain Power Area (Colorado and parts of Wyoming and South Dakota) are published annually by the Western Systems Coordinating Council (WSCC). The WSCC reported that surplus generation capacity for the near term was available in the Rocky Mountain area (North American Electric Reliability Council, 1989). However, the 1988 WSCC forecast showed scheduled capacity additions to serve an electric load totaling 1,568 MW in the area from 1988 to 1997 (WSCC, 1988).

The Federal Energy Regulatory Commission (FERC) also provides independent assessments of power needs. Within Colorado in 1988, FERC established the need for new power resources in EA's for hydropower projects at Paonia Dam (44FERC 62,010; 7/1/88), Lemon Dam (43FERC 62,305; 6/16/88), and Maroon Creek (Project 10,441; 7/20/88). The proposed AB Lateral Facility, under a 40-year lease from Reclamation and with a potential 50-year project life, would be useful in meeting a portion of the immediate and future power needs within Colorado and the immediate region.

Integrating facility power into the local grid would supply additional benefits to local power quality and reliability. Operating the facility, with its proximity to the Montrose load center, would provide an alternate power source in case temporary outages occur at Colorado-Ute Electric Association thermal plants or transmission lines. In addition, the facility would provide needed voltage support to the local system, alleviating a problem that usually occurs when load is separated from generators by long transmission lines.

The conservation potential of Public Service, as well as other regional utilities, would remain intact after the AB Lateral Project is completed. Construction of the project would not eliminate any conservation options nor make them more expensive. Public Service already has a demand management program in place that is expected to continue to help offset the need for additional construction. Anticipated load savings from this program are already included in their base forecasts.

Finally, operation of the facility would enhance the State of Colorado's electrical reliability by contributing to fuel diversity. Colorado and the rest of the Rocky Mountain power area rely heavily on coal to fuel major powerplants. Adding hydroelectric generation to the system would help mitigate economic difficulties if the coal supply were interrupted, if coal prices were to increase substantially, or if acid rain legislation required installing emissions reduction equipment at existing facilities.

RENEWABLE RESOURCES

In passing the National Energy Act of 1978, Congress found that:

> [T]he protection of the public health, safety, and welfare, the preservation of national security, and the proper exercise of congressional authority under the Constitution to regulate interstate commerce require...a program providing for increased conservation of electric energy, increased efficiency in the use of facilities and resources by electric utilities, and equitable retail rates for electric consumers, [and]...a program to provide for the expeditious development of hydroelectric potential at existing small dams to provide needed hydroelectric energy (PURPA, Section 2; Public Law 95-617).

One of Congress' key motivations in passing this bill was to reduce the national dependence on fossil fuels (other sources of preserving fossil fuels are energy conservation and solar generation). Developing the AB Lateral Facility would eliminate the need to construct and (or) operate an equivalent amount (40 to 50 MW) of fossil-fueled generation, thus reducing dependence on fossil fuels.

The primary natural resource involved in this project is water, which is considered renewable. The facility would lessen the need for energy produced from nonrenewable resources such as coal and oil. Approximately 400,000 barrels of oil per year or 125,000 tons of coal annually would be needed to equal the energy that would be produced under alternative E. Therefore, these natural resources would be conserved because of this project.

Recently, emissions-related problems have been brought to the forefront of national attention. The principal smokestack gases released from fossil-fueled powerplants include sulfur and nitrogen oxides and carbon dioxide. The sulfur and nitrogen oxides are thought to be major contributors to the phenomenon known as "acid rain." Carbon dioxide, and, to a lesser extent, nitrogen oxides, are believed to be principal causes of the "greenhouse effect" (the slow warming of overall climate). Thus, a strong need exists to reduce emissions of these gasses where economically feasible.

Operation of the proposed facility would result in emissions reductions from existing and/or future fossil-fueled plants in direct proportion to the facility's generation. The alternatives considered would result in emissions offsets (reductions) of sulfur oxides ranging from 750 tons per year to 825 tons per year. Nitrogen oxide emissions would be reduced by 1,235 to 1,375 tons per year. Offsets or reductions in carbon dioxide emissions, the major contributor to the "greenhouse effect," would range from 223,000 to 247,000 tons per year as a result of facility operation.

IRRIGATION SYSTEM

Facility development would include installing automated stream gauges, gate control equipment, and remote telemetry devices at key locations on the UVWUA system. Information from these units would be fed directly to the UVWUA headquarters in Montrose. The instrumentation would allow the UVWUA to more efficiently control the flow of water needed to serve both irrigators and the hydropower facility.

The facility penstock would provide an alternate route for irrigation water to travel from the Tunnel to the Selig, Ironstone, Garnet, and East Canals (see figure 1.1). If emergency repairs are ever necessary to the South Canal during the irrigation season, water flows could still be maintained for most of the UVRP, increasing the reliability of the irrigation system.

UVWUA REVENUES

The UVWUA currently has outstanding rehabilitation and betterment (R&B) loans of approximately $2.1 million due to the State of Colorado and an additional debt of $3.5 million owed to the Federal Government under construction loans originally lent for the Uncompahgre Project. The principal source of revenue to meet these expenses is the sale of water to UVWUA irrigators. One impact of the project would be assistance to the UVWUA in repayment of this debt. As currently planned, initial revenues would be used for debt retirement on an accelerated basis. Revenues from water charges could then be used for more comprehensive operation and maintenance (O&M) activities.

Overall charges to farmers could thus be held constant, or in the long run, possibly decrease, while greatly improving system efficiency. The Federal debt, which is not fully due until 2048, could be repaid by 2004.

BACKGROUND

The proposed hydropower development would be located within the boundaries of the UVRP, which now supplies irrigation water to nearly 86,000 acres and includes the Taylor Park Dam and Reservoir in Gunnison County, 7 diversion dams, 152 miles of canals, and 414 miles of laterals in Montrose and Delta Counties. Water from the Gunnison River is diverted through the Tunnel and delivered by the South Canal to the Uncompahgre River for rediversion to UVRP lands. The UVRP canal system and irrigated lands begin about 6 miles south of Montrose and extend downstream (northward) to Delta for 34 miles along both sides of the Uncompahgre River. Figure 1.1 shows the location of the major canals of the UVRP and other features of the study area.

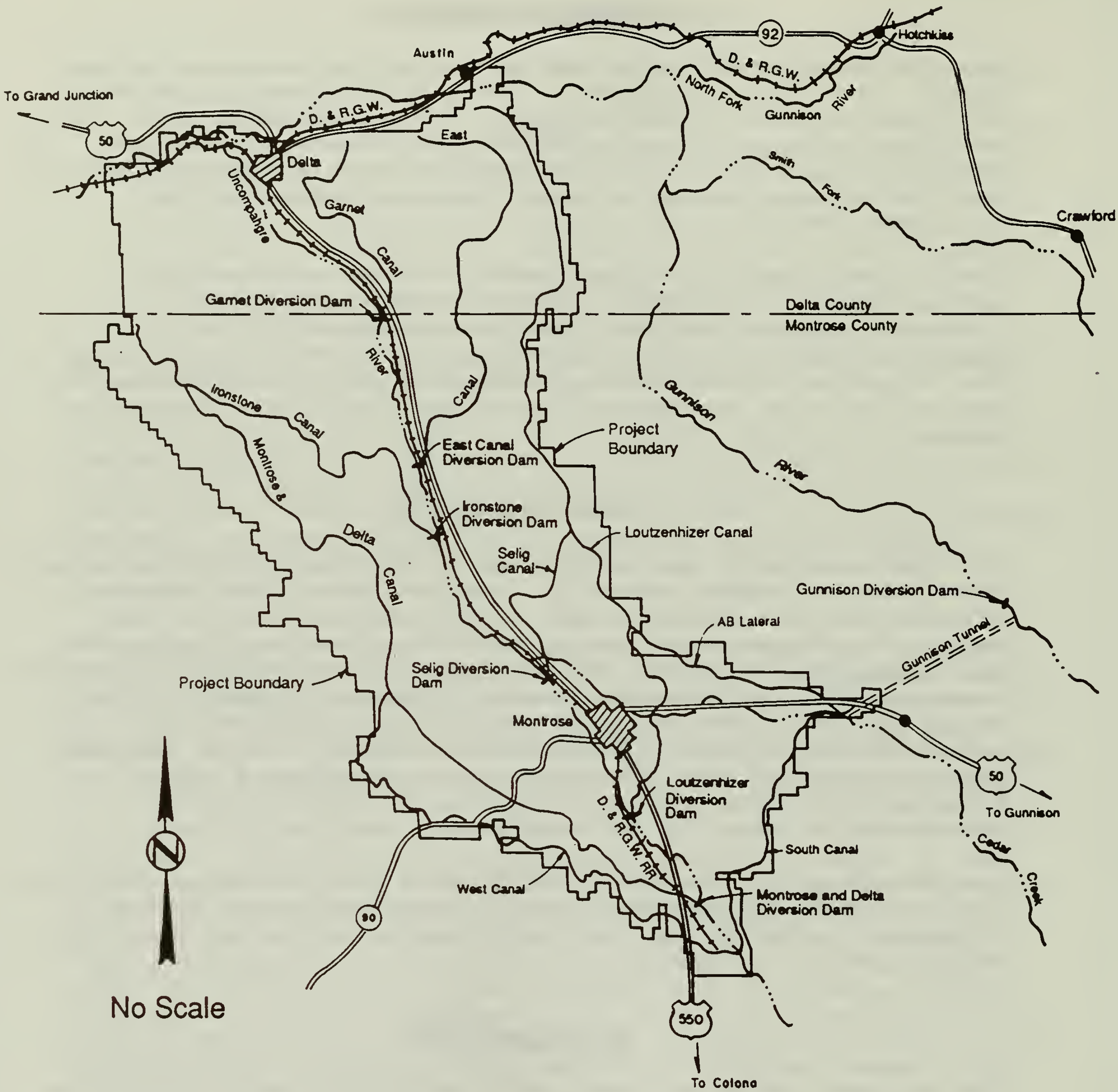


Figure 1.1. Uncompahgre Valley Reclamation Project.

Irrigation and water supply demands for the UVRP are met by diverting flows from the Gunnison and Uncompahgre Rivers. Historically, about 505,000 acre-feet of water annually flows into the Uncompahgre Valley. About two-thirds of this flow is supplied by the Gunnison River through the existing Tunnel; the remaining supplies enter from the Uncompahgre River.

The average annual flow in the Gunnison River is about 1,360 cubic feet per second (ft^3/s) upstream from the Tunnel, which is more than five times greater than the average annual flow of the Uncompahgre River near Colona, just upstream of UVRP boundaries. Historically, both rivers carry high natural flows during late spring and early summer resulting from snowmelt.

Natural flows on both rivers are now regulated by dams operated by Reclamation upstream from UVRP lands. Crystal, Morrow Point, and Blue Mesa on the Gunnison River comprise Reclamation's Wayne N. Aspinall Unit. Ridgway Dam on the Uncompahgre River is part of Reclamation's Dallas Creek Project. Taylor Park Dam, which is part of the UVRP and operated by the UVWUA, provides irrigation storage and is located on the Taylor River upstream of Blue Mesa Dam. Figure 1.2 shows the location of these dams.

The Gunnison and Uncompahgre Rivers have been linked by a network of canals and laterals since the early 1900's. The major features of this linkage are the Tunnel and the South Canal, which convey diverted flows from the Gunnison River into the Uncompahgre River. Portions of these flows are diverted from the South Canal to meet demands along its length, including those of the AB Lateral and West Canal. However, the majority of the 336,000 acre-feet plus of water annually diverted from the Gunnison River are combined with Uncompahgre River water to irrigate UVRP lands.

Water is diverted from the Uncompahgre River at six diversion dams and passed through several hundred miles of canals, laterals, and drains to meet irrigation needs. Moving downstream from the South Canal outfall, other major canal systems include the Montrose and Delta (M&D), Loutzenhizer, Selig, Ironstone, East, and Garnet Canals. Annual irrigation diversions for the UVRP and other private systems have averaged about 559,000 acre-feet per year. About half of the flow diverted to these canals is used consumptively (mainly for irrigation), and the remainder returns to the Uncompahgre River for downstream use and ultimately joins the Gunnison River near Delta.

Historic UVRP operations have been constrained by two major factors, the capacity of the Tunnel and periodic flooding on the Uncompahgre River downstream of the South Canal. Presently, the capacity of the Tunnel is 1,135 ft^3/s, based upon tests conducted by the UVWUA and the Colorado State Engineer in September 1987 (Colorado State Engineer, personal communication, 1987).

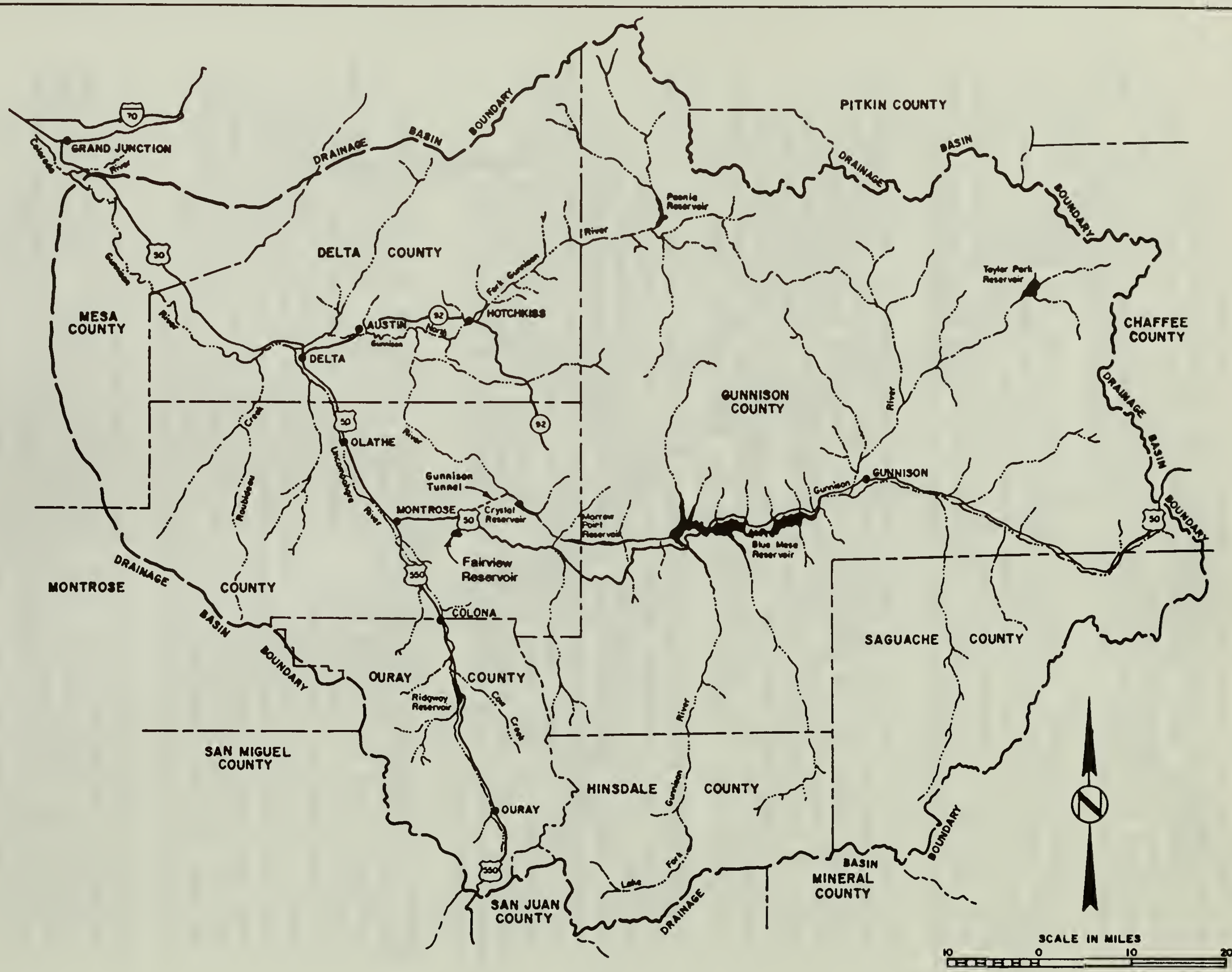


Figure 1.2. Gunnison River Basin

The Tunnel is 5.8 miles long and crosses under the hydrologic divide between the Gunnison and Uncompahgre River Basins. Construction on the Tunnel was started by private interests before 1900 but was stopped due to financial problems. Construction began again in 1904, shortly after development efforts were assumed by Reclamation (then known as the Reclamation Service). The Tunnel was completed in 1909, but full operation did not begin until 1912, when the Gunnison Diversion Dam was completed. Because of its significance to the historical development of the region and because of the history surrounding the actual construction, the Tunnel has been placed on the National Register of Historic Places. It has also been registered by the American Society of Civil Engineers as a National Engineering Landmark.

RELATIONSHIP WITH OTHER PROJECTS

The Gunnison and Uncompahgre River Basins have been the subject of numerous projects, plans, and programs discussed below. The proposed development would operate in concert with existing projects and become part of future management plans for the two basins.

UNCOMPAHGRE VALLEY RECLAMATION PROJECT

The Tunnel, the South Canal, and the AB Lateral of the UVRP would be used by the proposed development to deliver water for hydropower generation. A detailed description of the modifications to these features is presented in chapter 2 of this report.

The Tunnel is now operated during the irrigation season, with periodic use during the winter to provide water to Fairview Reservoir (see figure 1.2). With development, the Tunnel would be operated year round, although periodic inspection and maintenance would be performed. Year-round operation would not affect the integrity or life expectancy of the Tunnel. Physical modifications to the Tunnel would not occur in three of the four development alternatives. For alternative C, the Tunnel would be modified to increase its hydraulic capacity to 1,300 ft^3/s.

The South Canal would be modified to incorporate a larger diversion structure to the AB Lateral. These modifications would be constructed when they would least disrupt irrigation deliveries. The construction work would include temporary provisions for water delivery downstream from the modifications.

A portion of the AB Lateral would be modified to provide greater discharge capacity in the lateral. The modifications would include concrete-lining the affected length, estimated to be approximately 7,100 feet from its diversion at the South Canal to the proposed penstock intake structure. Irrigation deliveries would not be impaired during construction of the modifications or operation of the proposed facility.

Under any circumstances, operation of the proposed development would not reduce deliveries of irrigation water to UVWUA members. Irrigation water for the Selig, Ironstone, Garnet, and East Canals would pass through the proposed facility rather than the South Canal. Flows in the Uncompahgre River in combination with Gunnison River water would be used to meet the demands of the M&D and the Loutzenhizer Canals. However, these systems would not place a call on the river that would prevent Ridgway Reservoir from storing water when the Tunnel water right for direct flow could be used to meet irrigation demands.

Operation of the proposed development would provide some insurance against a failure of the South Canal. Acreage irrigated under the project would not increase.

WILD AND SCENIC RIVERS ACT

Section 5(a) of the Wild and Scenic Rivers Act identified the Gunnison River as a "Candidate River" for designation (Public Law 93-621; January 3, 1975). The NPS completed a study and concluded that 26 miles of the river from the upstream boundary of the Black Canyon of the Gunnison National Monument (Monument) downstream to the Smith Fork confluence are eligible for designation as a wild river. The eligibility was based upon five criteria: (1) it is free-flowing; (2) its length is sufficient to provide a meaningful experience to the recreation users; (3) it has adequate volumes of high quality water; (4) its watershed and shoreline are primitive and relatively inaccessible; and (5) its environs possess outstanding scenic, geologic, recreational, and wildlife values (USDI, NPS, 1979b).

Development of any of the proposed alternatives would primarily affect criterion 5, recreation use, and criterion 3, volume of water, as discussed in detail in chapter 3. The river would remain eligible for "wild and scenic" status under all alternatives.

WILDERNESS AREAS

Both a wilderness area and a wilderness study area exist along the Gunnison River downstream from the Tunnel. An area of 11,180 acres in the Black Canyon of the Gunnison National Monument has been designated as wilderness, and 21,038 acres of public land managed by BLM downstream from the monument have been designated the Gunnison Gorge Wilderness Study Area (WSA). The

BLM (1990) has published a FEIS recommending the entire Gunnison Gorge WSA, plus an additional 1,040 acres (or 22,078 total acres) as preliminarily suitable for wilderness designation.

Operation of alternative hydropower plans would affect river flows through these areas and this, in turn, would affect recreation use. These impacts are discussed in chapter 3.

BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT

The Black Canyon of the Gunnison National Monument was established in 1933 and borders the Gunnison River immediately downstream from the Tunnel. River flows through the Monument are regulated by the upstream Aspinall Unit Reservoirs and by diversions through the Tunnel. Alternatives being considered under the project would further alter these flows. The flow changes and their effects are discussed in chapter 3.

EXPANSION OF BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT

The NPS, in accordance with the House Conference Report accompanying the Interior Appropriations Bill (Public Law 100-446, 102 Stat. 1174, approved on September 27, 1988), is currently evaluating expansion of the Monument along the Gunnison River. A draft report has been released for public review evaluating several alternatives including expanding the Monument. The BLM has suggested study of the area as a National Conservation Area as an alternative to Monument expansion.

GUNNISON GORGE RECREATION MANAGEMENT AREA

The Gunnison Gorge Special Recreation Management Area (64,000 acres), which borders the Gunnison River downstream from the Black Canyon of the Gunnison National Monument, includes the Gunnison Gorge WSA. These lands are managed by the BLM under the Gunnison Gorge Recreation Area Management Plan and the Uncompahgre Basin Resource Management Plan. The BLM indicates that the Gunnison Gorge is being managed for biological, aesthetic, and primitive recreational values. The BLM also indicates that the hydropower facility would conflict with those management plans.

WAYNE N. ASPINALL UNIT

The Aspinall Unit Reservoirs--Blue Mesa, Morrow Point, and Crystal--were completed in 1966, 1970, and 1976, respectively. The Aspinall Unit, along with Glen Canyon Dam in Arizona, Flaming Gorge Dam in Utah, and Navajo Dam in New Mexico comprise the four major storage units of the Colorado River Storage Project (CRSP).

The CRSP was authorized in 1956 to provide storage to ensure that water commitments to the Lower Colorado River Basin States are met and to allow the Upper Colorado River Basin States to develop water for hydroelectric power, irrigation, and municipal and industrial use. The Aspinall Unit, located in Gunnison and Montrose Counties, provides water storage and hydroelectric power generation along the 40-mile section of the Gunnison River between the city of Gunnison and the Gunnison Diversion Dam at the Tunnel.

Flows in the Gunnison River are largely controlled by Blue Mesa Reservoir, the largest and most upstream of the three Aspinall Reservoirs. Water released through the Blue Mesa Powerplant receives short-term reregulation by Morrow Point and Crystal Reservoirs, immediately downstream. Blue Mesa Reservoir has a storage capacity of 940,700 acre-feet, while Morrow Point and Crystal Reservoirs have capacities of 117,000 and 26,000 acre-feet, respectively. At Blue Mesa, storage allocations are 748,430 acre-feet for active conservation and flood control; 81,071 acre-feet inactive storage; and 111,200 acre-feet dead storage (USDI, Reclamation, 1981). The reservoir is normally drawn down in the late summer, fall, and winter period; major filling occurs between April and August. Water releases through Blue Mesa and Morrow Point are primarily for peaking power, while releases through Crystal Powerplant are uniform to satisfy downstream water rights and to maintain an instream flow of 300 ft^3/s downstream from the Tunnel (see chapter 3 for background on the 300-ft^3/s instream flow).

Operation of the proposed development would not affect the operation or purposes of the Aspinall Unit Reservoirs nor would it prevent future changes in the operation of the Aspinall Unit. The proposed hydropower plant would be operated as a "run-of-the-river" facility, meaning that water would be diverted as it is available in the streambed without placing water rights calls on upstream storage. Consequently, the proposed development would not result in reduced storage or lower water levels in the Blue Mesa Reservoir.

DALLAS CREEK PROJECT

Ridgway Dam and Reservoir, part of the Dallas Creek Project, were completed in 1988 on the Uncompahgre River approximately 25 miles upstream (south) of Montrose. The reservoir includes 55,000 acre-feet of storage to be used for municipal, industrial, and irrigation purposes in the Uncompahgre Valley.

Reclamation's proposed operation of this reservoir has been incorporated into the Sponsors' water supply studies. The analysis was based upon projected operating schedules and releases from the reservoir for a 32-year period (from 1952-1983). Development of the AB Lateral alternatives would not affect water levels in the Ridgway Reservoir nor would it increase the amounts of water withdrawn for irrigation or other purposes.

SMITH FORK PROJECT

The Smith Fork Project was constructed by Reclamation in the early 1960's and is located in Delta and Montrose Counties about 25 miles east of Delta. (The Smith Fork is the largest tributary to the Gunnison River between Crystal Dam and the North Fork.) Using flows of the Smith Fork and Iron, Muddy, and Alkalai Creeks, the project provides supplemental irrigation water to 8,924 acres and a full service supply to 1,423 acres of land. The principal feature is Crawford Dam about a mile south of Crawford on Iron Creek. The 14,395-acre-foot Crawford Reservoir stores the direct surplus flows of Iron, Muddy, and Alkalai Creeks, as well as flows of the Smith Fork through the Smith Fork Feeder Canal. Water from the reservoir is supplied to project lands by Aspen and Clipper Canals.

The Crawford Water Conservancy District operates and maintains the project, while the Colorado Division of Parks and Outdoor Recreation administers the recreation at Crawford Reservoir that includes fishing, boating, and camping. The Smith Fork Project would not be affected by operation of any of the AB Lateral alternatives.

UNCOMPAHGRE REHABILITATION AND BETTERMENT PROGRAM

Although maintenance and rehabilitation has been regularly performed during UVRP operation, much of the UVRP system needed repair and modernization by the 1970's. In 1979 (at UVWUA's request), Reclamation began a detailed inspection of UVRP facilities to determine the extent and nature of needed improvements; the study was completed in 1981. A R&B report was approved that authorized a R&B loan from the United States to the UVWUA; work was begun in 1982 on that program.

Completed rehabilitation work includes: (1) replacement of the needle valves and associated structures at Taylor Park Dam with jet flow valves, (2) replacement of the wooden flume through Olathe with buried concrete pipe, (3) reconstruction of the wooden flume section on the Ironstone Canal with a concrete-lined section, (4) installation of new concrete-lined sections on the West Canal to prevent leakage and slippage, (5) repair of the lining along the South Canal, (6) repair of the Tunnel and tunnels along the South Canal, and (7) capping the downstream apron on the Ironstone and M&D Diversion Dams and replacing the sluice gate on the Selig Diversion Dam. Completing the R&B program would not be affected by AB Lateral alternatives.

COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM

The Lower Gunnison Basin Unit of the Colorado River Water Quality Improvement Program was authorized for construction in 1984 under Public Law 98-569. The winter water portion of the unit would replace winter livestock water in the UVRP system with delivery through the rural domestic systems. Also, part of the overall plan is to concrete-line approximately 60 miles of canals and 195 miles of laterals on the east side of the Uncompahgre Valley. The winter water component of the plan was initiated in January 1990 as the initial phase of development. Construction and operation of the unit would not be affected by alternatives being considered for the hydropower project.

SHAVANO FALLS HYDROPOWER FACILITY

The Sponsors also propose to develop a 2.9-MW hydroelectric station at Shavano Falls on the M&D Canal about 6 miles west of Montrose. Power and energy from the Shavano Falls Facility would be sold to Public Service Company. Reclamation prepared an EA in 1986 and issued a finding of no significant impact in 1987 (USDI, Reclamation, 1986 and 1987b).

Developing the AB Lateral Facility would reduce the amount of hydropower water that would be diverted to this unit. This action would reduce the energy production at Shavano Falls; however, developing the AB Lateral Facility would not diminish the quantity of water in the M&D Canal for irrigation.

OTHER WATER PROJECTS

The Colorado Water Resources and Power Development Authority (Authority) is presently conducting a study of water and related resources of the Upper Gunnison and Uncompahgre Basins. The primary objective of this study has been to identify and evaluate water resources development plans to enhance the water-based economy of the study area in an environmentally sound manner with the goals to provide adequate future water supplies, to improve fisheries and recreational opportunities, and to provide greater public access for these activities. The Authority has included developing alternative B in its hydrologic modeling studies.

Several entities, some of which propose to divert water from the Gunnison Basin and transfer it to the east slope of the Rocky Mountains for municipal and industrial use, have filed competing water rights applications for using Upper Gunnison Basin water. Because these projects are still in the conceptual stage, the impacts of their development cannot be assessed. However, such diversions would be made in accordance with Colorado water law--water would be diverted in priority subject to the provision of adequate water supplies to senior water rights within the Gunnison Basin.

CHAPTER 2

ALTERNATIVES INCLUDING PROPOSED ACTION

SUMMARY OF ALTERNATIVES

Water is presently diverted from the Gunnison River to meet agricultural, domestic, municipal and industrial, and other needs in the Uncompahgre Valley. As mentioned previously, the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners (referred to as the Sponsors of the proposed development) intend to use a portion of the Gunnison River diversions to generate hydroelectric power. Additional diversions from the Gunnison River during the winter, and, to a lesser extent, during the irrigation season, are proposed.

The purpose of this chapter is to describe the various alternatives for developing the hydropower potential of the Uncompahgre Valley Reclamation Project (UVRP). The Sponsors have performed detailed technical and economic analyses for numerous development alternatives that involve various design flow options, different penstock routes, power potential of the South Canal, and different locations for the powerplant.

The financially feasible alternatives were given detailed environmental consideration. Alternatives that were not financially feasible were eliminated from detailed environmental study but are discussed in this chapter. The purpose of each alternative is to develop the power potential of discharges as they fall from the Gunnison Tunnel (the Tunnel) to the Uncompahgre River. Alternative methods of generating electricity, such as thermal or combustion powerplants, were not considered.

The alternatives involve generating hydroelectric power using flows diverted from the Gunnison River and the elevation difference between the West Portal of the Tunnel and the Uncompahgre River in Montrose. A portion of the flows that would be diverted would also be used to meet UVRP irrigation needs; the remaining flows would be diverted solely for power generation.

ALTERNATIVE A (NO ACTION)

Alternative A is the no-action alternative and represents the conditions of the affected area without development. It establishes the baseline for evaluating environmental impacts of hydropower development and anticipated conditions in the affected areas without development. Alternative A assumes that irrigation diversions made to the various canals would be made according to historic use.

ALTERNATIVE B

The AB Lateral Facility would be developed to a capacity of 1,135 cubic feet per second (ft^3/s). Irrigation demands were assumed to equal historically recorded diversions. Minimum instream flow in the Gunnison River was assumed to be 300 ft^3/s during all months of the year. Tunnel capacity is 1,135 ft^3/s.

ALTERNATIVE C

The AB Lateral Facility capacity and minimum flow for this alternative are the same as those values for alternative B (1,135 ft^3/s and 300 ft^3/s, respectively). However, the Tunnel capacity would be increased to 1,300 ft^3/s.

ALTERNATIVE E

This alternative proposes developing the AB Lateral Facility to a capacity of 950 ft^3/s, without altering the Gunnison Tunnel. The minimum instream flows were assumed to be 300 ft^3/s for all months of the year. A further operational change included in alternative E is represented by providing (through the South Canal) an additional 1,000 acre-feet of water in the Uncompahgre River upstream from the tailrace during August and September. This flow would be used in the river as directed by the Colorado Division of Wildlife (CDOW), should a fishery be developed in the Uncompahgre River. For modeling water flows, this amount has been estimated at an average of 8 ft^3/s in each of the 2 months. Also, flushing flows from the Aspinall Unit would be bypassed. Alternative E is Reclamation's preferred alternative.

ALTERNATIVE F

This alternative would be designed identical to alternative B; however, it would be operated differently. During winter months, if ice buildups occurred at locations that would threaten existing structures or habitat, diversions would be reduced to increase flows in the Gunnison River. For modeling water flows, this amount has been assumed to equal 600 ft^3/s for 7 days each month, which is an average monthly increase of 68 ft^3/s in January and 75 ft^3/s in February. Alternatives E and F would provide additional water to the Uncompahgre River.

DETAILED DESCRIPTION OF ALTERNATIVES

ALTERNATIVE A (NO ACTION)

Existing UVRP operating conditions would continue under alternative A. Water diverted from the Gunnison River through the Tunnel is delivered to the Uncompahgre River through the South Canal and, to a lesser extent, Cedar Creek. Cedar Creek is used because of capacity limitations in the South Canal (see chapter 3). After entering the Uncompahgre River, Gunnison River flows are combined with Uncompahgre flows and diverted into six major canal systems -- the Montrose and Delta (M&D), Loutzenhizer, Selig, Ironstone, East, and Garnet. Water supplies are delivered to the West Canal via a direct diversion from the South Canal. (Each of these systems is described in detail in chapter 3).

In addition to the West Canal, flows are diverted from the South Canal into the AB Lateral and several other small laterals along its 11.6-mile length. Project 7, which also diverts a portion of its water supplies from the South Canal, is a rural water supply system that provides domestic supplies to three area water conservancy districts as well as for Montrose, Olathe, and Delta. Project 7 water diverted from the South Canal is stored in Fairview Reservoir, adjacent to the canal about 1 mile downstream from the West Portal of the Tunnel.

Average annual historical supplies and diversions for the UVRP are presented in table 2.1. Values shown in this table are based upon a 32-year period of record used as the basis for analyzing the remaining development alternatives.

Periodic flooding on the Uncompahgre River has caused the UVWUA to reduce diversions through the Tunnel to prevent additional flows from being introduced to the Uncompahgre River. In general, flooding conditions occur annually along the Uncompahgre, although the severity of flooding has varied greatly. Ridgway Dam is not specifically operated for flood control, but its operation will reduce flooding along the Uncompahgre. Flood conditions are described in chapter 3.

Before the Aspinall Unit was constructed, it was not uncommon for Gunnison River daily flows to fall below 100 ft^3/s or to exceed 7,000 ft^3/s. However, the Aspinall Unit has helped to stabilize flows in the Gunnison River which in turn has allowed a Gold Medal fishery to be established in the river between the Tunnel portal and the North Fork of the Gunnison River. To protect this

Table 2.1.--Estimated supplies and historical demands for the Uncompahgre Valley Reclamation Project

Location	Mean annual volume (acre-feet)
Water available to system[1]	
Diverted from Gunnison through Tunnel	336,411
Uncompahgre River at Colona	168,685
Total supplies	505,096
Water diverted for irrigation[2]	
AB Lateral (existing conditions)	18,112
Cedar Creek wasteway	11,077
West Canal	49,177
Other South Canal laterals	22,453
Non-UVRP demands above South Canal[3]	10,955
Montrose & Delta Canal	163,326
Non-UVRP demands below South Canal[3]	11,482
Loutzenhizer Canal	42,925
Selig Canal	60,081
Ironstone Canal	102,309
East Canal	45,868
Garnet Canal	21,307
Total diversion demands	559,072

Sources:
[1] Reclamation simulation models for Uncompahgre and Gunnison Rivers.
[2] UVWUA historical records of daily diversions.
[3] See chapter 3 for description.

fishery and to meet downstream water rights, the Bureau of Reclamation (Reclamation) has controlled releases from Blue Mesa Dam to meet irrigation demands at the Tunnel as well as to allow a minimum instream flow of 200 ft^3/s. The goal has recently been increased to 300 ft^3/s when available.

The cornerstone of the UVRP is the Tunnel, which is 5.8 miles long and crosses under the hydrologic divide between the Gunnison and Uncompahgre River basins. Tunnel dimensions vary throughout its length; it was designed to have a rectangular section 11 feet wide and 12 feet high with an arched roof, having a slope of approximately 10 feet per mile. In some sections, the Tunnel is completely lined with reinforced concrete, whereas in others only the Tunnel floor is lined. In the unlined portions, the Tunnel floor is relatively smooth, but occasional rock outcrops protrude outward from the walls and ceiling that restrict the Tunnel's hydraulic capacity. Tunnel sections and dimensions are described in table 2.2.

Table 2.2.--Description of Gunnison Tunnel sections

Section	Percent of tunnel length	Description
A	38.5	Floor lined, walls and ceiling unlined. Width varies from 11.0′ to 14.5′, and height varies from 11.3′ to 14.3′. Walls are generally rough with numerous projections into flow area.
B	6.7	Floor and walls lined to Tunnel spring line. Width varies from 9.3′ to 11.5′; height to spring line varies from 7.0′ to 11.5′, as constructed. Some sections showing evidence of erosion behind walls.
C	8.0	Floor and walls lined to Tunnel ceiling. Height and width are same as section A.
D	21.1	Floor and walls lined to ceiling. Vertical walls, with partially lined arch ceiling. Width varies from 9.0′ to 11.5′, and wall height varies from 11.0′ to 11.7′. Timber beams exposed in some sections.
E	15.6	All surfaces are lined. Sidewalls are sloping and flat, and ceiling is arched. Width varies from 9.0′ to 11.5′, and height varies from 11.0′ to 11.7′.
F	10.1	All surfaces are lined and smooth. Section is horseshoe-shaped with an arched floor. Maximum height of section is 10.0 feet.

Source: USDI, Reclamation, 1984.

The UVWUA has participated in a Rehabilitation and Betterment (R&B) Program for the last several years to repair and modernize UVRP facilities, including construction activities to repair and replace the Tunnel lining. This work is expected to continue in the near future.

Under the no-action alternative, other individuals or corporations may attempt to proceed with similar developments. However, Reclamation and the UVWUA would have to approve such development, subject to provisions of Public Law 75-698.

ALTERNATIVE B

Alternative B would divert water from the South Canal and AB Lateral into a penstock that would convey water to a new powerhouse located in north Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace. The location of these features is shown in figure 2.1.

Features of Alternative B

Certain physical facilities would be constructed for this alternative. Other facilities that currently exist and are operated by the UVWUA would be modified. New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. Modifications of existing facilities would include a portion of the existing AB Lateral, South Canal, and access roads; however, no modifications would occur to the Tunnel.

Each of these features is described in detail below, which is based upon conceptual development studies. Further studies of geotechnical, hydraulic, equipment, and other design parameters may result in minor changes.

Canal Modifications

The development begins at the AB Lateral diversion works on the South Canal. Presently, flows are diverted into the lateral by two sluice gates located on the South Canal right wall. Alternative B modifies this diversion by removing the sluice gates, replacing them with a single radial gate, and widening the AB Lateral to accommodate the increased flows.

Under alternative B, the present diversion works would be modified on the South Canal to restrict the amount of water flowing down the South Canal during project operation. This diversion is presently accomplished by a narrow restriction in the South Canal channel located a few yards downstream of the AB Lateral sluice gates. This restriction creates a backwater effect, allowing water to divert into the AB Lateral.

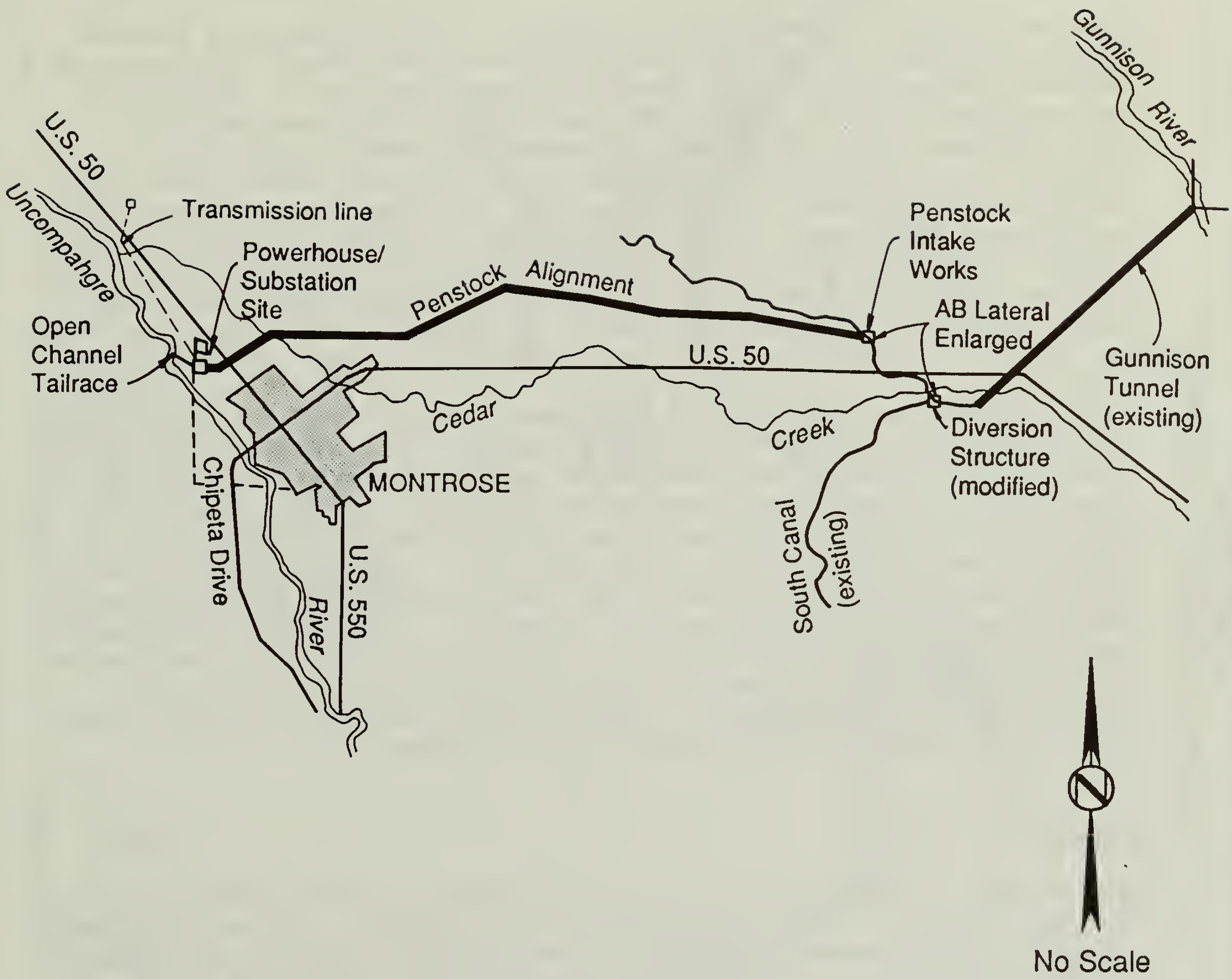


Figure 2.1. Location of project features.

Alternative B would replace the narrow channel gate with a single radial gate. This gate, together with the gate proposed for the AB Lateral, would be opened or closed by a hydraulic operator and remotely controlled from the UVWUA's Montrose headquarters.

The existing AB Lateral is an unlined channel having a bottom width of about 8 feet and uneven channel sections. Alternative B would enlarge about 7,100 feet of the lateral to a capacity of approximately 1,235 ft^3/s. Between the South Canal and U.S. Highway 50, a distance of about 650 feet, the modified lateral would have a rectangular cross section with 8-foot high walls and a 20-foot bottom width and would be constructed with reinforced concrete. The remaining 6,450 feet of the modified lateral would be widened to a bottom width of slightly more than 20 feet. The channel sections would be trapezoidal and lined with reinforced shotcrete. The flow depth at full capacity would be about 6.5 feet, leaving approximately 1.5 feet of freeboard.

The enlarged portion of the AB Lateral would continue to provide irrigation deliveries to areas served by this lateral. Construction of the enlargements would be made, to the maximum extent possible, during the nonirrigation season. To the extent construction would infringe upon the irrigation season, the Sponsors would deliver the required flow. The enlarged lateral would include sluice gates to deliver irrigation supplies to Cedar Creek and the ABB and ABC laterals. A fourth sluice gate would be installed in the intake structure to provide deliveries to the remaining portion of the AB Lateral that would be unaffected by development. The proposed lateral alignment and typical lateral sections are shown in figure 2.2.

Penstock

The penstock intake would be constructed of reinforced concrete and would have a total capacity of 1,135 ft^3/s. It would include a rock lip to prevent cobbles or other large rocks from entering the penstock and turbine. A steel trashrack would be equipped with a motorized hoist to allow removal of trash and other debris. The intake would also include stoplogs to be used to isolate the penstock from water flows during annual maintenance and inspection periods. The intake would also include a square-to-round transition section to funnel water into the penstock with minimum hydraulic disruptions. The structure would also include a gate or valve mechanism that would prevent flows from entering the penstock in case of an emergency. Options include a radial-type gate located in the intake flume upstream of the trashracks and a butterfly or gate valve located within the penstock immediately downstream of the transition piece.

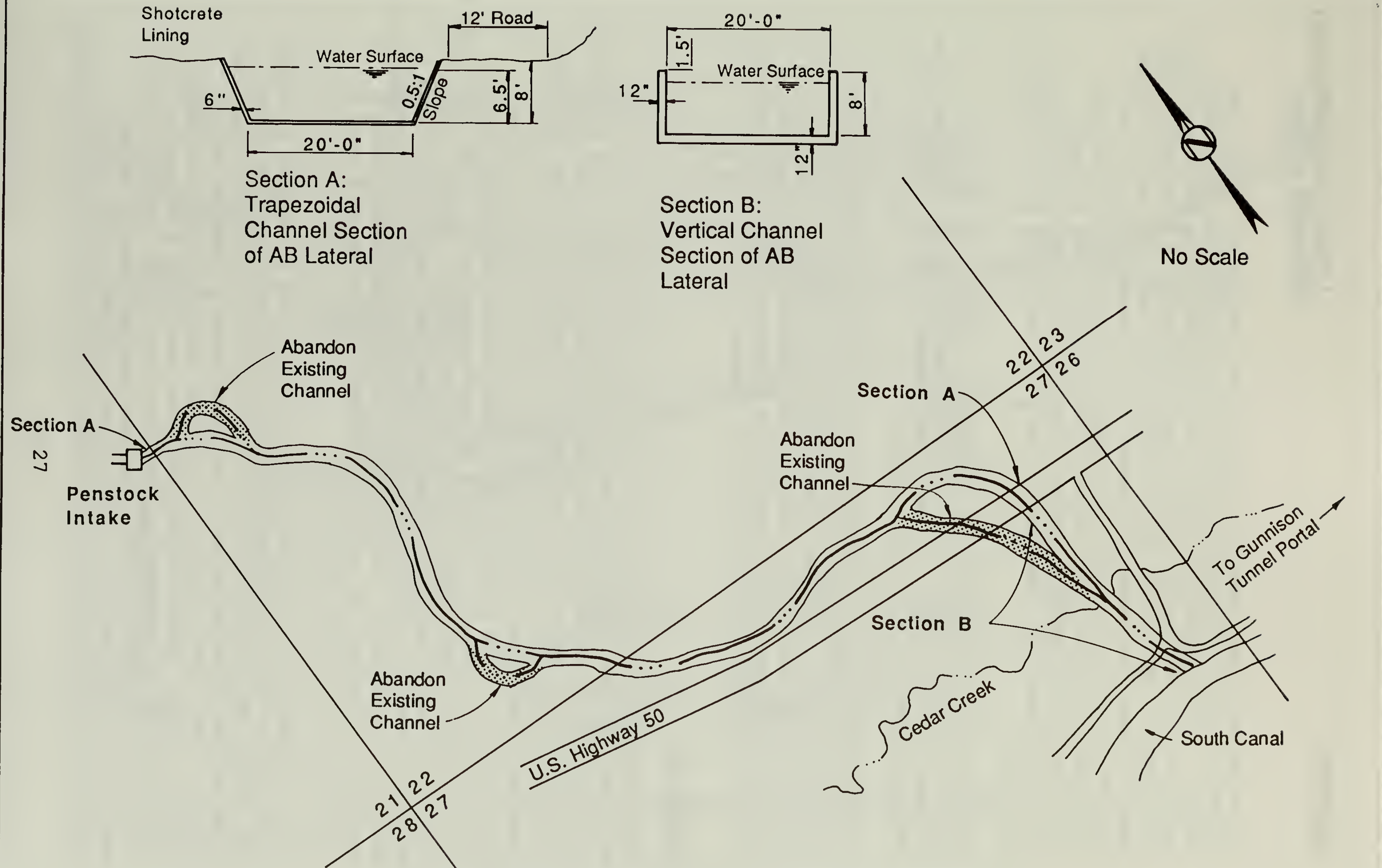


Figure 2.2. Proposed modification to AB Lateral.

The proposed steel penstock would have a diameter of between 10 and 11 feet, installed in 40-foot lengths in an excavated trench. Bell-and-spigot joints would probably be used and would be welded in the field during installation to assure watertight conditions. The inside of the pipe would be lined with a 16-mil layer of coal-tar epoxy to prevent rust deterioration. The outside of the pipe would be wrapped with polyvinyl tape to a thickness of 80 mils to further inhibit rust. As a final rust-preventive measure and to prevent electrolysis, cathodic protection would be used along the full length of the 38,380-foot pipeline.

During preliminary and final design of alternative B, the Sponsors would consider using prestressed concrete cylinder pipe instead of steel pipe. Final pipe diameters would also be determined during the design phase.

A number of potential alignments for the penstock route were considered in the concept development. Selection of the preferred route was based upon evaluating hydraulic and energy production parameters as well as considering land use. The proposed alignments, along with the preferred route and typical construction details, are shown in figure 2.3.

Powerhouse

The powerhouse would be located in the northwestern part of Montrose near an abandoned sewage treatment plant. The structure would contain two Pelton turbines and synchronous generators, along with the appurtenant equipment necessary for the safe and efficient operation of the turbines and generators. The powerhouse would be constructed both above and below current ground level. The portion below grade would be constructed of reinforced concrete. It would be approximately 52 by 54 feet and would contain the turbine and generator floors. Above grade, the powerhouse would be constructed of steel and fabricated sheet metal; however, in the final design phase, this may be changed to reinforced concrete. This portion of the powerhouse would contain the generator, station service control panels, and conventional support facilities.

The turbines would be designed to safely pass a maximum flow of 1,135 ft^3/s, with an estimated lower operating limit of 50 to 100 ft^3/s. Water flow into the turbines would be controlled by globe valves located outside the powerhouse in buried valve vaults. The valves would be remotely controlled and operated hydraulically. These valves would be used only for turbine isolation during maintenance periods; they would not be used to control the amount of flow into the turbines during normal operations. In case of an unplanned shutdown, water would continue to pass through the turbines but would be deflected away

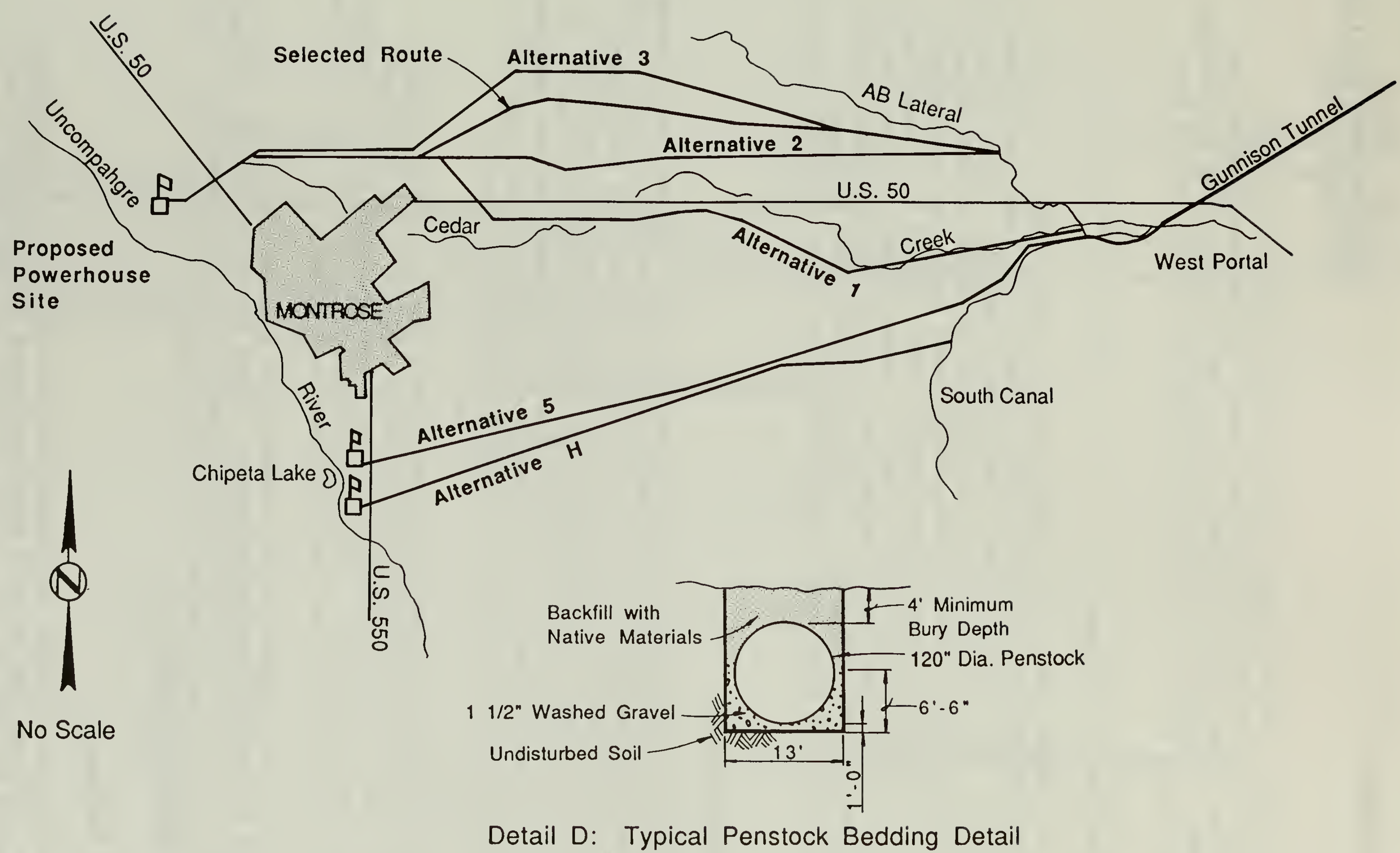


Figure 2.3. Selected and alternative penstock alignments.

from the turbine runner, allowing the continuous flow of irrigation water to downstream canal systems and preventing sudden water-level fluctuations in the Gunnison and Uncompahgre Rivers. Figure 2.4 shows the conceptual facilities at the powerhouse site.

Stilling Basin and Tailrace

As the water leaves the powerhouse, it would enter a stilling basin designed to slow the water velocity to less than 5 feet per second. The stilling basin would be lined with riprap to prevent bank and bed erosion. An earth-lined tailrace, approximately 1,600 feet long, would convey water away from the powerhouse to the Uncompahgre River. The channel shape would be trapezoidal, with a 25-foot bottom width and 2:1 side slopes. Riprap would be placed at its confluence with the river to prevent bank erosion and channel degradation. Figure 2.5 shows the alignment, sections, and bank stabilization details to be used for tailrace construction.

Transmission Line

Power from the proposed development would be transmitted through a new 115,000-volt (115 kilovolts [kV]) transmission line. This three-phase, wood pole line would begin at the new powerhouse substation and run generally 1/2 mile northwest to tap into an existing line. The existing line, which is currently rated at 46 kV, runs from the Bullock Substation in southwestern Montrose, north to Garnet Mesa. It passes approximately 1,000 feet east of the North Mesa Substation, 2 miles north of the Project powerhouse.

Approximately 3 miles of the existing line (Bullock to North Mesa) would be upgraded from 46 kV to 115 kV. An additional 1,000 feet of new line would connect the upgraded line to North Mesa (see figure 2.6). The transmission line, including both new and upgraded sections, would be raptor-proofed.

The Sponsors propose as an alternative a modification to the above by rerouting approximately 1 mile of the existing, upgraded 46/115 kV line so that it runs directly to the powerplant. This modification would reduce the total length of new line by approximately 1/2 mile.

Bank Stabilization

According to studies performed for this FEIS, the Uncompahgre River channel bed is well protected with cobbles and is not expected to degrade once the facility begins operating

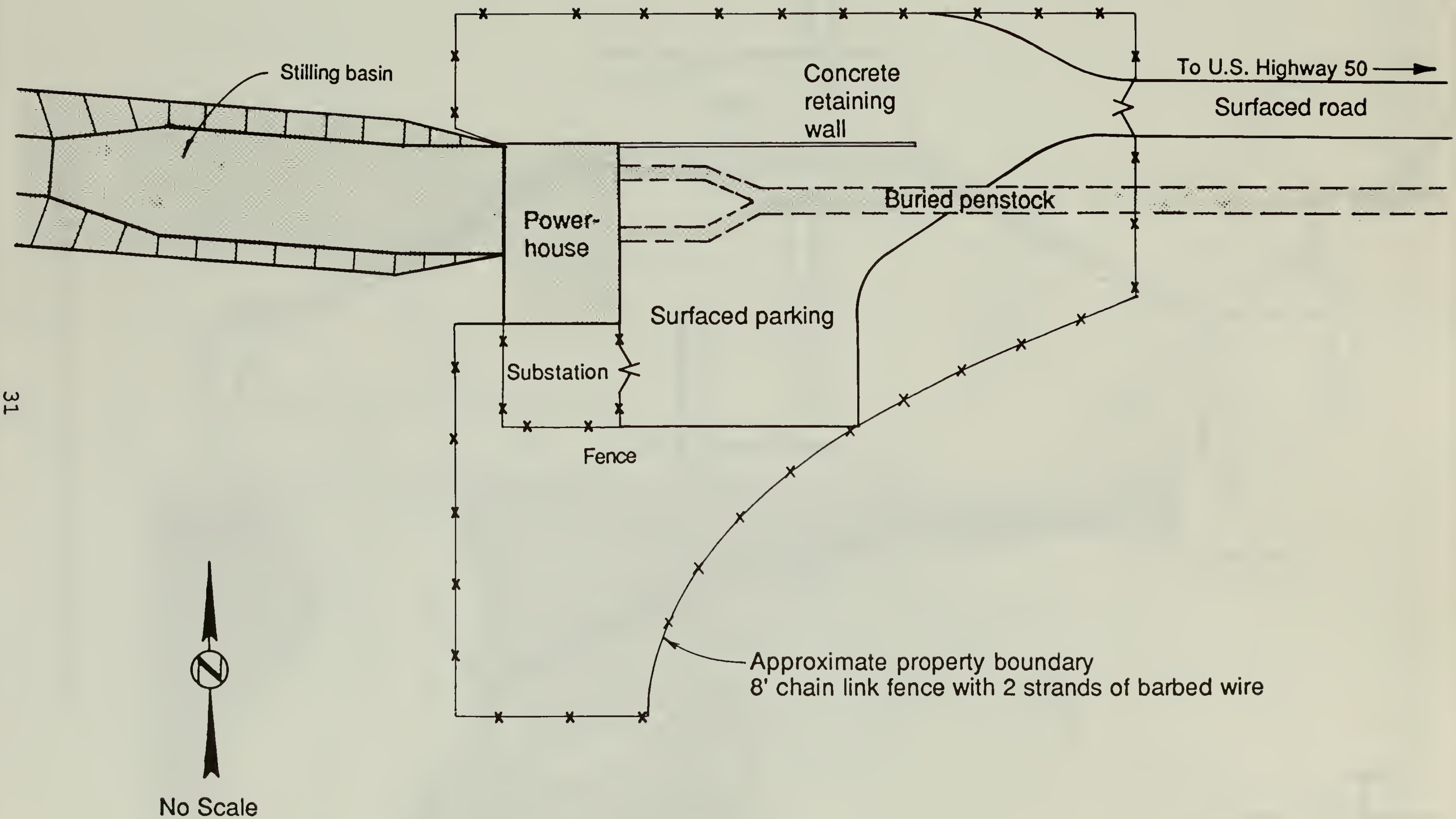
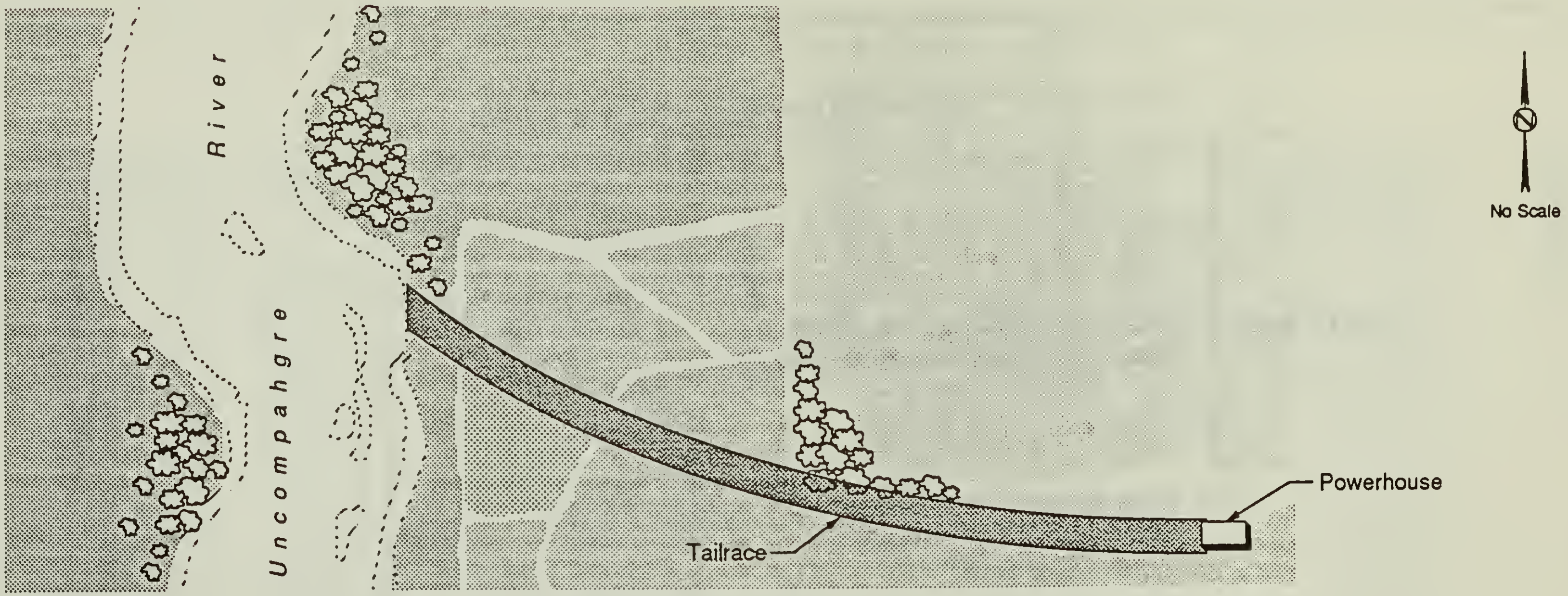
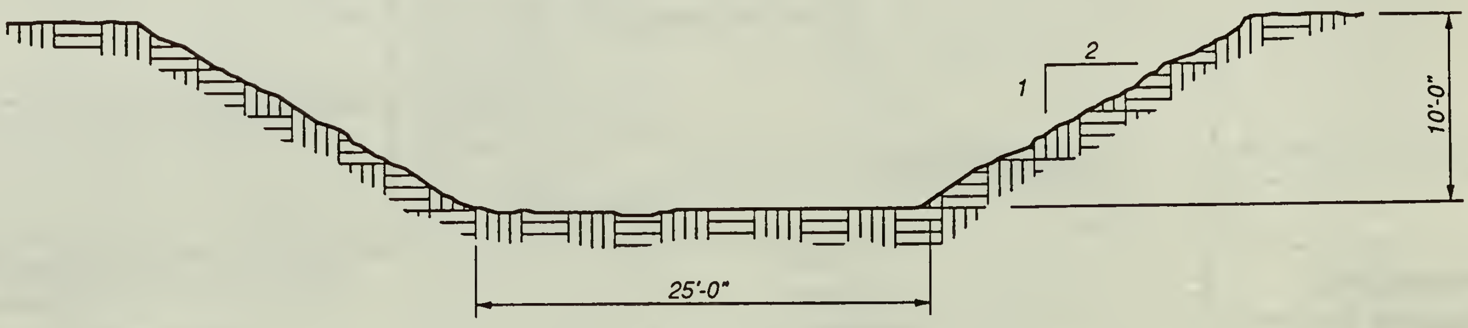


Figure 2.4. Plan of powerhouse site.



Plan for tailrace (no scale).



Typical section of tailrace (no scale).

Figure 2.5. Tailrace details.

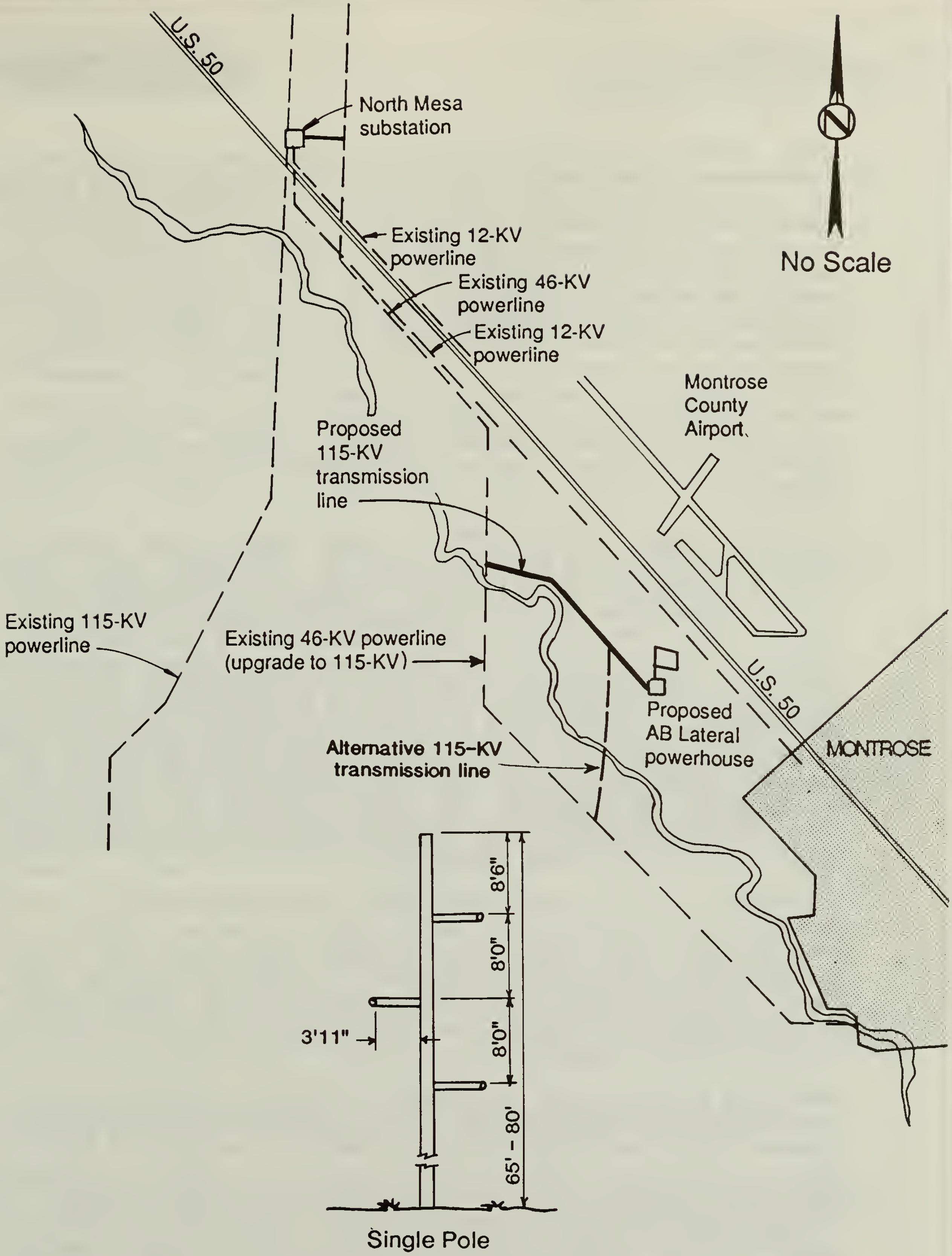


Figure 2.6. Proposed location of transmission line.

(HDR, 1989b). However, introducing additional flow to the Uncompahgre River would increase lateral erosion along portions of the existing channel banks downstream from the tailrace. Bank instability along the river between the Selig Canal and the river's mouth in Delta has been a problem in the past, particularly during floods. At some locations, the additional volume of water introduced to the river as a result of the proposed development would accelerate this erosion unless measures were taken to stabilize the riverbanks. Therefore, the Sponsors have proposed to mitigate the potential streambank erosion damage by implementing a bank stabilization program, which would consist of installing various measures before operation of the proposed facility and continuous monitoring, maintenance, and replacement (as necessary) after operation begins.

Presently, approximately 37,000 linear feet of bank protection is in place that has been installed by the UVWUA, county and local governments, and individual landowners. An additional 52,740 linear feet would be installed by developing the alternatives. This installation would reduce the need for private landowners and local governments to install stabilization measures. The preliminary design of these measures would be reviewed by Reclamation, the Corps of Engineers (COE), the Fish and Wildlife Service (FWS), the Environmental Protection Agency (EPA), and the CDOW. Final design of the measures would be prepared after the Section 404 Permit application submitted by the Sponsors is approved. All measures would be installed during the construction period for other features of the development before the facility was operating.

The purpose of the proposed stabilization measures would be to stabilize the existing riverbanks where increased erosion would result in economic damages to property owners near the stream. In addition, consideration was also given to protecting the riparian vegetation within or near the existing river channel. Several stabilization alternatives were considered in formulating this mitigation program.

Among the alternatives described in the DEIS but subsequently rejected were channelization of the river and rock jetties. Channelization would be used as a means of moving the additional water volumes away from eroding areas into a channel designed to adequately convey the increased discharges without erosion. The measure was rejected, however, because channelization tends to increase channel velocities, thus increasing flooding and erosion problems in downstream areas. Increased velocities could also increase the potential for channel degradation, which could subsequently lead to a lowering of the water table and diminishing the water supplies to existing wetlands.

Rock jetties would deflect water flows away from the eroding bank towards the center of the channel; this measure was also rejected. The existing channel width along much of the river is relatively narrow, creating danger of deflecting the water through the center of the channel and into the opposite bank. Unless the opposite bank was also protected against the flow, this action would result in additional bank erosion and the possible formation of a new meander channel that could cut into existing cultivated lands.

Other stabilization alternatives evaluated but rejected include anchored trees, gabions[1], fences, and channel drop structures. Anchored trees have been frequently used by property owners to protect streambanks; in some areas, this method has been quite effective. However, because of the magnitude of the program, this method was rejected due to availability of construction materials and potential damages resulting from lowland flooding. Gabions were rejected because of the cost of placement and long-term maintenance and because gabions are not effective in promoting long-term plant growth.

Fencing was given serious consideration in the design process. Fences have been used by property owners along the Uncompahgre and have been effective at reducing bank erosion. Fences trap vegetative and other debris floating in the river, creating a still water area between the fence and existing bank; also, fences would not disrupt or displace any existing wetlands. The measure was rejected from detailed consideration (except in special situations where preferred by land owners) due to concerns expressed by the CDOW and the FWS, based principally on issues of river access and appearance.

Channel drop structures were also evaluated as possible stabilization measures. Their purpose would be to reduce the energy gradient of the river, thus reducing the erosive velocities that affect the banks. The structures would be formed by placing large boulders across the river in a V-formation, with the V pointed upstream. This method has been used with some success in Western streams; however, it was rejected for this program (except in special situations) because of potential flooding problems and downstream channel scour concerns.

The selected stabilization measures include riprap revetment and streambank vegetation. Rock riprap would be placed where erosive forces would be greatest and the risk of loss of cultivated fields or structures would be the most significant. Streambank vegetation was not judged reliable enough given the risks in these locations; instead, vegetation would be used at other sites

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[1] A wire basket filled with earth or stones; used in building fieldworks or as revetments in mining.

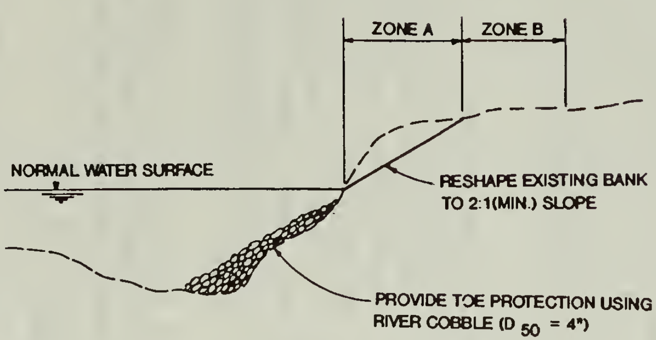
where its likelihood of success would be higher or economic risk of failure is low. The rock riprap material would be large, dense, angular rock which is well graded to minimize air voids. For the Uncompahgre River, the bank soils are such that a filter blanket would not be required. The material would be placed on the existing banks at a 2:1 slope and have a thickness of not less than 30 inches. The toe of the blanket would be placed in an excavated trench which is at least 3 feet below the bottom of the channel. The toe of the revetment would have a thickness of 45 inches (see figure 2.7). The upstream and downstream ends of the blanket would be tied into the bank at a stable point.

At least two selected riprap sites would be covered with topsoil in the initial stabilization program. This procedure involves placing soils in the revetment and then seeding or planting small trees or shrubs. If this program is successful, additional sites would be similarly treated through the ongoing maintenance program.

Methods and criteria suggested by the COE were used in sizing the revetment blanket and materials. The method of tractive force, following procedures outlined in the manual Hydraulic Design of Flood Control Channels (U.S. Department of the Army, COE, 1970), was used to determine the size of material and slope of the revetment blanket. Criteria for blanket thickness and gradation and toe design were taken from the Urban Storm Drainage Criteria Manual, Volume II (Denver Regional Council of Governments, 1969).

Construction access would be provided using existing farm and field lanes (with the landowner's permission) wherever possible. The Sponsors would construct temporary lanes from fields to the bank revetment site where necessary. When existing private roads are used, drainage culverts would be protected from the additional loading exerted by construction access.

Where access to the site occurs from the top of the bank, temporary access lanes would be sited according to the landowner's desires and would not disrupt any existing wetlands or wooded areas. After access lanes are completed, the area would be reclaimed for subsequent use by the landowner. In some instances, access to the site would only be obtained from the river side of the bank. For these cases, construction of the temporary access road could result in disruption of an existing wetland, depending upon landowner negotiations. Where wetlands would be affected, the temporary access road would be in place for only a short time, usually less than 1 week but no more than 2 weeks. After installation completion, the road and any materials used for its construction would be removed and the wetland area would be restored.

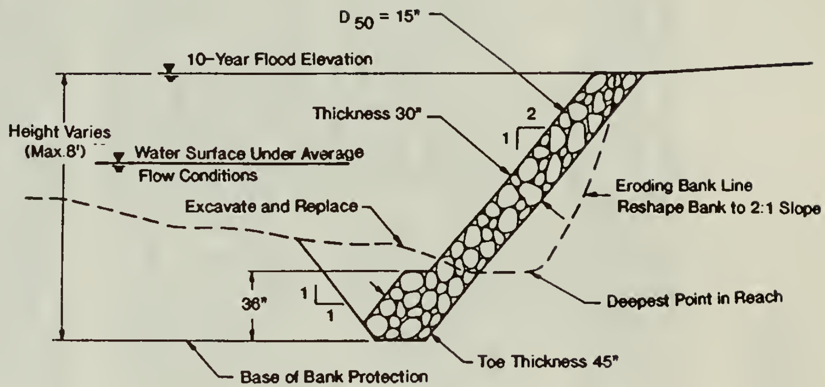


ZONE A* – GRASS MIXTURE
- SWITCHGRASS
- WHEATGRASS
- REED CANARY GRASS

ZONE B* – WOODY SPECIES
- WILLOW
- COTTONWOOD
- DOGWOOD

* – FINAL VEGETATION MIXTURE TO BE DETERMINED WITH CDOW & FWS.

Typical section of streambank vegetation.



NOTE: Height of revetment blanket shall be to the top of bank or 10–year flood elevation, whichever is less.

Typical section of bank revetment.

Figure 2.7. Bank stabilization plan and details.

Permanent access roads, located near but not necessarily next to the revetment site, would be necessary for periodic inspection and maintenance and would use existing roadways and farm lanes. Permanent access roads would not be located in an existing wetland.

Material from the Dakota Sandstone formation would be used for riprap. The source of rock for revetment would be local quarries now used by the UVWUA. These quarries have been used as riprap sources by the UVWUA for the past several years, and in at least one location near the Selig Canal, rock mined from these quarries has been in place since the mid-1930's. Tests on one sample of the material resulted in a 14.9 percent loss in the Aggregate Sulfate Soundness test, and 19.7 and 47.9 percent loss after 100 and 500 revolutions, respectively, in the LA Abrasion Test. These results indicate a material of relatively low durability that would require more frequent inspection and maintenance than if granitic material were used. Therefore, the material would be periodically inspected and replaced as necessary.

Streambank vegetation would be used along the banks of wetlands areas and, where technically feasible, in areas where the risk of economic losses are lower. Streambank vegetation is one of the most effective methods of controlling bank erosion under natural conditions (Gray and Leiser, 1982). It is also the least costly, when maintained in good condition, according to the Soil Conservation Service (SCS). The design template for this alternative (see figure 2.7) would consist of planting and watering various species of grasses, principally reed canary grass, switchgrass, and wheatgrass along the riverbank. On the first terrace, seedlings of woody plants such as willow would be planted in rows having 3-foot centers over a bank width of approximately 50 feet. This alternative would be used primarily along the banks of terraces north of Olathe between the treatment facility and Delta.

The vegetation installed as part of the stabilization program would be protected against toe erosion by a 1-foot thick blanket of river cobbles. The source of this cobble would be from existing material stockpiles at the Selig and Ironstone canals and from material excavated at the powerhouse site. The cobble material would have a mean diameter of no less than 4 inches and a minimum size of not less than 2 inches. This gradation is stronger than the existing channel bed and would protect the toe against sloughing when the vegetation roots are developing.

The Sponsors would monitor the vegetated areas during project operation and would replace plants and restore banks where required. They have incorporated replacing as much as 40 percent of the vegetation during the first 2 years of operation into facility maintenance costs.

The final determination of species to be planted and planting methods would be made by consulting with the SCS, CDOW, the Colorado State Forest Service (who would provide the majority of plants), and the landowner. Emphasis would be placed on the use of native species, although non-native species would also be included in areas where they would be more effective to prevent bank erosion. However, local willows would be used as a source of sprigs, with cuttings taken through landowners' permission and planted during the early spring. All plantings would be made at least 1 year before the facility was operating to allow sufficient time for the root zone to establish.

When installing streambank vegetation, care would be taken not to disrupt existing vegetation where it could accomplish the same purpose--erosion protection. In areas where a well-shaped bank with established vegetation is already in place, vegetation will not be disturbed. Particular care will be taken to preserve mature vegetation with extensive root structures already in place, such as cottonwoods or willows.

Stabilization measures would be installed before facility operation at 66 distinct sites along the river between the tailrace and Delta. In Delta County, a total of 27,450 linear feet of bank protection would be installed, including 8,000 feet of revetment and 19,450 feet of vegetation. In Montrose County, the estimated quantity of revetment is 16,550 linear feet. In addition, 8,740 feet of streambank vegetation would also be installed. The proposed stabilization measures to be installed before facility operation are summarized in table 2.3. The installation locations are shown in figure 2.8a and 2.8b.

Table 2.3.--Summary of bank stabilization measures

Type of installation	Length (ft)
Riprap revetment	24,550
Streambank vegetation	28,190
Total	52,740
Feet of river between tailrace and mouth	288,620
Existing protection (estimated)	37,000
Existing protection (%)	13
Total protection (52,740 plus 37,000; with development)	89,740
Protection (with development; %)	31

Source: HDR, 1989b.

Before operation, detailed aerial photography of the river would be taken that would be used to prepare ortho-corrected maps of the river and to establish predevelopment bank locations. This

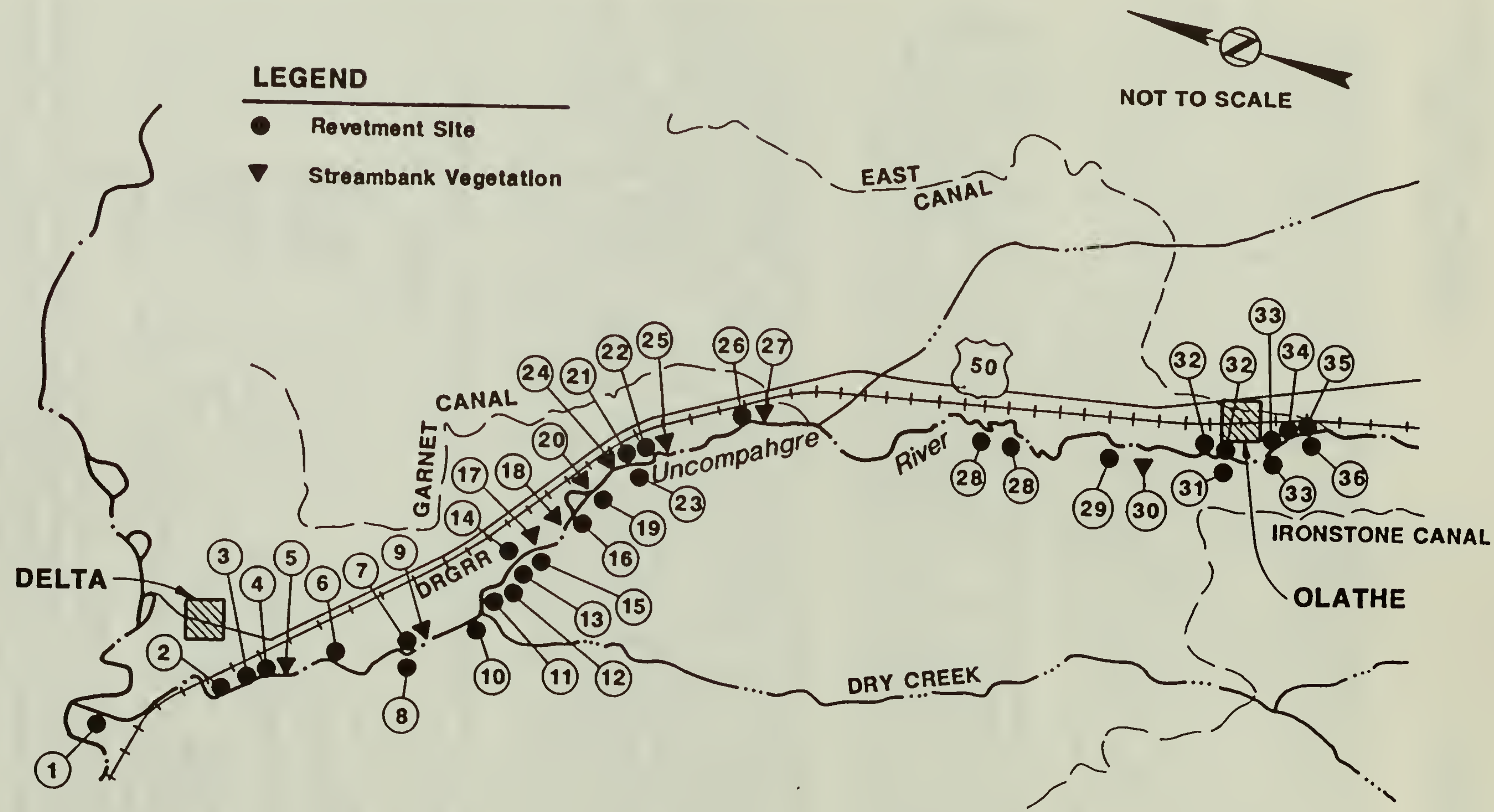


Figure 2.8a. Proposed bank stabilization locations for the Uncompahgre River between Delta and Olathe (AB Lateral Project; 36 planned sites).

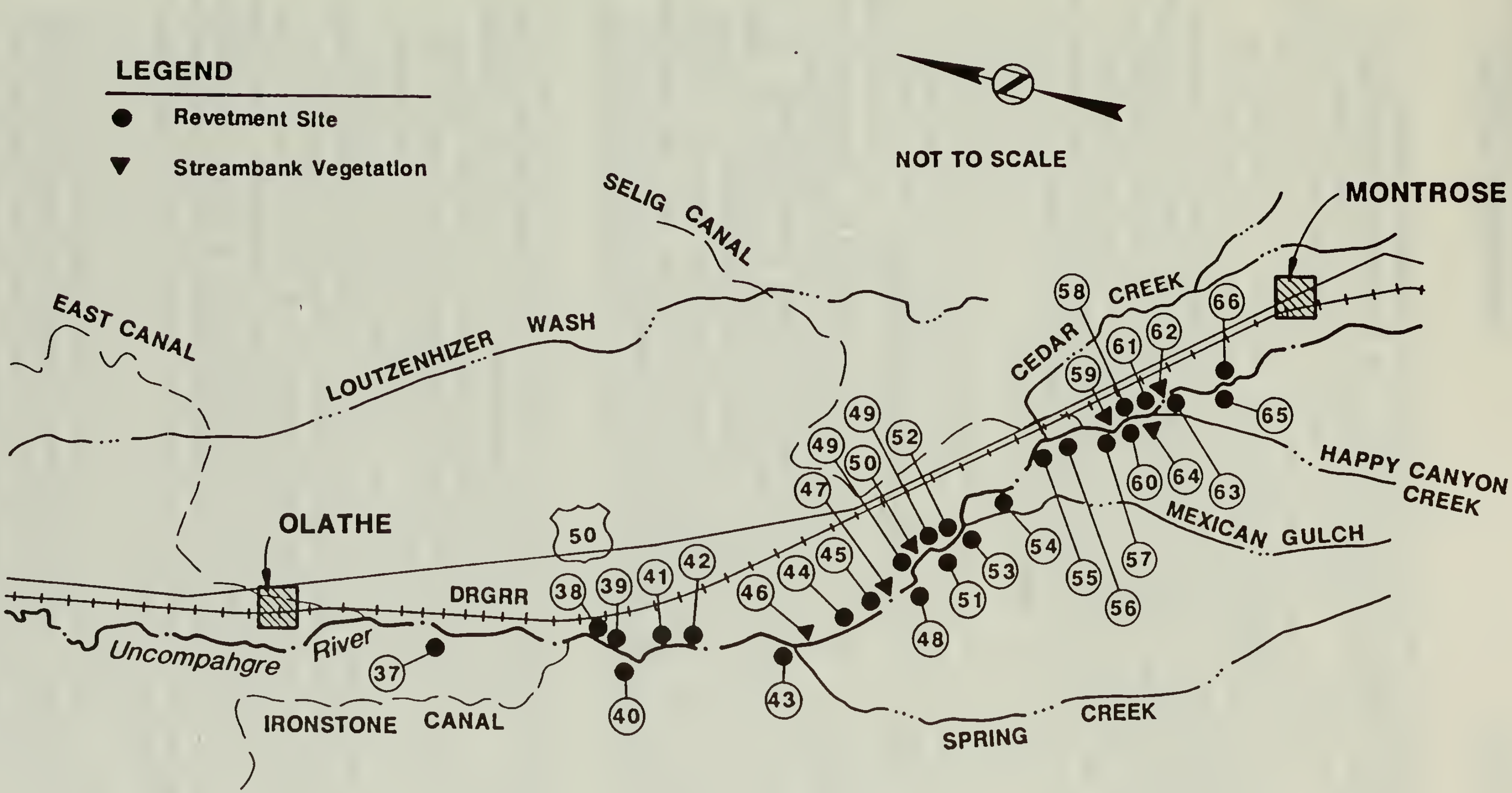


Figure 2.8b. Proposed bank stabilization locations for the Uncompahgre River between Olathe and Montrose (AB Lateral Project; 30 planned sites).

information would be used in subsequent, postdevelopment monitoring of the river, conducted by the Sponsors, who have agreed to mitigate postdevelopment damages resulting from facility-caused erosion. This monitoring program would consist of five parts: (1) accurate recordkeeping of flows diverted through the facility for irrigation and power; (2) recording daily flows in the Uncompahgre River at various locations upstream and downstream from the facility tailrace; (3) aerial photography of the river taken annually during the late fall when facility and river flows are at an ebb; (4) periodic visual inspection conducted by UVWUA personnel made on a regularly scheduled basis as well as in response to landowner concerns; and (5) annual maintenance of riprap and vegetation measures installed before facility operation.

The first two steps would firmly establish how much water is in the river at various locations along its course and how much water is being added to the river from Gunnison River diversions. Data recorded by the U.S. Geological Survey (USGS) at Colona and Delta would be used in conjunction with an existing gauge at the Garnet Canal headgate. In addition, rating curves would be established for the Selig, Ironstone, and East Canal river aprons. The UVWUA currently has rating curves for each of these canals but does not record flows passing the headgates. Water budget algorithms would be used to determine the amount of flow entering the river from the numerous tributaries as well as from ground-water seepage. All canal and intermediate flow data (river flows other than Colona and Delta) would be recorded daily by the UVWUA.

In conjunction with ground surveys, aerial photography would be used to establish the location and movement of the banks during the previous year. This information, taken in concert with recorded observations made during visual inspection, would be used to determine the effectiveness of stabilization measures installed before plant operations and to identify maintenance needs or additional areas for protection. The photography would document areas of erosion and deposition. If additional stabilization measures are required because of the operation of the facility, they would be installed by the Sponsors. The type of measure to be installed would most likely be riprap revetment, using a design identical to that shown in figure 2.7. Vegetative treatment could also be used. Funding for additional work would be taken from hydropower revenue.

Aerial photography, supported by ground-level inspection, would also be used to document unanticipated changes to wetlands that could occur due to project-related scour or erosion. If a net loss of wetlands is caused by project operation beyond that estimated in this FEIS, the Sponsors would be required to mitigate the loss through replacement or enhancement pursuant to Federal regulations and further consultation with Reclamation, COE, and EPA.

Access to Facilities

Access to work areas would be from U.S. Highway 50, county roads, and existing UVWUA maintenance roads. Bridge improvements for equipment hauling would not be needed, although some minor roadways would be upgraded to prevent damages from occurring as a result of heavy equipment loads. Along the AB Lateral, the existing maintenance road, which now has a dirt and light gravel surface, would be widened to 12 feet and upgraded to a crushed rock surface.

Safety Features Incorporated into Facility Design

The Sponsors would incorporate a number of safety features into the facilities for protecting human and wildlife resources. In the enlarged AB Lateral, escape ladders would be constructed at 600-foot intervals. Safety fencing would also be installed at the U.S. Highway 50 crossing, the penstock intake, and the stilling basin west of the powerhouse. Big game escape ramps would be included in the AB Lateral in front of the penstock intake and near the U.S. Highway 50 crossing. These features would be designed according to CDOW criteria.

Air-release check valves would be installed along the penstock for accumulated air to be released during filling times. Manholes would also be installed for proper ventilation and access during construction and maintenance periods. The number and location of the check valves and manholes would be determined during the final design.

In case of an emergency or unplanned shutdown of power generation, water flow would be maintained through the penstock and released to the river through the turbines. Pressure-sensing devices would be installed along the penstock to detect any rapid pressure drops indicating a ruptured pipeline. If this unlikely event occurred, the gates at the penstock intake would be automatically closed and the South Canal gates would be automatically opened, allowing diversion through the South Canal. The Cedar Creek wasteway could also be used, thus preventing the South Canal from overflowing. If this event occurred during the nonirrigation season, the Tunnel gate would be gradually closed. The turbine valve would remain open to allow water to drain from the penstock downstream of the rupture point. Design of these emergency features and control systems would be reviewed and approved by Reclamation.

Rights-of-Way

Easements for the construction and operation of the penstock, powerhouse, tailrace and transmission lines would be obtained by the Sponsors. Table 2.4 summarizes the anticipated rights-of-way requirements for developing alternatives B, C, E, and F. Following construction, easement widths would be reduced from 200 feet to 100 feet. Any land rights acquired for the modification of the AB Lateral would be donated to the United States to maintain control over the irrigation system.

Table 2.4.--Rights-of-way requirements for alternatives B, C, E, and F

Facility	Rights-of-way Width (ft)	Rights-of-way Length (ft)	Total area construction (acres)	Total area operation (acres)
Penstock	[a] 200	38,380	172	86
AB Lateral enlargement	200	7,100	32	[b] 16
Powerhouse	--	--	4	4
Tailrace	100	2,400	11	6
Transmission line	100	4,500	15	15
Total acres			234	127

[a] Width would be reduced to 75 feet for special environmental areas and to 100 feet for operation and maintenance needs.
[b] Includes 1.7 acres of Bureau of Land Management (BLM) land.
Source: USDI, Reclamation, 1988.

Costs and Financing

The project would be funded totally by Montrose Partners. Capital costs would be provided by a combination of equity and debt. Assuming current market conditions, the overall (combined equity and debt) cost of capital would be approximately 13 to 15 percent if these conditions were to continue. This figure would rise or fall with varying interest and equity rates and debt and equity ratios required by the funding institutions.

The use of bank financing would result in loans being secured by the project itself. However, there would be no attendant liens or encumbrances against the UVRP or any facilities owned by the U.S. Government. Nor would the UVWUA be required to cosign the loans, thereby risking any of their irrigation-related rights or assets.

The Sponsors have obtained preliminary bids and quotes for various portions of the project. Table 2.5 shows a summary of these costs and expense projections. Alternative B would cost approximately $62 million.

Table 2.5.--Cost estimate for alternative B

Item	Cost ($000's)
Civil works	$ 7,694
Penstock, materials and installation	26,554
Turbine, generators and electrical	13,116
Land acquisition	600
Bank stabilization--Uncompahgre River	1,400
Miscellaneous	465
Engineering, administration, and contingency	3,130
Development costs[1]	9,155
Total costs	$62,114

[1] Development costs include previously incurred expenses, finance and legal fees, interest during construction, and construction management.
Source: HDR, personal communication, 1989.

Costs include approximately $1.4 million for bank stabilization and $300,000 for wetlands replacement, deer escape, fish barrier, and conservation measures for endangered species.

ALTERNATIVE C

Like alternative B, alternative C would divert water from the South Canal and AB Lateral into a penstock that would convey water to a new powerhouse in northwest Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace.

Physical features of alternative C would have structural dimensions and configuration identical to those of alternative B. However, alternative C differs from B in that it would enlarge the capacity of the Tunnel to 1,300 ft^3/s.

Features of Alternative C

New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. In addition to enlarging the Tunnel, existing facilities including a portion of the AB Lateral and South Canal and access roads would be modified. The dimensions, composition, and configuration of these features would be identical to those described for alternative B, as would access roads, safety features, and rights-of-way needs.

To develop alternative C, the Sponsors would increase the Tunnel's capacity to approximately 1,300 ft^3/s. Specific features include modifying the Tunnel entrance and upper reaches to provide a smoother hydraulic transition between the entrance section, the maintenance hallway and the main portion of the Tunnel. Additional minor work would be done in the unlined section, removing rock outcrops and repairing holes and erosion voids to lower the resistance to flow. Excess material removed from the Tunnel would be used in constructing other development features. All work plans would be approved by Reclamation before construction.

Costs for alternative C would be similar to those for alternative B, with an additional $750,000 budgeted for Tunnel modifications. Total cost for alternative C is estimated to be $63 million.

ALTERNATIVE E

Under alternative E, water from the South Canal and AB Lateral would be diverted into a penstock that would convey water to a new powerhouse in northwest Montrose. Discharges from the powerhouse would enter the Uncompahgre River through an excavated tailrace.

The physical features of this alternative are similar to those of alternative B; hence, they are not described in detail. However, the proposed plant design capacity of alternative E would be 950 ft^3/s, less than that of alternative B. The dimensions of several of the features would also be smaller as described below. Alternative E is Reclamation's recommended alternative.

Features of Alternative E

Certain facilities would be constructed for this alternative, while other existing facilities operated by the UVWUA would be modified. New construction would include the powerhouse, penstock, transmission line, access roads, and tailrace. Existing facilities would be modified, including portions of the existing AB Lateral, South Canal, and access roads; each of these features is described in greater detail below. No modification to the Tunnel would occur as part of development of this alternative. Further studies of geotechnical, hydraulic equipment, and other design parameters may result in minor changes.

Canal Modifications

Alternative E begins at the AB Lateral diversion works on the South Canal. Flows are presently diverted into the lateral by two sluice gates located on the right wall of the South Canal. The planned diversion works would be identical to alternative B; however, the AB Lateral would be modified to a channel width of only 15 feet.

Penstock

The proposed steel penstock would have a diameter between 9 and 10 feet and would be installed similarly to alternative B. The location also would be the same as alternative B.

Powerhouse

The powerhouse location and other features would be similar to those described for alternative B. However, for alternative E, the turbines would be designed to use a maximum flow of 950 ft^3/s with an estimated lower limit of 45 to 90 ft^3/s. The transmission line, site access, rights-of-way, and safety features incorporated into the design would be identical to those described for alternative B.

Construction of alternative E would cost significantly less than alternative B. Primary savings would occur in pipe, turbine, and powerhouse costs. Table 2.6 summarizes the costs (approximately $57 million for alternative E).

Table 2.6.--Cost estimate for alternative E

Item	Cost ($000's)
Civil works	$ 7,398
Penstock, materials and installation	23,342
Turbine, generators and electrical	12,119
Land acquisition	600
Bank stabilization--Uncompahgre River	1,400
Miscellaneous	465
Engineering, administration, and contingency	3,130
Development costs[1]	8,614
Total costs	$57,068

[1] Development costs include previously incurred expenses, finance and legal fees, interest during construction, and construction management.
Source: HDR, personal communication, 1989.

ALTERNATIVE F

The location, dimensions and configuration of the physical features and the plant operations would be the same as those for alternative B. Plant flow capacity would be 1,135 ft^3/s. No improvements of the Tunnel would be made as part of this alternative.

The primary difference between alternatives B and F is additional environmental commitments for winter flows in the Gunnison River would be made for alternative F. These commitments, described later in this chapter, would result in less flow through the turbines, thus producing a smaller amount of average annual energy. Construction costs for alternative F ($62 million) are identical to those for alternative B.

WATER SUPPLY AND OPERATION OF DEVELOPMENT ALTERNATIVES

WATER SUPPLY ALLOCATION

All water to be used in producing electrical energy would be diverted from the Gunnison River. All alternatives would use a priority system for allocating water for irrigation, instream flow, and hydropower demands; however, irrigation and instream flow demands would always be given priority over hydropower demands. However, the Uncompahgre River would be used as much as possible to meet irrigation needs in the M&D and Loutzenhizer Canals, permitting use of Gunnison River water for power production. The irrigation needs for the Selig, Ironstone, East, and Garnet Canals would be met using water that has passed through the powerplant. The West Canal would continue to be supplied by the South Canal.

The priority system for flow allocation would be as follows: (1) Irrigation demands would be diverted, up to the hydraulic capacity of the Tunnel. Hydropower operations would not interfere with or reduce the amounts of water diverted for irrigation; (2) Minimum flows in the Gunnison River would be met to values stipulated in the environmental commitments for each alternative. Hydropower operations would not divert water that would reduce flows below the specified minimums; and (3) Remaining flow in the Gunnison River would be diverted for power generation, up to the hydraulic capacity of the turbines.

When the Uncompahgre River does not have adequate supplies to meet irrigation demands in the M&D and the Loutzenhizer Canals and other senior water rights, the demands would be met by water from the Gunnison River. Hydropower generation would be curtailed; this method is similar to historic operations.

The Tunnel and South Canal presently convey water to the Fairview Reservoir for municipal and industrial needs. These diversions would always be met before hydropower needs. In addition, the existing water exchange under the Dallas Creek Project would be met before hydropower needs. This exchange calls for using Ridgway Reservoir for irrigation in return for using an equal amount of Tunnel water for municipal and industrial purposes.

CONTROL SYSTEMS FOR FACILITY AND WATER SUPPLY OPERATIONS

Powerhouse operations would occur without an onsite operator. However, control design for the powerhouse would provide for local manual and automatic and remote automatic control. The UVWUA would have the primary responsibility for plant operation by controlling the amount of water diverted into the penstock and through the turbines.

Remote control and operation of the facility would be accomplished with two separate supervisory control and data acquisition (SCADA) systems. One system would be designed to remotely operate the power-generating functions using a master control station at either the UVWUA headquarters or the Delta-Montrose Electric Association (DMEA) Montrose service center. This system would continuously monitor operator criteria for the turbine and generator, including penstock pressures, generator temperatures, oil levels, and other technical parameters. The control system would include automatic startup sequencing, normal and emergency shutdown, and local and remote loading control.

Except for unplanned shutdown, the development would operate continuously, provided water is available. Annual maintenance of all project features would be scheduled to coincide with annual turbine maintenance at Crystal Dam.

Under all development alternatives, a second SCADA system would be used to manage the water supply system. It would be designed to integrate the hydropower alternatives with the existing irrigation function of the UVRP daily using a computerized water management program (WMP). The WMP would isolate and separate hydropower demands from irrigation demands so that diversions specific to each function could be monitored. The SCADA/WMP system would remotely operate gate controllers at the AB Lateral intake gate and the South Canal control gate in response to the available supplies in the Gunnison and Uncompahgre Rivers and irrigation demands. The efficiency and reliability of water management on the UVRP would thus be maximized. The system would also produce written records of flows at key locations including the Gunnison River.

The SCADA/WMP would operate using daily flow data collected from remote terminal units (RTU's) installed at key points in the irrigation system; RTU's would include locations at the headgates for the Loutzenhizer Canal, Cedar Creek, and the AB Lateral. The RTU's would transmit discharge levels to a SCADA system located at the UVWUA headquarters. Instantaneous data would be acquired from existing satellite links to the Uncompahgre gauge at Colona and the Gunnison River gauge downstream of the East Portal of the Tunnel. This information would be supplemented with the release data from Crystal Reservoir supplied by Reclamation and the normal daily settings and readings taken by the UVWUA watermaster and the ditch riders. All data would be combined and processed through the SCADA/WMP system to yield the amount of flow available to the hydropower plant.

When releases from Crystal Dam are less than 1,500 ft^3/s, the SCADA/WMP system would take specific measures to ensure that hydropower diversions comply with the minimum Gunnison River flow commitments of 300 ft^3/s. The SCADA/WMP system would show which diversions are related to hydropower and thus would be used to adjust proportional gate settings for hydropower diversions. The Gunnison River flow estimates would be checked twice daily against instantaneous measurements at the USGS gauge at East Portal and at Crystal Dam to insure accuracy and to prevent minimum flow encroachments. The Sponsors would coordinate these activities with Reclamation to identify anticipated fluctuations in Crystal Dam releases, further minimizing the risk of short-term minimum flow encroachments between gauge checks.

SPECIFIC WATER SUPPLY CONSIDERATIONS

Although all water used to generate hydroelectric power would be supplied by the Gunnison River, the amounts used for each alternative would vary according to the plant and tunnel capacity and the stipulated instream flow. The estimated flows available for hydropower production were determined using a computerized model of the regional water system. This model used water use data provided by the UVWUA and simulated flows in the Gunnison and Uncompahgre Rivers developed by Reclamation. The period of study used for the model was 1952 through 1983, which included several dry and wet periods in addition to average flow periods. Further description of this model is presented in the AB Lateral Unit Water Supply Study (HDR, 1989a).

Alternative A

The Gunnison River is now operated with a minimum flow of 300 ft^3/s downstream from the Tunnel and would be expected to operate this way in the future. However, irrigation demands and existing Aspinall Unit operation may occasionally reduce flows below 300 ft^3/s during extremely dry periods, a potential that exists with or without development.

Alternative B

The development of this alternative would not place new or additional demands on the Aspinall Unit reservoirs, and the Tunnel capacity would not be increased. If this alternative is developed, an average of 508,128 acre-feet (702 ft^3/s) would pass through the turbines (see table 2.7).

Alternative C

The development of this alternative would not place new or additional demands on the upstream Aspinall Unit reservoirs. However, the Tunnel capacity would be increased to 1,300 ft^3/s. If this alternative is developed, an average of 544,011 acre-feet (751 ft^3/s) annually would pass through the turbines (see table 2.8).

Alternative E

The development of this alternative would not place new or additional demands on the upstream Aspinall Unit reservoirs. If this alternative is developed, an average of 478,204 acre-feet (661 ft^3/s) annually would pass through the turbines (see table 2.9).

Alternative F

The development of this alternative would not place new or additional demands on the upstream Aspinall Unit reservoirs. If this alternative is developed, an average of 502,986 acre-feet (695 ft^3/s) annually would be passed through the turbines (see table 2.10).

SPECIFIC CONSIDERATIONS FOR OPERATION OF THE PROJECT

The operation of each alternative would be as described previously. However, the amounts of power and energy produced by

Table 2.7

Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
(Alternative B -- 1,135-ft^3/s turbine capacity, no Tunnel modifications)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	1,127	1,127	1,127	1,034	754	862	748	545	676	782	1,127	1,127	918
1953	927	870	855	491	622	839	599	444	448	800	1,031	1,127	754
1954	409	140	0	252	505	439	483	247	343	284	0	0	259
1955	344	0	0	418	370	661	408	388	161	122	0	728	302
1956	822	692	599	400	636	780	506	525	190	436	975	1,109	639
1957	1,127	1,127	1,127	825	680	864	859	799	800	986	1,127	1,127	953
1958	1,127	1,127	1,127	1,007	878	851	748	644	325	799	990	1,127	895
1959	688	423	213	223	500	707	599	453	237	367	420	1,127	498
1960	923	854	840	854	677	861	734	545	291	805	983	1,088	788
1961	645	356	135	511	460	714	520	454	468	423	416	1,127	520
1962	1,127	1,127	1,127	916	779	634	683	548	444	899	884	1,081	853
1963	634	372	176	239	431	399	415	457	307	115	0	470	335
1964	786	643	506	467	752	801	559	531	335	713	1,025	1,127	688
1965	1,127	1,127	1,127	1,039	695	756	846	587	824	1,027	1,127	1,127	949
1966	1,027	942	910	531	665	617	515	482	188	226	653	1,127	656
1967	692	530	245	194	333	521	522	428	279	87	0	1,127	414
1968	985	943	948	542	597	795	557	712	630	808	1,127	1,127	814
1969	1,127	1,127	811	912	650	657	635	465	550	1,036	1,127	1,127	850
1970	1,127	1,127	1,127	999	856	818	669	459	891	1,029	1,127	1,127	945
1971	1,127	1,127	1,127	852	618	772	732	533	673	832	1,127	1,127	886
1972	843	746	720	249	480	438	515	441	261	475	1,127	1,127	619
1973	1,127	1,127	1,037	1,024	904	862	839	491	668	733	1,127	1,127	921
1974	908	845	873	736	785	640	703	465	239	176	1,101	1,127	716
1975	1,127	1,127	1,127	861	644	814	843	626	617	507	1,127	1,127	877
1976	799	674	556	280	436	591	582	418	205	231	639	1,102	543
1977	298	0	0	292	425	498	422	306	462	209	0	0	244
1978	1,127	1,127	0	258	614	832	756	559	314	577	1,085	1,127	695
1979	1,127	1,127	1,127	1,023	869	889	835	496	542	681	1,070	1,127	908
1980	1,127	1,127	1,127	988	755	784	692	387	188	725	1,127	1,127	845
1981	1,127	899	739	450	358	457	616	272	241	434	331	381	524
1982	497	1,127	1,127	404	308	602	628	524	778	994	1,127	1,127	768
1983	1,127	1,127	1,083	928	737	827	827	617	495	641	1,079	1,127	883
Average	910	839	739	631	618	706	644	495	440	592	819	996	702
Maximum	1,127	1,127	1,127	1,039	904	889	859	799	891	1,036	1,127	1,127	953
Minimum	298	0	0	194	308	399	408	247	161	87	0	0	244
Std.dev.	262	358	420	307	170	148	137	115	216	303	424	319	218

Source: HDR, 1989a.

Table 2.8
Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
(Alternative C -- 1,135-ft^3/s turbine capacity, with Tunnel modified to 1,300 ft^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	1,135	1,135	1,135	1,135	919	1,027	913	710	841	947	1,135	1,135	1,013
1953	927	870	855	491	722	1,004	599	609	448	965	1,031	1,135	805
1954	409	140	0	252	505	439	483	247	343	284	0	0	259
1955	344	0	0	418	370	661	408	388	161	122	0	728	302
1956	822	692	599	400	675	780	506	690	190	436	975	1,109	657
1957	1,135	1,135	1,135	990	845	1,029	1,024	964	965	1,135	1,135	1,135	1,052
1958	1,135	1,135	1,135	1,135	1,043	1,016	913	809	325	880	990	1,135	971
1959	688	423	213	223	500	707	599	618	237	367	420	1,135	513
1960	923	854	840	854	842	990	793	710	291	970	983	1,088	845
1961	645	356	135	511	460	714	520	619	468	423	416	1,135	535
1962	1,135	1,135	1,135	1,081	944	799	848	713	444	1,064	884	1,081	938
1963	634	372	176	239	431	399	415	622	307	115	0	470	349
1964	786	643	506	467	917	801	559	696	335	713	1,025	1,135	716
1965	1,135	1,135	1,135	1,135	860	921	1,011	752	989	1,135	1,135	1,135	1,039
1966	1,027	942	910	531	830	617	515	647	188	226	653	1,135	685
1967	692	530	245	194	333	521	522	593	279	87	0	1,135	429
1968	985	943	948	542	762	960	722	877	795	973	1,135	1,135	898
1969	1,135	1,135	811	1,037	815	796	758	630	665	1,135	1,135	1,135	931
1970	1,135	1,135	1,135	1,135	1,021	983	834	624	1,056	1,135	1,135	1,135	1,037
1971	1,135	1,135	1,135	1,017	783	937	897	698	838	997	1,135	1,135	986
1972	843	746	720	249	480	438	515	606	261	475	1,135	1,135	634
1973	1,135	1,135	1,037	1,135	1,069	1,027	1,004	656	801	733	1,135	1,135	999
1974	908	845	873	736	950	640	703	630	239	176	1,101	1,135	745
1975	1,135	1,135	1,135	1,026	809	979	1,008	791	782	507	1,135	1,135	963
1976	799	674	556	280	436	591	582	583	205	231	639	1,102	557
1977	298	0	0	292	425	498	422	306	462	209	0	0	244
1978	1,135	1,135	0	258	712	997	921	724	314	577	1,085	1,135	747
1979	1,135	1,135	1,135	1,135	1,034	1,054	1,000	661	542	681	1,070	1,135	975
1980	1,135	1,135	1,135	1,135	920	949	857	552	188	725	1,135	1,135	916
1981	1,135	899	739	450	358	457	616	272	241	434	331	381	525
1982	497	1,135	1,135	404	308	602	793	671	885	1,072	1,135	1,135	812
1983	1,135	1,135	1,083	928	902	992	992	782	660	806	1,079	1,135	968
Average	914	842	742	682	718	791	727	639	492	648	822	1,002	751
Maximum	1,135	1,135	1,135	1,135	1,069	1,054	1,024	964	1,056	1,135	1,135	1,135	1,052
Minimum	298	0	0	194	308	399	408	247	161	87	0	0	244
Std.dev.	265	362	423	363	241	216	207	157	282	358	426	321	251

Source: HDR, 1989a.

Table 2.9
Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
(Alternative E -- 950-ft^3/s turbine capacity, no Tunnel modifications)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	950	950	950	950	754	862	748	545	676	782	950	950	838
1953	927	870	855	491	622	839	599	444	448	800	950	950	732
1954	409	140	0	252	505	439	483	247	343	284	0	0	259
1955	344	0	0	418	370	661	408	388	161	122	0	728	302
1956	822	692	599	400	636	780	506	525	190	436	950	950	624
1957	950	950	950	825	680	864	859	799	800	950	950	950	877
1958	950	950	950	950	878	851	748	644	325	799	950	950	828
1959	688	423	213	223	500	707	599	453	237	367	420	950	483
1960	923	854	840	854	677	861	734	545	291	805	950	950	773
1961	645	356	135	511	460	714	520	454	468	423	416	950	505
1962	950	950	950	916	779	634	683	548	444	899	884	950	799
1963	634	372	176	239	431	399	415	457	307	115	0	470	335
1964	786	643	506	467	752	801	559	531	335	713	950	950	667
1965	950	950	950	950	695	756	846	587	824	950	950	950	862
1966	950	942	910	531	665	617	515	482	188	226	653	950	635
1967	692	530	245	194	333	521	522	428	279	87	0	950	399
1968	950	943	948	542	597	795	557	712	630	808	950	950	781
1969	950	950	811	912	650	657	635	465	550	950	950	950	785
1970	950	950	950	950	856	818	669	459	891	950	950	950	861
1971	950	950	950	852	618	772	732	533	673	832	950	950	812
1972	843	746	720	249	480	438	515	441	261	475	950	950	589
1973	950	950	950	950	904	862	839	491	668	733	950	950	849
1974	908	845	873	736	785	640	703	465	239	176	950	950	688
1975	950	950	950	861	644	814	843	626	617	507	950	950	804
1976	799	674	556	280	436	591	582	418	205	231	639	950	530
1977	298	0	0	292	425	498	422	306	462	209	0	0	244
1978	950	950	0	258	614	832	756	559	314	577	950	950	641
1979	950	950	950	950	869	889	835	496	542	681	950	950	833
1980	950	950	950	950	755	784	692	387	188	725	950	950	768
1981	950	899	739	450	358	457	616	272	241	434	331	381	509
1982	497	950	950	404	308	602	628	524	778	950	950	950	706
1983	950	950	950	928	737	827	827	617	495	641	950	950	818
Average	824	756	671	617	618	706	644	495	440	582	728	851	661
Maximum	950	950	950	950	904	889	859	799	891	950	950	950	877
Minimum	298	0	0	194	308	399	408	247	161	87	0	0	244
Std.dev.	196	295	361	289	170	148	137	115	216	290	362	260	192

Source: HDR, 1989a.

Table 2.10

Monthly average flows entering AB Lateral Hydropower Facility, in ft^3/s.
(Alternative F -- 1,135-ft^3/s turbine capacity, no Tunnel modifications, with de-icing flows)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	1,127	1,127	1,127	1,034	754	862	748	537	668	782	1,127	1,127	917
1953	859	795	855	491	622	839	599	436	440	800	1,031	1,127	741
1954	341	65	0	252	505	439	483	239	335	284	0	0	247
1955	276	0	0	418	370	661	408	380	153	122	0	728	295
1956	754	617	599	400	636	780	506	517	182	436	975	1,109	626
1957	1,127	1,127	1,127	825	680	864	859	791	792	986	1,127	1,127	952
1958	1,127	1,127	1,127	1,007	878	851	748	636	317	799	990	1,127	894
1959	620	348	213	223	500	707	599	445	229	367	420	1,127	485
1960	855	779	840	854	677	861	734	537	283	805	983	1,088	775
1961	577	281	135	511	460	714	520	446	460	423	416	1,127	507
1962	1,127	1,127	1,127	916	779	634	683	540	436	899	884	1,081	852
1963	566	297	176	239	431	399	415	449	299	115	0	470	322
1964	718	568	506	467	752	801	559	523	327	713	1,025	1,127	675
1965	1,127	1,127	1,127	1,039	695	756	846	579	816	1,027	1,127	1,127	948
1966	959	867	910	531	665	617	515	474	180	226	653	1,127	643
1967	624	455	245	194	333	521	522	420	271	87	0	1,127	401
1968	917	868	948	542	597	795	557	704	622	808	1,127	1,127	801
1969	1,127	1,127	811	912	650	657	635	457	542	1,036	1,127	1,127	849
1970	1,127	1,127	1,127	999	856	818	669	451	883	1,029	1,127	1,127	943
1971	1,127	1,127	1,127	852	618	772	732	525	665	832	1,127	1,127	884
1972	775	671	720	249	480	438	515	433	253	475	1,127	1,127	606
1973	1,127	1,127	1,037	1,024	904	862	839	483	660	733	1,127	1,127	919
1974	840	770	873	736	785	640	703	457	231	176	1,101	1,127	703
1975	1,127	1,127	1,127	861	644	814	843	618	609	507	1,127	1,127	876
1976	731	599	556	280	436	591	582	410	197	231	639	1,102	530
1977	230	0	0	292	425	498	422	298	454	209	0	0	237
1978	1,127	1,127	0	258	614	832	756	551	306	577	1,085	1,127	694
1979	1,127	1,127	1,127	1,023	869	889	835	488	534	681	1,070	1,127	907
1980	1,127	1,127	1,127	988	755	784	692	379	180	725	1,127	1,127	843
1981	1,127	824	739	450	358	457	616	264	233	434	331	381	517
1982	429	1,127	1,127	404	308	602	628	516	770	994	1,127	1,127	761
1983	1,127	1,127	1,083	928	737	827	827	609	487	641	1,079	1,127	882
Average	874	803	739	631	618	706	644	487	432	592	819	996	695
Maximum	1,127	1,127	1,127	1,039	904	889	859	791	883	1,036	1,127	1,127	952
Minimum	230	0	0	194	308	399	408	239	153	87	0	0	237
Std.dev.	290	378	420	307	170	148	137	115	216	303	424	319	222

Source: HDR, 1989a.

each development alternative would vary because of different flow capacities and annual available flow volume. Power and energy generated by the project would be sold to the Public Service Company for use within the State of Colorado. The power and energy for each alternative are described in the following paragraph.

The installed capacity for alternative B would be 66,240 horsepower [49,415 kilowatt (kW)], with an average production of 261,001 megawatt-hours (MWh) of energy annually. The installed capacity for alternative C would be 66,240 horsepower (49,415 kW), producing an average of 274,911 MWh of energy annually. Alternative E's installed capacity would be 57,267 horsepower (42,721 kW). Development would produce an average of 247,264 MWh of energy per year. The installed capacity for alternative F would be 66,240 horsepower (49,415 kW), resulting in an average annual production of 258,619 MWh of energy.

ENVIRONMENTAL COMMITMENTS AND MEASURES

The Sponsors are including the following environmental measures as part of facility development and operation. An environmental commitment plan will be prepared by Reclamation and will contain all commitments in this environmental statement, together with additional measures included in project permits. The Sponsors will comply with Reclamation's plan through project design, construction, and operation. The environmental commitments would also be included in the lease of power privilege to ensure compliance. Environmental commitments are summarized in attachment A.

ENVIRONMENTAL COMMITMENTS AND MEASURES COMMON TO ALL ALTERNATIVES

Environmental measures would be included with the development of all alternatives and are described below for the Gunnison River, the Uncompahgre River, and the lands and wildlife affected by each alternative. (Environmental commitments are also discussed in attachment A). Meeting these commitments would be a provision of the lease of power privilege.

Gunnison River

During operation of the power facility, minimum flow requirements would be met in the Gunnison River. None of the alternatives would divert any Gunnison River water that would reduce flows below the Tunnel to less than 300 ft^3/s, even if the hydropower water right were senior to any future instream flow right or even if future instream flow rights were less than 300 ft^3/s or not designated at all. The hydropower water right is junior to the Federal reserved water right for the Black Canyon of the Gunnison National Monument.

Year-round operation of the Tunnel could lead to additional fish loss from the Gunnison River through the Tunnel. The Sponsors would construct a fish barrier where the AB Lateral diverts from the South Canal. It would be constructed in an irrigation system and therefore would not require a Section 404 Permit. Fish passing through the Tunnel during the irrigation season could be guided to the South Canal, creating a situation similar to current conditions. The barrier would consist of a steel rack containing bars spaced to limit loss of adult trout. Detailed barrier design would be coordinated with the CDOW.

The Sponsors would coordinate with Reclamation and the CDOW for periodic flushing of the pool created in the South Canal during the nonirrigation season. Annual Tunnel maintenance would be performed by the UVWUA and would be coordinated with Crystal Dam maintenance to minimize Gunnison River fluctuations. Annual meetings would be held with the Sponsors, the BLM, the CDOW, the NPS, and Reclamation to discuss Gunnison River aspects of the project and potential ways to solve any problems.

Uncompahgre River

Tunnel diversions would be reduced if they contributed to a flooding hazard along the Uncompahgre River. The Sponsors would monitor river flows during floods, controlling Tunnel and canal diversions accordingly. To prevent hydropower operations from affecting Reclamation's ability to fill Ridgway Reservoir, the Sponsors have agreed that the UVRP would not place a call on the Uncompahgre River using its senior water rights for the West, M&D, and Loutzenhizer Diversions, if the Tunnel were diverting water in excess of UVRP irrigation demands, including UVRP diversions downstream from the proposed tailrace.

The Sponsors would stabilize portions of the Uncompahgre River banks before beginning operations to prevent serious erosion damages (see figures 2.8a and 2.8b for location). A Section 404 Permit would be required for this work. In addition, the Sponsors would establish a monitoring program to document changes to the river resulting from power operations. The program would monitor bank erosion and wetlands and riparian vegetation. This program would be approved by Reclamation before construction and would be based upon low-level aerial photography of the channel obtained during design phases.

Affected Lands

The Sponsors would pay for any damages to crops or other property associated with obtaining the required construction and operation easements.

In construction areas, topsoil would be stripped and separately stockpiled to be used later for revegetation. Approximately 211 acres of land would be revegetated, including disturbed areas along the AB Lateral and the transmission line, the penstock right-of-way, other areas disturbed as a result of penstock construction, and areas near the tailrace and powerhouse. Any areas disturbed as a result of stockpiling excess materials would also be revegetated. The landowner would direct the type of revegetation required on cultivated lands. All other areas would be seeded according to SCS recommendations. A revegetation plan would be prepared by the Sponsors for Reclamation approval before construction. Lands within the penstock and canal easements (where not required for permanent maintenance roads) would be returned to existing uses after construction was completed.

Excess material from penstock construction would be disposed of only in areas designated in contract specifications. Materials would not be disposed in wetlands or in areas of greasewood shrubland.

Affected Wildlife

Transmission lines would be of a raptor-proof design to reduce the possibility of raptor electrocution. Design recommendations suggested in Suggested Practices for Raptor Protection on Powerlines - The State of the Art in 1981 (Olendorff and others, 1981) would be followed.

Two deer escape ramps would be constructed in the concrete-lined portion of the AB Lateral. The ramps would be a modified "Richmond" design (Rautenstrauch and Krausman, 1986), would have a 4:1 slope, would be set diagonally to the canal wall, and would have a cable barrier just downstream to direct deer to the escape. Final designs would be approved by the CDOW. The enlarged AB Lateral would be lined to reduce seepage and resulting salt loading to the Uncompahgre River.

Approximately 11 acres of wetlands would be a direct loss due to construction of any of the alternatives. The Sponsors would develop 12 acres of replacement wetlands on acquired land. An additional 20 acres of riparian vegetation would be planted to mitigate indirect losses due to flow changes in the Uncompahgre River. The wetland replacement plan is described in chapter 3. The final plan would require Reclamation and Corps of Engineers

(COE) approval before any project features are constructed, and the wetlands would have to be completed before the facility is operational in the second year.

Pollution Control and Aesthetics

Construction specifications would include provisions to limit noise and air pollution. The powerhouse, tailrace and associated features would be designed and landscaped to reduce visual impacts. A containment plan would be prepared as part of facility design for oil storage at the powerhouse. State and Federal water quality permits would be obtained by the Sponsors and would be followed during construction and operation. Irrigation and domestic water supplies would not be interrupted during construction and operation of the facility.

Endangered Species

Plans for protecting endangered species have been developed in accordance with the FWS biological opinion (USDI, FWS, 1988a). Special construction techniques to limit any disturbances to these species would be included in the specifications and used along the penstock right-of-way where an endangered plant species occurs. Plans to protect the plants would require approval before construction. In addition, the Sponsors would acquire approximately 60 acres of the plant's habitat in an area designated by the FWS and the BLM, land that would be donated to the BLM before plant operation. If the land were unavailable, the Sponsors would be required to complete an alternative plan as designated by the FWS before operation. Reclamation and the FWS would need to approve a written plan for protecting these plants during construction. The endangered plant species are discussed in detail in chapter 3.

To monitor bald eagles within the Gunnison River corridor, the Sponsors would perform a standard aircraft or river survey of the Gunnison River below the Black Canyon of the Gunnison National Monument to the confluence of the North Fork annually for 3 years following the initiation of the project. The survey would also be conducted during the two winters before project operation. Similar surveys will be performed in 1 year of any subsequent year that may represent an abnormally severe winter (provided a severe winter is not represented in the initial 3-year study period). A separate survey would be conducted approximately every 2 weeks from January through the first of March (five surveys annually). The surveys would be performed by qualified biologists with experience with raptor surveys and would assess species, number, and age classes of eagles; waterfowl or other potential prey numbers; and extent of ice buildup.

Survey plans would be approved by the BLM and FWS before the survey is initiated. The National Park Service (NPS) would be involved to help determine if monitoring should also include portions of the Black Canyon of the Monument. The Sponsors would provide annual and final progress reports of the surveys to the FWS, BLM, and Reclamation. Any significant impacts or problems noted during the eagle surveys would be brought immediately to the FWS's attention.

In an effort to better document prey use on the Gunnison River, the Sponsors would do ground and river observations of foraging eagles. Fourteen workdays or more by a qualified observer would be conducted from December through March to record observations of eagle hunting activity and species of prey captured. Attempts would be made to locate day and night perches and roosts to collect and analyze eagle castings.

If impacts to prey species or icing impacts are projected or are realized during the study, appropriate measures to reduce adverse effects would be taken through consultation with the FWS, BLM, and NPS. Such measures may include water augmentation during periods of extreme cold to prevent adverse icing conditions.

SPECIFIC ENVIRONMENTAL COMMITMENTS AND MEASURES

In addition to the commitments and measures described previously, each proposed alternative includes specific commitments unique to its features and are described in the following paragraphs.

Alternative B

No increases to the Tunnel capacity would be made as part of the hydropower development features for this alternative.

Alternative C

Because this alternative proposes to increase the Tunnel's capacity, the Sponsors would agree to limit diversions from the river during the nonirrigation season to the proposed capacity of the unit (1,135 ft^3/s). During the irrigation season, flows could be diverted to as much as 1,300 ft^3/s, subject to availability, priority, and irrigation requirements.

Alternative E

No increases to the Tunnel capacity would be made as part of the hydropower development features for this alternative. In coordination with the CDOW, the BLM, and the NPS, releases from the Aspinall Unit would periodically be bypassed at the Gunnison Tunnel to provide flushing flows in the Gunnison River to reduce siltation, a measure intended to mitigate impacts of the reduced winter flows. The Sponsors would also provide 1,000 acre-feet of water diverted from the Gunnison River to be conveyed through the South Canal for fisheries in the Uncompahgre River during the summer.

Alternative F

No increases to the Tunnel capacity would be made as part of the hydropower development features for this alternative. During the winter, the Sponsors would bypass a minimum flow in the Gunnison River of 600 ft^3/s when and if ice buildups occur. The Sponsors would provide 1,000 acre-feet of water diverted from the Gunnison River to be conveyed through the South Canal for fisheries in the Uncompahgre River. This flow would be made available during the late summer and would be exclusive of power or irrigation demands.

ALTERNATIVES ELIMINATED FROM STUDY

The Sponsors considered a number of other alternatives that have been eliminated from further study. These were compared with other alternatives using the same financial feasibility formulas as were used for all alternatives. In many instances, the alternatives eliminated were dimensional variations of the selected alternatives. For instance, five different penstock diameters, two types of penstock (steel pipe and prestressed concrete pipe), and two types of penstock lining were considered for each alternative. In addition, five possible penstock routes were evaluated. The penstock type, size, and lining options were optimized to maximize economic returns. Penstock routing was optimized to reduce impacts to endangered plants, land use, and landowners.

Within the region, two other possibilities were identified for hydropower production--expanding existing facilities at Crystal Dam and installing new facilities at Ridgway Dam. Reclamation had considered hydropower development on both structures but discontinued efforts because of poor economic returns at Crystal Dam and because non-Federal financing is being considered at Ridgway Dam. As stated in the introduction in chapter 1, the development of hydropower resources within the UVRP was authorized by Public Law 75-698. Neither Crystal Dam nor Ridgway Dam is within the boundaries of the UVRP and they are not considered to be part of that Project; thus, both structures were eliminated from further consideration.

Three additional alternatives seriously studied as part of this report include one variation of alternative C and two alternatives involving sites along the South Canal; they are described below.

ALTERNATIVE D

This alternative was considered to maximize hydropower potential. It is similar to alternative C, except that in addition to increasing Tunnel capacity to 1,300 ft^3/s, the maximum flow through the turbines would also be 1,300 ft^3/s. If developed, alternative D would produce an average of approximately 277,698 MWh annually by diverting 565,323 acre-feet through the turbines, which is 21,312 acre-feet more than alternative C.

The design features of this alternative would be similar to those of alternative C. However, to accommodate the increased flows, the AB Lateral would be widened to 23 feet, and the tailrace would be widened to 30 feet. Although the powerhouse dimensions would remain the same, the equipment would be somewhat larger and heavier, resulting in an increase of the capital costs of this alternative of nearly $1 million greater than alternative C. (Alternative D would cost approximately $64 million.) Annual operating costs would increase $150,000.

Developing this alternative would reduce the average annual flows below the Tunnel to about 533 ft^3/s (compared to 563 ft^3/s for alternative C). Under the no-action alternative, these flows would be 1,103 ft^3/s.

This alternative was eliminated from further study. Even though it would produce more energy than any of the selected alternatives, the increased development costs for alternative D resulted in slightly lower financial returns. Also, developing the alternative would result in increased environmental impacts to the Gunnison and Uncompahgre Rivers.

ALTERNATIVE G (SOUTH CANAL SITES)

The original hydropower concept proposed in 1981 by the Sponsors involved developing five sites located at existing drop structures or steep grade sections along the South Canal. These developments were analyzed in detail from January 1981 through September 1983 when preliminary designs were prepared. One of the sites was then eliminated because of poor economics.

Detailed negotiations occurred with contractors and equipment suppliers. The Sponsors also negotiated power sales and wheeling agreements with Public Service and Colorado-Ute Electric Association (Colorado-Ute).

The configuration and operation of each of the four sites were similar. Water would be diverted from the South Canal through a concrete headrace and trashrack, passed through a 10-foot-diameter steel penstock and horizontal tube-type turbines, and returned to the canal via a stilling basin and a concrete-lined tailrace. In most cases, the powerhouse would be below natural grade, and only a small entrance shelter would be above ground.

Water levels would be controlled by a radial gate in each headrace. Power and energy generated at each site would be connected to the existing transmission grid via new 46-kV transmission lines, which would be constructed within the existing canal right-of-way or within existing county road rights-of-way. A summary of site characteristics is presented in table 2.11, and the approximate location of each site is shown in figure 2.9.

Table 2.11.-- Summary of characteristics, alternative G

Characteristic	Site 1	Site 3	Site 4	Site 5
Turbine flow (ft^3/s)	900	900	900	900
Net head at maximum flow (ft)	51	46	62	28
Rated capacity (kW)	3,514	3,177	4,198	1,908
Average annual energy (MWh)	22,164	19,717	26,260	10,994

Source: HDR, personal communication, 1988.

With alternative G, the operation of the irrigation system would be identical to the no-action alternative. However, additional flows would be diverted during the irrigation season up to the Tunnel capacity and during the nonirrigation season up to 900 ft^3/s to increase energy production. The estimated average annual energy production at the four sites would be about 79,136 MWh. If unplanned shutdown of the turbines would occur, the radial gate in the headrace would be closed, allowing the uninterrupted flow of irrigation supplies through the South Canal.

Development of the South Canal sites would have two major differences from the AB Lateral alternatives. First, no changes to the historic flow patterns of the irrigation water would occur. Although more water would be diverted from the Gunnison River (646,196 acre-feet versus the historic 336,411 acre-feet),

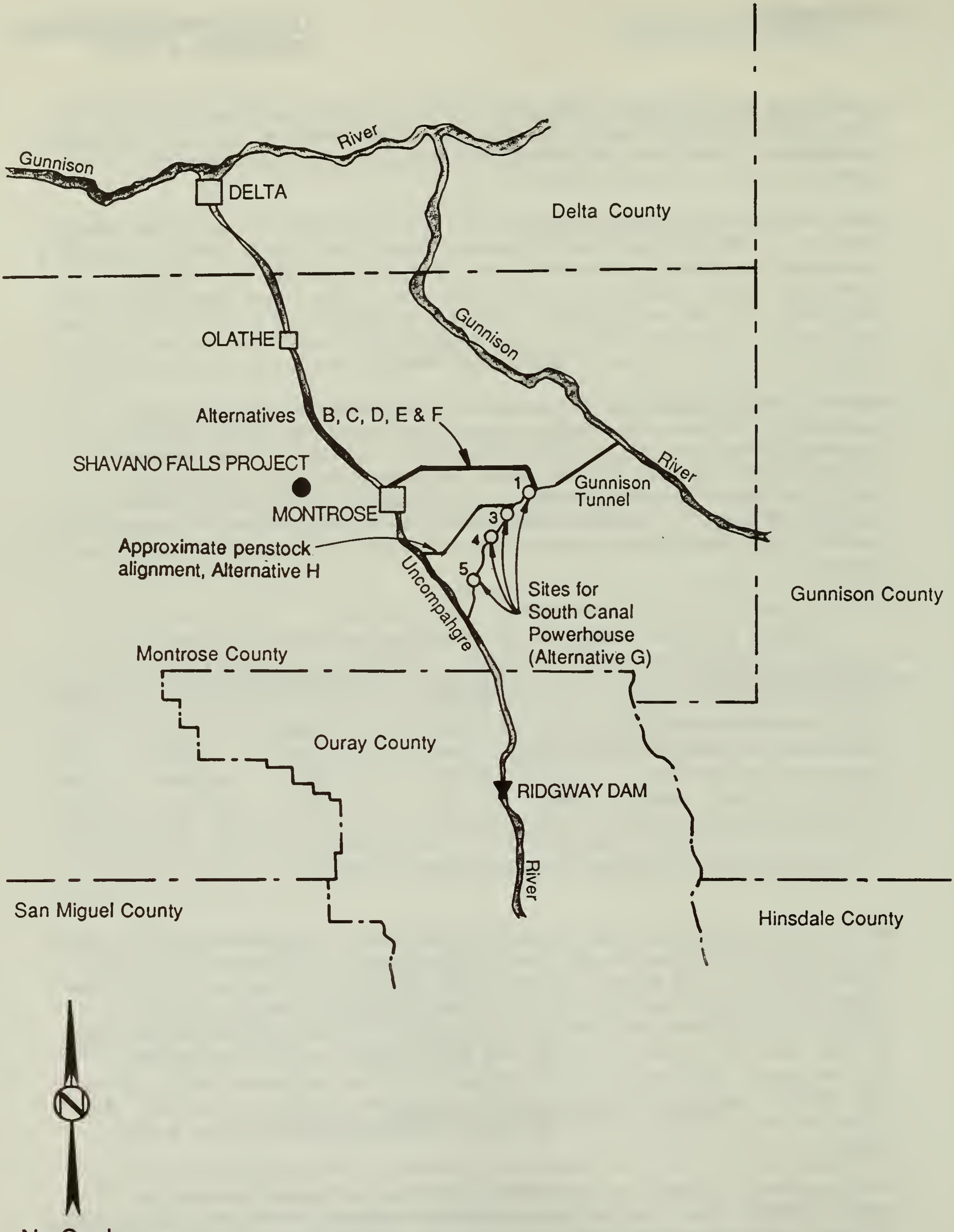


Figure 2.9. Location of Alternative G (South Canal sites).

the water would be discharged into the Uncompahgre River at the South Canal terminus. Second, because flow patterns do not change, development of this alternative would greatly increase the flows in the Uncompahgre River downstream of the South Canal terminus.

Alternative G was eliminated from further consideration because, although the development was feasible in 1983, power rates have fallen in the past 5 years and tax credits have been eliminated, while construction costs have risen, a combination of events that have rendered the alternative economically infeasible. Also, development of the South Canal sites does not take full advantage of the potential hydropower resource, which can be seen by comparing the energy produced by alternative E, 247,264 MWh (with a similar design flow of 950 ft^3/s) to the energy produced at the South Canal sites--79,135 MWh. Thus, additional studies were initiated in 1984 that resulted in the present AB Lateral concept (alternative E). Lastly, the increased flows between the South Canal terminus and the city of Montrose would result in increased bank erosion on the Uncompahgre River. This action would add further erosion mitigation costs to the costs of mitigating those same impacts between Montrose and Delta.

ALTERNATIVE H

The inefficiencies of the South Canal sites can be partially offset by alternative H, which harnesses much of the elevation difference between the South Canal and Uncompahgre River by relocating the diversion works farther downstream from the AB Lateral. For this alternative, a diversion structure would be located about 3 miles downstream of the West Portal of the Tunnel at the upper end of South Canal Site 3 (see figure 2.9). Here water would be diverted into a penstock that terminates at a powerhouse located almost due west of the diversion works and just upstream from the Loutzenhizer Canal Diversion Dam.

The features of this alternative would be similar to those of alternative B. Minor modifications of the South Canal would be needed to increase its capacity to 1,135 ft^3/s between the AB Lateral and the proposed diversion. The diversion structure would consist of two radial gates, one on the South Canal and one in the headrace. The latter feature would be a rectangular channel about 20 feet wide and 50 feet long that would convey flows from the canal to the penstock trashrack and intake.

The penstock would be about 28,500 feet long, have a 10-foot diameter, and would be constructed similar to alternative B. Construction and features of the powerhouse would also be similar to alternative B. The estimated rated capacity of the turbines would be about 40,000 horsepower (or 29,800 kW).

Coupled with this alternative would be the development of South Canal Site 1 (see alternative G) near the West Portal of the Tunnel. Developing both sites would produce about 195,923 MWh annually. Because the diverted flows enter the Uncompahgre River upstream of the Loutzenhizer Canal, the demands of that canal can be passed through the powerhouse in addition to those of the Selig Canal and other downstream canals. However, if the Uncompahgre River cannot satisfy all of the demands in the M&D Canal, additional flows would have to be bypassed through the South Canal away from the turbines.

Alternative H would have the advantage of adding water to the Uncompahgre River upstream of Montrose, increasing the potential for area recreational development. However, the additional flow would also result in erosion problems within this reach caused by high flows during the winter.

This alternative was eliminated from detailed consideration because the development costs exceeded the estimated benefits and because of environmental reasons. The average flow diverted from the Gunnison River would be 956 ft^3/s annually, leaving an average of 613 ft^3/s per year in the river. These figures are identical to those of alternative B, yet the energy production of alternative H (including site 1) is 25 percent less than alternative B and it also produces less energy at a greater cost than alternative E.

INCREASED MINIMUM FLOWS IN THE GUNNISON RIVER

Several alternatives were evaluated that considered the effects of increasing the instream flows in the Gunnison River. Alternatives F-3 and F-4 considered a minimum instream flow of 350 and 400 ft^3/s, respectively, for June through August. These values and months were selected to determine the economic impacts of the development of providing greater flows for rafting and other interests while still protecting fisheries. Alternative F-5 was studied for similar reasons, although this alternative evaluated a minimum instream flow of 400 ft^3/s during July through September. For each of these alternatives, it was also assumed that deicing flows would be provided to the river during January and February. For alternative F-6, minimum flows were modeled as 450 ft^3/s in December, 600 ft^3/s in January, and 450 ft^3/s in February to accomplish deicing, and 450 ft^3/s in August, 600 ft^3/s in September, and 450 ft^3/s in October to provide additional water for rafting interests. Under these alternatives and the no-action alternative, flows would still periodically fall below the levels discussed (350, 400, 450, and 600 ft^3/s) due to runoff conditions and upstream water rights.

Each of these alternatives was analyzed in terms of the economic effect to the proposed development as well as the environmental effects to the Gunnison River. In table 2.12, the results of the analysis are compared to alternatives E and F, which are feasible alternatives that reduce diversions through the capacities of the turbines or through ice control releases. Alternatives F-3 through F-6 would increase the average annual volume of water in the Gunnison River, which in turn would subsequently benefit rafting, and in some years, the fishery would benefit. However, for each of these alternatives, the volume of water available for power production would be diminished, resulting in a loss of revenues without a concurrent reduction in overall development costs.

From studying table 2.12, it is seen that despite increasing the minimum instream flows during specified summer and winter months, the average annual flows in the Gunnison River would still be less than those for alternative E, except for alternative F-6. The financial feasibility ratio for each of the alternatives (F-3 through F-6) is less than 1.0, showing that the costs of development incurred by the Sponsors would be greater than the benefits. The ratio does not include recreation, fish and wildlife, emission offsets, and other environmental costs and benefits; it is a financial analysis used to determine one aspect of an alternative's feasibility.

SMALLER PROJECTS

Facilities with designs similar to the one proposed for alternative E, but with lower design flows, were also studied. Projects with design flows of less than approximately 700 ft^3/s were not economically feasible.

Alternatives with design flows in the range of 700 to 900 ft^3/s were considered. Environmental impacts for these projects, such as changes in Gunnison and Uncompahgre flows from April through October, year-round flows through Montrose, Uncompahgre bank stabilization, and penstock and transmission line rights-of-way requirements, would remain essentially unchanged from the larger projects. For a 700-ft^3/s project, winter flows in the Gunnison would increase, on an average, about 160 ft^3/s beyond alternative E, with most of the increase occurring during already high flows. Environmental effects of flow changes would be reduced. However, emissions offsets, power benefits, UVWUA payments, and regional economic benefits would be reduced with smaller projects.

Moreover, the Sponsors have determined that projects in the range of 700 to 900 ft^3/s are too sensitive to varying economic conditions, such as construction costs and interest rate volatility, and include insufficient potential profits to justify

Table 2.12.--Summary of minimum flow alternatives

Parameter	Alternative[1]					
	E	F	F-3	F-4	F-5	F-6
Water flow data, in ft^3/s						
Entering Black Canyon	654	619	623	627	629	655
Diverted through Tunnel	915	951	946	942	940	914
Through AB facility	661	695	690	686	684	658
Uncompahgre River at Cedar Creek	633	679	674	670	668	642
Economic data						
Power production, MWH	247,264	258,619	251,812	250,098	249,302	240,355
Total capital cost ($1,000)[2]	$57,068	$62,114	$62,114	$62,114	$62,114	$62,114
Financial feasibility ratio	1.04	1.01	0.98	0.97	0.97	0.93

[1] Alternatives F-3 through F-6 assume similar facility parameters to Alternative F with the following exceptions:

a. Alternative F-3 assumes minimum instream flow of 350 ft^3/s during June through August.
b. Alternative F-4 assumes minimum instream flow of 400 ft^3/s during June through August.
c. Alternative F-5 assumes minimum instream flow of 400 ft^3/s during July through September.
d. Alternative F-6 assumes 450 ft^3/s instream flows during February, August, October and December, 600 ft^3/s in January and September, 300 ft^3/s in remaining months.

[2] Total capital cost includes construction costs and net present worth of annual operation and maintenance costs.

Source: HDR, personal communication, 1989.

the risks inherent in building and operating the facility. As such, the smaller projects did not represent viable alternatives and were not pursued further.

PERMITS AND REGULATORY APPROVALS

Before constructing any alternative, the Sponsors would obtain various permits and agreements as necessary for complying with Federal, State, and municipal laws, codes, and regulations. A lease of power privilege to use UVRP facilities would be executed with Reclamation. The Sponsors would obtain (in the name of the United States) all land rights necessary for relocating reaches of the AB Lateral from BLM and private landowners.

Clean Water Act permits would be required from the COE for constructing the tailrace and bank protection on the Uncompahgre River. A Section 401 water quality certification and a Section 402 water discharge permit also would be required from the State of Colorado for construction.

For penstock crossings, various agreements would be obtained as required from local and State agencies, utilities, and the Denver and Rio Grande Railroad. The Sponsors would work directly with the city of Montrose, the Colorado Department of Highways, and Montrose County in designing and constructing crossings and other features.

WATER RIGHTS

Under all alternatives, the hydropower facility would be operated according to Colorado water law. Colorado has a priority system to allocate surface waters for beneficial use. A priority date is assigned based upon the year a decree application is filed with the State. Use of the water is then prioritized, with the earliest priority date receiving the first call on water. The Sponsors have applied for and received two separate water rights specifically for the proposed development. The first, having a 1982 priority date, is for 900 ft^3/s. The second, an additional 235 ft^3/s, carries a 1987 priority date. Together, these rights allow hydropower use for up to the full capacity (1,135 ft^3/s) of the Tunnel.

For the use and benefit of the UVRP, a decree was awarded in 1913 (Priority No. 111-1/4) for as much as 1,300 ft^3/s. While that water right has historically been used for agriculture, it has been suggested that it may be possible to operate the hydropower project under this decree. However, to operate under this decree would probably require a court decision to that effect. The Sponsors applied for the 1982 and 1987 water rights to avoid the need for such a determination by the Colorado State Water Court.

The Sponsors plan to operate the project under these latter specific decrees. The Sponsors have committed to a 300-ft^3/s minimum flow in the Gunnison River downstream from the Tunnel while recognizing that this flow may not be possible in dry years when water is needed to satisfy senior irrigation rights, as in the existing operations. Hydropower diversions would never reduce flows below the 300-ft^3/s minimum.

Operating the proposed facility under any of the development alternatives would constitute a nonconsumptive use. All flows into the facility would be returned to the river system without being diminished. Flows would be diverted from the Gunnison River at the existing Gunnison Diversion Dam and returned approximately 47 miles downstream at the confluence of the Uncompahgre and Gunnison Rivers. In addition, the facility would be operated according to "run-of-the-river," meaning that it would possess no active storage, would have no call on the existing upstream storage reservoirs, and would use flows only as they are released by the reservoir operators under their own operating criteria.

Nonconsumptive, run-of-the-river operation also means that the facility's principal interaction with other water rights holders would be in the reach of the Gunnison River between the Tunnel and the city of Delta. Within this reach are several irrigation rights including the North Delta Canal and the Relief, Hartland, and Bona Fide Ditches. Flow demands from these rights can be met from discharges from the North Fork and other tributaries as well as the 300-ft^3/s instream flow below the Tunnel. In addition, three conditional storage (proposed reservoir) rights are held by the city of Delta, Colorado-Ute, and The Nature Conservancy, respectively. Although these rights have not been perfected (developed), they are all senior to both the 1982 and the 1987 hydropower rights. If they are developed, they would be given priority for water use.

The Nature Conservancy, whose right was previously held by the Pittsburg and Midway Coal Mining Company, is negotiating an agreement to convert their storage right into a direct flow, or instream flow right of 300 ft^3/s. If they are successful, the modified right would probably be senior to both the 1982 and the 1987 hydropower rights. Even if not senior, the hydropower development has agreed to honor a 300-ft^3/s minimum flow in the Gunnison River below the East Portal of the Tunnel.

In addition to these decreed rights, additional constraints might be imposed by Federal reserved rights. These reserved rights would be for instream flow or possibly other purposes and are carried with special Federal land management designations. Courts have ruled that in establishing a special management zone such as the Black Canyon of the Gunnison National Monument (enacted 1933), Congress intended to reserve enough water to accomplish the original purpose of the reservation. To date, reserved water rights associated with the Monument have not been quantified. Should they be quantified in the future, they would be senior to the 1982 and 1987 hydropower rights but junior to the 1913 decree previously discussed. The Sponsors have committed to honor either that flow required by the adjudicated Federal reserved right for the Monument or 300 ft^3/s, whichever is greater. Reclamation will include this requirement in its lease of power privilege contract with the Sponsors. Water rights associated with future congressional designations would be junior to hydropower rights.

The irrigation portion of the Tunnel and most of the UVRP carries water rights with a 1901 priority date. Irrigation rights are senior to the hydropower rights and would be unaffected by operation of the proposed development under any of the alternatives.

SUMMARY COMPARISON OF ALTERNATIVES

Development alternatives B through F are compared in summary form to the no-action alternative in tables 2.13 through 2.15. Alternatives that were deleted from consideration were discussed earlier. Table 2.13 compares various physical and water-related parameters, table 2.14 compares economic factors, and 2.15 compares various environmental parameters. Many of the parameters that are compared are dependent upon streamflows in the Gunnison and Uncompahgre Rivers. A summary of these streamflows, including duration curves and monthly average flow curves for flows entering the Black Canyon, is presented in attachment D.

The analysis of alternatives included the financial feasibility ratio where the benefits to the Sponsors, represented by revenues from the sale of power, were compared to the costs of constructing and operating the facility. Net present revenues and costs were determined using three different discount rates (13, 14, and 15 percent) which account for the time-value[2] of money in ranges expected by the Sponsors. Construction costs, anticipated to occur from 1990 through 1992, were based upon preliminary proposals submitted to the Sponsors by several contractors. Included in the cost estimates are the estimated construction costs of environmental mitigation measures, such as bank stabilization, endangered vegetation species mitigation, and

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[2] This concept accounts for the effect of the passage of time on the value of money. Discounting is used to transform future benefits and/or costs into dollars of present worth. Money in the present is worth more than in the future because of the ability of money to earn interest.

Table 2.13.--Summary comparison of alternatives

Item	Alternative				
	A	B	C	E	F
Water flow data (in ft^3/s)					
Gunnison River					
Entering Black Canyon (average annual)	1,103	613	563	654	618
Average December through February flows	1,392	476	471	581	499
Average July through September flows	897	730	637	730	730
Minimum flows	300	300	300	300	300[1]
Below Delta (all periods)	No change	No change	No change	No change	No change
Uncompahgre River					
Below South Canal (average annual)	540	342	342	342	343
Average December through February flows	88	88	88	88	88
Average July through September flows	910	579	579	579	585
Below Montrose & Delta Canal (average annual)	312	113	113	113	115
Average December through February flows	60	60	60	60	60
Average July through September flows	471	140	140	140	145
Entering Montrose (average annual)	269	65	65	65	67
Average December through February flows	48	48	48	48	48
Average July through September flows	392	58	58	63	63
Below Cedar Creek (average annual)	202	684	735	643	679
Average December through February flows	38	956	960	850	932
Average July through September flows	279	442	536	442	442
Through turbines (average annual)	- NA -	702	751	661	695
Average December through February flows	- NA -	918	922	812	894
Average July through September flows	- NA -	527	621	527	522
Production data					
Rated capacity (HP)	- NA -	66,240	66,240	57,267	66,240
Rated capacity (kW)	- NA -	49,415	49,415	42,721	49,415
Average annual energy production (MWh)	- NA -	261,006	274,911	247,264	258,619
Design flow capacity (ft^3/s)	- NA -	1,135	1,135	950	1,135
Net head at maximum capacity (feet)	- NA -	580	580	603	580
Physical data					
Pipeline diameter (in.)[2]	- NA -	120	120	114	120
Tunnel modifications	None	None	Enlarged	None	None

[1] The minimum flow for alternative F would be increased as necessary during winter months for eliminating ice buildup in the Gunnison River downstream of the Tunnel.

[2] Penstock diameters are preliminary and subject to change.

Table 2.14.--Alternative cost data and financial feasibility analysis (in $1,000)

Item	Alternative A	B	C	E	F
Alternative cost data (in 1990 dollars)					
Construction costs[1]	- NA -	$52,959	$53,709	$48,454	$52,959
Development costs[2]	- NA -	$9,155	$9,245	$8,614	$9,155
Total capital costs	- NA -	$62,114	$62,954	$57,068	$62,114
Annual operation and maintenance costs	- NA -	$1,050	$1,050	$950	$1,050
Financial analysis (in 1992 dollars)[3]					
Discount rate = 13 percent					
Present value, fixed costs	- NA -	$68,870	$69,797	$63,269	$68,870
Present value, variable costs	- NA -	$8,551	$8,551	$7,737	$8,551
Present value, revenues from sale of power	- NA -	$78,549	$82,733	$74,405	$77,848
Financial feasibility ratio	- NA -	1.015	1.056	1.048	1.006
Discount rate = 14 percent					
Present value, fixed costs	- NA -	$66,037	$66,926	$60,666	$66,037
Present value, variable costs	- NA -	$8,174	$8,174	$7,396	$8,174
Present value, revenues from sale of power	- NA -	$75,106	$79,107	$71,144	$74,436
Financial feasibility ratio	- NA -	1.012	1.053	1.045	1.003
Discount rate = 15 percent					
Present value, fixed costs	- NA -	$63,419	$64,273	$58,261	$63,419
Present value, variable costs	- NA -	$7,827	$7,827	$7,081	$7,827
Present value, revenues from sale of power	- NA -	$71,933	$75,764	$68,138	$71,290
Financial feasibility ratio	- NA -	1.010	1.051	1.043	1.001

1 Includes design and building, land acquisition, and environmental mitigation costs.
2 Includes financing, engineering design, licensing and legal fees, interest during construction, and administrative costs.
3 Discount rates evaluated represent the rate at which future costs and revenues are returned to 1992 dollars.
Source: HDR, personal communication, 1989.

Table 2.15.--Impacts of alternatives

Item	Alternative A	B	C	E	F
Water quality and quantity					
Salt-loading reduction (tons)	0	3,044	3,256	2,866	3,014
Annual flow entering Black Canyon (Gunnison R.; ft^3/s)	1,103	613	563	654	618
Annual flow entering Montrose (Uncompahgre R.; ft^3/s)	269	65	65	65	67
Annual flow below Cedar Creek (Uncompahgre R.; ft^3/s)	202	684	735	643	679
Endangered species					
Clay-loving wild buckwheat affected by construction (acres)	0	<5	<5	<5	<5
Mitigation acreage provided by the Sponsors (acres)	0	60	60	60	60
Endangered fisheries affected	None	None	None	None	None
Endangered wildlife affected	None	Bald eagle	Bald eagle	Bald eagle	Bald eagle
Wetlands					
Acreage directly affected	0	11	11	11	11
Acreage indirectly affected	0	29	29	11	29
Constructed wetland acreage provided by the Sponsors acres	0	12	12	12	12
Additional riparian acreage planted	0	20	20	20	20
Land use					
Permanent easement requirements (acres)	0	127	127	127	127
Temporary easement requirements (acres)	0	249	249	249	249
Recreation					
Wilderness eligibility retained	Yes	Yes[3]	Yes[3]	Yes[3]	Yes[3]
Gunnison River Wild & Scenic eligibility retained	Yes	Yes[3]	Yes[3]	Yes[3]	Yes[3]
Rafting, user days	4,673	4,066	3,440	4,066	4,066
Present value, direct expenditures ($1,000)[1]	$4,454	$3,924	$3,480	$3,924	$3,924
Economic impacts ($1,000)	$0	-$530	-$974	-$530	-$530
Fishing, user days	17,680	20,078	21,414	20,063	20,078
Present value, direct expenditures ($1,000)[1]	$6,387	$7,261	$7,748	$7,261	$7,261
Economic impacts ($1,000)	$0	$874	$1,361	$874	$874
Cultural resources					
Cultural resources sites affected	0	0	1	0	0
Air quality					
Air pollutant emissions offset: SO_2 (tons/yr)	0	800	825	740	800
NO_x (tons/yr)	0	1,300	1,375	1,235	1,300
CO_2 (tons/yr)	0	234,000	247,000	223,000	234,000
Present value, emissions offset[2] SO_2 ($000's)	0	$ 4,799	$ 4,938	$ 4,444	$ 4,799
NO_x ($000's)	0	$ 6,715	$ 7,090	$ 6,360	$ 6,715
CO_2 ($000's)	0	$ 74,993	$ 76,790	$ 66,698	$ 74,993

[1] Direct expenditures for rafting and fishing shown as net present value; 1988 values inflated at 5 percent per year and discounted to 1992 dollars at 8.875 percent. Annual expenditures (in 1988 dollars) are shown in chapter 3.

[2] Present value of emission offset is calculated using technology for calculating cost of alternative reductions (see chapter 3). 1988 values are inflated at 5 percent per year and discounted to 1992 at 8.875 percent.

[3] Although eligibility is retained, values would be affected as discussed in chapter 3 of the EIS.

a fish barrier at the AB Lateral and South Canal diversion. Operating expenses include environmental monitoring costs associated with each alternative, in addition to technical operations and maintenance, insurance, and property taxes.

The financial feasibility ratios presented in tables 2.12 and 2.14 incorporate the costs and benefits that the Sponsors of the proposed development would bear. Because the development would not involve Federal expenditures, the analysis does not incorporate other benefits or costs, including environmental benefits and costs, that might ordinarily be included if the development were to be Federally funded.

Thus, the financial feasibility ratio is not a true "benefit/cost" (B/C) ratio under Federal evaluation procedures for Federal projects. It instead represents the financial feasibility of each alternative. Overall financing rates were assumed to be 13 percent, and discount rates used in the analysis in table 2.14 represent the range of the time-value of money expected by the Sponsors, based upon a financial life of 15 years. Since these rates include estimates of minimum allowable returns on equity, an alternative with a financial feasibility ratio of 1.0 represents the minimum feasible project for the Sponsors, assuming all of the assumptions going into the ratio are actually realized. Financial feasibility ratios of greater than 1.0 provide additional returns to the Sponsors, or greater flexibility to cover costs above or revenues below projections. All alternatives were evaluated on the same financial basis.

Implementing any of the development alternatives would result in additional impacts to the regional economy and environment that are not included in the Sponsor's financial feasibility ratio. Some of these impacts, such as the impacts to an endangered plant, are impossible to fully economically quantify. Table 2.15 summarizes the major impacts that could be reasonably expected to occur if development occurred. Where possible, economic impacts have been shown.

Alternative C produces the highest financial feasibility ratio and was presented as the Sponsors' preferred alternative in the DEIS. Reclamation is recommending alternative E, which is financially feasible and also reduces risks of environmental impacts.

Alternative E diverts an average of 100 ft^3/s less from the Gunnison River during the winter, thus reducing impacts to both the Gunnison and Uncompahgre Rivers.

CHAPTER 3

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Developing the AB Lateral Hydropower Facility alternatives would create both short- and long-term consequences to the surrounding region. The purpose of this chapter is to describe the existing conditions of the region, the consequences of the no-action and development alternatives, and the effect of mitigative measures that would be implemented by the Sponsors.

GENERAL DESCRIPTION OF THE REGION

The Uncompahgre Valley, which is about 31 miles in length, lies along the western flank of the Rocky Mountains with elevations ranging from 4,950 feet above sea level near Delta to 6,500 feet above sea level near Montrose. The valley slopes gently from southeast to northwest and is divided by the Uncompahgre River (see figure 3.1). The Gunnison River flows east of the valley through the Black Canyon of the Gunnison National Monument (Monument) and the Gunnison Gorge Recreation Area (see figure 3.2).

The climate of the region is typical of lower intermountain valleys of the western United States, with low annual precipitation, low humidity, abundant sunshine, and a wide range of annual and daily temperatures. The average annual precipitation at Montrose is approximately 9 inches, about half of which occurs as winter snow.

The principal natural vegetation within the Uncompahgre Valley is the semidesert grass shrub community which is common in the intermountain west between elevations of 3,000 to 6,000 feet. Sagebrush, saltbush, and greasewood are characteristic plants. Stands of deciduous trees such as cottonwood and willow typically line natural drainages. Seepage from irrigation canals and laterals, along with irrigation return flows, have contributed to wetlands developing along the irrigation features. Sparse stands of pinyon pine and juniper occur along elevated mesas and foothills around the valley.

About 505,000 acre-feet of water flows into the Uncompahgre Valley annually. Nearly two-thirds of this volume is imported from the Gunnison River via the Gunnison Tunnel (Tunnel), and the remaining volume is derived from the Uncompahgre River and its tributaries. Of the water entering the valley, about 233,000 acre-feet are consumptively used through irrigation or evaporation and the remainder flows northward out of the valley and into the Gunnison River at Delta.

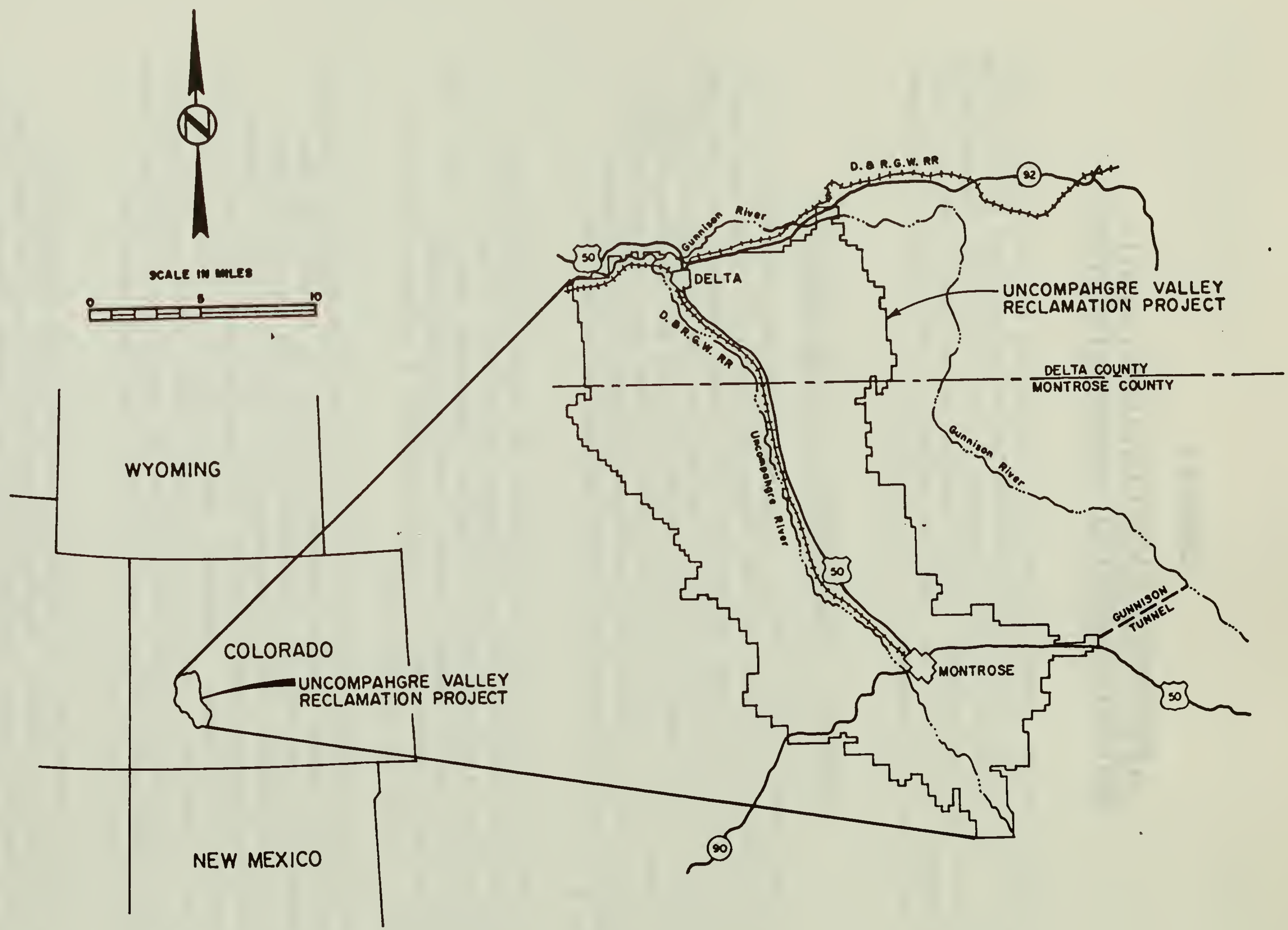

Figure 3.1. General area map,
Uncompahgre Reclamation Project.

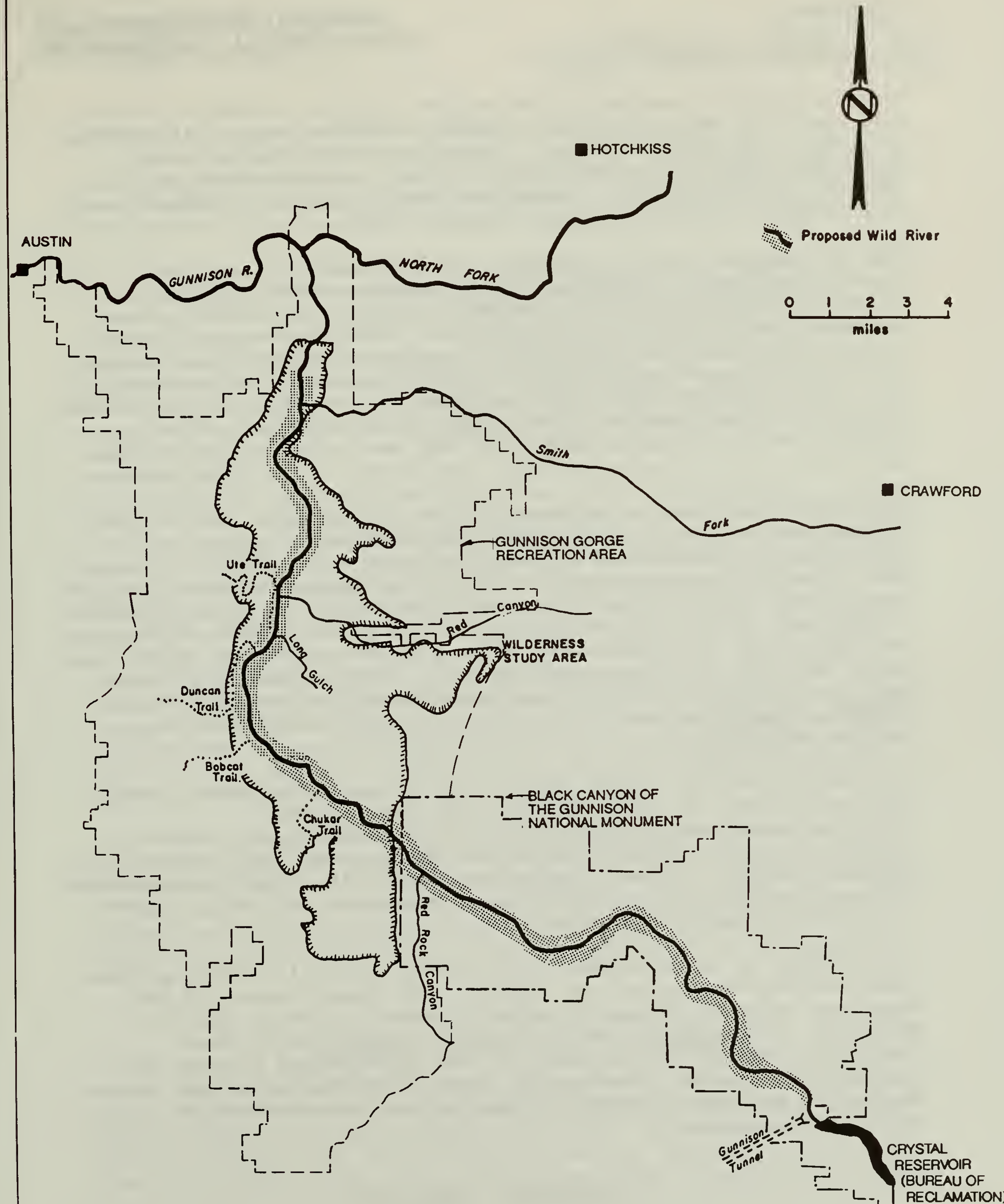

Figure 3.2. Gunnison Gorge area.

Common wildlife species in the region include nongame wildlife and the mule deer, cottontail rabbit, mourning dove, ring-necked pheasant, and Gambel's quail. Waterfowl that use the area seasonally include Canada goose, mallard, green-winged teal, gadwall, and shoveler. Furbearers include beaver, muskrat, gray fox, badger, river otter, and striped skunk.

The Uncompahgre River provides a sport fishery of limited importance due to its dominance by western white, bluehead and flannelmouth suckers. The fishery potential of the river is adversely influenced by high sediment load, low summer flow in certain reaches, low winter flows, and high summer temperatures. Observations made during 1988 and 1989 indicate that segments of the river upstream from Montrose have improved because of Ridgway Reservoir. The Gunnison River supports an excellent trout fishery between Crystal Reservoir and several miles downstream from the river's confluence with the North Fork of the Gunnison.

Cultural resources in the area include evidence of prehistoric inhabitants of the Archaic Stage and evidence of water development, mining, and agriculture in historic times. Mining and timbering have occurred in the surrounding mountains, but the Uncompahgre Valley remains primarily agrarian. About two-thirds of Montrose County is national forest or public lands, with about 642,000 acres in private ownership. Of the privately owned land, about 400,000 acres are agricultural. Twenty percent of this area is irrigated by the Uncompahgre Valley Reclamation Project (UVRP). Crops include corn, alfalfa, pinto beans, potatoes, onions, and fruit.

Population density in the study area is low. The population of Montrose County is about 25,250, with approximately 10,000 persons residing within the city of Montrose. Delta County, in the northern half of the study area, has a population of about 21,230. Other communities within the study area include Olathe, about 11 miles northwest of Montrose, and Delta, about 11 miles northwest of Olathe.

In addition to agriculture, tourism and recreation are important local industries during the summer. The Black Canyon of the Gunnison National Monument, which is about 10 miles east of Montrose, is the principal attraction. Montrose is also centrally located with respect to the Uncompahgre Plateau and San Juan Mountains. During the winter, the Telluride ski area south of Montrose brings visitors to the area because of Montrose's airport.

GENERAL IMPACTS

As presented in chapter 2, the Bureau of Reclamation (Reclamation) has evaluated four development alternatives in addition to the no-action alternative (alternative A). If no action is taken, conditions in the valley are not expected to change significantly in the foreseeable future. Water resources development in the Gunnison River drainage, including the Uncompahgre River Basin, would be expected to continue.

Any of the four development alternatives would result in short-term construction-related and long-term operational impacts. Short-term impacts include vegetation clearing, erosion, and construction disturbance, as well as short-term additions to the local economy. Long-term impacts would be related to the decreased flows in the Gunnison River, the increased flows in the Uncompahgre River, and the long-term additions to the local economy resulting from power production at the facility.

The ecology of the Gunnison River has been significantly modified over the last 100 years by the construction of major and minor impoundments and diversions, in addition to land use changes in the river basin. The combination of impoundments and diversions has partially reversed the natural runoff cycles. Highest average flows entering the Black Canyon now occur in the winter, although snowmelt peaks are still observed in the spring (see attachment B). The native fish of the river have been largely replaced by species such as brown and rainbow trout. The existing ecosystem is productive and provides excellent fish and wildlife habitat as well as excellent recreation opportunities. The proposed alternatives would affect this new ecosystem by altering flow regimes, primarily by reducing winter flows and, to a lesser extent, summer flows.

The following sections describe the current conditions and the expected impacts to the region if the project were undertaken. The impact analysis has been based upon studies completed as part of this report as well as previous studies conducted by Montrose Partners and the Uncompahgre Valley Water Users Association (UVWUA; hereafter both are called the "Sponsors"), Reclamation, or others.

STREAMFLOWS AND FLOODING

Water for the alternatives would be diverted from the Gunnison River, passed through the turbines, and returned to the Gunnison River at Delta via the Uncompahgre River. Under all alternatives, including the no-action alternative, streamflows in these rivers and UVRP canals were determined using a computerized model of the river and canal system. This section describes the existing and postdevelopment streamflows in the Gunnison and Uncompahgre Rivers and assesses the impacts to streamflows.

DERIVATION OF FLOW VALUES

Streamflows in the Gunnison River below the Tunnel have been recorded by the U.S. Geological Survey (USGS) since October 1903 and in the Uncompahgre River at Colona since October 1912. These two gauges indicate the water quantities flowing into the Black Canyon and into the UVRP lands, respectively. Although both gauges have an adequate period of record to estimate the impacts of the proposed development, recent Reclamation impoundments have altered the streamflow regimes so that the value of the recorded data is reduced. These impoundments store runoff that occurs in the late spring and early summer for release later in the year. The effect of this action is to change the slope of the flow duration curve by reducing extremely high and low flows and increasing the intermediate flows.

The study period selected for analyzing the proposed development included calendar years 1952 through 1983. This timeframe includes both high and low flow periods and was used by Reclamation for analyzing the Aspinall Unit unrelated to the proposed AB Lateral hydropower development. This same timeframe was used by other Governmental entities modeling the Gunnison River flow regimes.

To determine the effects of the proposed alternatives on streamflows, it was necessary to develop estimates of the Gunnison River flows that would have occurred had the Aspinall Unit been fully operational during this timeframe. These estimates were prepared by Reclamation using a computer model that mathematically simulates streamflows in the Gunnison River downstream from Crystal Dam but upstream from the Tunnel. The simulation model was based upon inflows to the Aspinall Unit Reservoirs taken from historical gauge data (where available from the USGS), as well as synthesized data based upon accepted hydrologic practices. Simulation results were then compared to the annual volumes recorded by the USGS at the gauge below the Tunnel to ensure that the simulation model yielded reasonable results.

Reclamation's simulation model for the Gunnison River included the current operating rules of the Aspinall Unit. This assumption resulted in eliminating flows less than 300 cubic feet per second (ft^3/s) entering the Black Canyon. Results of the simulation model were then combined with the historical records for Tunnel diversions and canal system diversions to determine the streamflow quantities at various locations within the area affected by the proposed development. A more complete description of this model, together with detailed results of the analyses for the no-action and development alternatives, is presented in the AB Lateral Unit Water Supply Study (HDR, 1989a). A summary of model results is presented in attachment D.

During the past several years, the UVWUA has tended to operate the Tunnel closer to its capacity in the peak irrigation season (primarily July and August) than it did during the 32-year study period. In addition, the capacity of the Tunnel has been expanded from about 1,000 ft^3/s to 1,135 ft^3/s since the late 1970's. As a result, the impact of hydropower operations would be less during the peak irrigation season than would be predicted by simply extending averages from the 32-year study. The effect can be seen by reviewing the extended hydrology tables in attachment B (particularly, 1985-1989). Thus, the FEIS may present greater flow changes in the Gunnison River during the irrigation season than would actually occur.

Since it is not clear that this recent trend in irrigation diversions will become a long-term rule of operations, and no method exists to predict to what degree the UVWUA will use the additional Tunnel capacity, the 32-year study period was not modified to take into account the possible changes. However, if the trends do continue, then hydropower impacts (relative to no-action conditions) during July and August will have been overestimated. By using the more conservative approach, the FEIS analysis approximates a worst case regarding Gunnison flows during the irrigation season.

Streamflow values presented in this report are based upon monthly time increments, which were used to reduce the volume of data required for analysis. Within a given month, the daily flows would fluctuate above and below the average flow for the month depending upon the time of year and power releases from the Aspinall Unit. However, in no instance would the daily flows entering the Black Canyon be reduced to values less than 300 ft^3/s for power production. Irrigation diversions, however, could still bring flows below 300 ft^3/s during dry periods.

EXISTING CONDITIONS

Gunnison River

The Gunnison River, which provides more than two-thirds of the water used for irrigation in the UVRP, originates in Saguache, Hinsdale, and Gunnison Counties to the east of the study area and flows generally north and west, where it joins the Colorado River in Grand Junction. At the Tunnel, the river drains an area of about 3,965 square miles. Flows in the river have been recorded by the USGS downstream from the Tunnel since October 1903. The maximum flow recorded there was 19,000 ft^3/s, which occurred in June 1921. Historically, high flows occurred in June and July and often exceeded 5,000 ft^3/s.

At several times during the period of record, no flow was observed in the river below the Tunnel. The most recent time when no flow occurred was September 1950. Periods of no flow have not occurred since Blue Mesa Reservoir was constructed in 1966. Mean monthly flows recorded by the USGS at the gauge below the Tunnel are presented in attachment B.

The effect of the Aspinall Unit reservoirs on Gunnison River streamflows has been to reduce large peak flows and to reduce occasional low flow periods with significantly increased winter flows. These changes can be seen in the flow duration curve in figure 3.3. Because of these flow changes, the actual USGS records were not used for this study. Instead, simulated flows in the river below Crystal Reservoir that incorporate the regulating effects of the Aspinall Unit were developed by Reclamation (see table 3.1).

Tributaries of the river downstream of Crystal Reservoir include the Smith Fork and North Fork of the Gunnison River, the larger of the two. Flows in the North Fork are gauged by the USGS several miles upstream of its confluence with the Gunnison. Of critical importance to the Gunnison River ecosystem are the flows remaining in the river downstream from the Tunnel. The authorizing documents for the Curecanti Unit (now Aspinall Unit) of the Colorado River Storage Project (CRSP) Act, the first formal flow statement on this reach of the river, provided for a minimum flow of 100 ft^3/s through the Black Canyon.

When Crystal Dam was completed, Reclamation began maintaining minimum flows of at least 200 ft^3/s in the Gunnison River. This figure was apparently based on downstream water rights considerations and not on any detailed biological or environmental considerations. The 200 ft^3/s was also later recommended by the Fish and Wildlife Service (FWS) in its 1978 Planning Aid Memorandum on the Aspinall Unit's fish and wildlife program.

In the early 1980's, the Colorado Division of Wildlife (CDOW) and Reclamation began instream flow studies on the Gunnison River. The result of these studies indicated significant habitat gains at flows between 200 and 300 ft^3/s. As a result, Reclamation began operating the Aspinall Unit with a 300-ft^3/s minimum flow, even though it was recognized that water supplies may not support that minimum in extremely dry years. The Nature Conservancy, the Colorado Water Conservation Board, and others are attempting to arrange a fixed water supply for the 300-ft^3/s minimum flow.

For this study, the minimum flow was always assumed to be 300 ft^3/s for each alternative (no-action and with development). The State of Colorado has not established a minimum flow in the

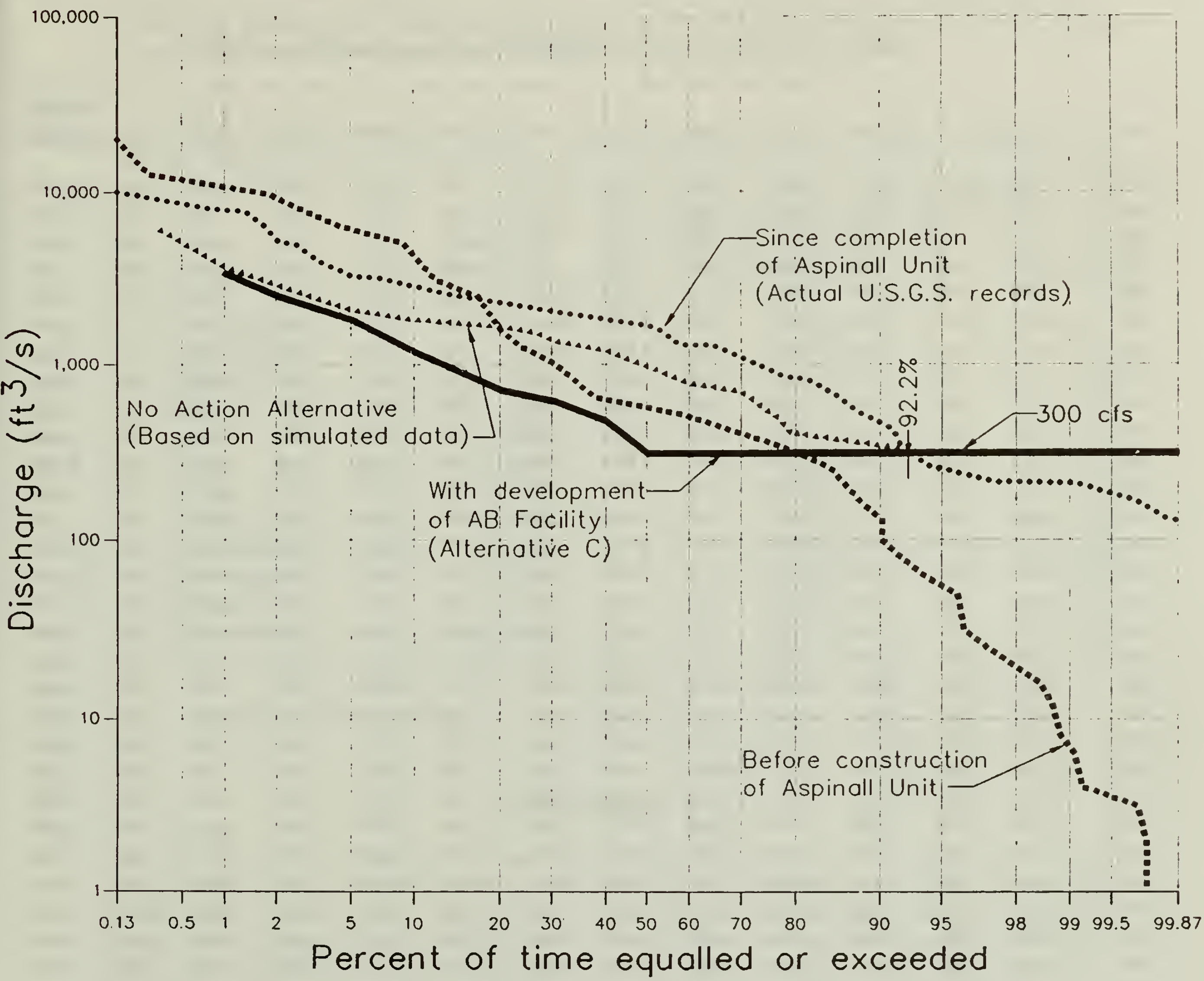

Figure 3.3. Flow duration curve of historic flow data Gunnison River below Gunnison Tunnel for the period 1903 through 1988.

Table 3.1.--Simulated flows in the Gunnison River below Crystal Reservoir (ft^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	1,889	2,066	2,210	2,946	3,078	4,561	3,519	1,780	1,700	1,761	1,746	1,466	2,392
1953	1,235	1,178	1,163	1,050	1,535	1,613	1,378	1,754	1,430	1,653	1,339	1,462	1,401
1954	717	448	339	1,023	1,300	1,300	1,300	1,300	1,157	782	333	300	861
1955	652	353	339	1,023	1,300	1,300	1,300	1,300	1,157	782	333	1,036	910
1956	1,130	1,000	907	1,023	1,474	1,407	1,300	1,726	1,157	1,106	1,283	1,417	1,246
1957	2,076	2,236	2,465	2,975	3,195	4,453	6,815	3,052	1,852	1,784	1,771	1,779	2,877
1958	1,862	1,938	2,040	2,460	3,211	4,225	2,047	1,741	1,208	1,516	1,298	1,501	2,086
1959	996	731	521	1,023	1,300	1,300	1,300	1,732	1,157	782	728	1,497	1,092
1960	1,231	1,162	1,148	1,266	1,623	1,564	1,494	1,723	1,244	1,698	1,291	1,396	1,406
1961	953	664	443	1,023	1,300	1,300	1,300	1,736	1,157	782	724	1,618	1,087
1962	1,797	1,880	2,073	2,709	2,651	2,674	3,265	1,730	1,389	1,622	1,192	1,389	2,033
1963	942	680	484	1,023	1,300	1,300	1,300	1,730	1,157	782	333	778	987
1964	1,094	951	814	1,023	1,734	1,393	1,300	1,767	1,163	1,387	1,333	1,458	1,288
1965	1,875	2,053	2,207	2,608	2,787	3,164	4,394	2,378	1,837	1,795	1,765	1,796	2,391
1966	1,335	1,250	1,218	1,024	1,713	1,327	1,300	1,714	1,157	782	961	1,681	1,291
1967	1,000	838	553	1,023	1,300	1,300	1,300	1,725	1,157	782	333	1,595	1,079
1968	1,293	1,251	1,256	1,127	1,676	1,868	1,730	2,035	1,750	1,754	1,745	1,735	1,604
1969	1,758	1,751	1,119	1,560	1,782	1,574	1,558	1,740	1,550	1,611	1,771	1,785	1,629
1970	1,897	1,991	2,205	2,398	2,915	3,298	3,386	1,771	1,808	1,793	1,775	1,790	2,254
1971	1,872	1,921	2,016	2,190	2,010	2,046	2,462	1,735	1,770	1,767	1,677	1,764	1,936
1972	1,151	1,054	1,028	1,023	1,300	1,300	1,300	1,703	1,157	949	1,769	1,543	1,274
1973	1,766	1,755	1,345	1,663	2,059	2,022	2,342	1,768	1,568	1,325	1,755	1,699	1,756
1974	1,216	1,153	1,181	1,135	1,938	1,424	1,359	1,718	1,157	867	1,409	1,725	1,359
1975	1,756	1,751	1,589	1,765	1,964	2,141	3,072	1,828	1,748	1,220	1,508	1,762	1,843
1976	1,107	982	864	1,023	1,300	1,300	1,300	1,726	1,157	782	947	1,410	1,160
1977	606	306	339	1,023	1,300	1,300	1,300	1,300	1,157	782	333	300	840
1978	1,728	1,749	339	1,023	1,533	1,785	1,754	1,735	1,240	1,225	1,393	1,507	1,415
1979	1,753	1,754	1,849	2,138	2,659	2,715	2,861	1,762	1,317	1,339	1,378	1,649	1,933
1980	1,757	1,822	1,909	2,288	2,512	2,570	3,268	1,735	1,157	1,350	1,629	1,684	1,975
1981	1,639	1,207	1,047	1,248	1,282	1,145	1,277	1,277	1,026	1,009	639	689	1,124
1982	805	1,533	1,501	1,202	1,180	1,410	1,604	1,582	1,542	1,513	1,566	1,689	1,426
1983	1,690	1,652	1,391	1,424	1,892	4,554	4,563	2,918	2,033	1,711	1,387	1,789	2,254
Average	1,393	1,346	1,247	1,545	1,878	2,082	2,180	1,788	1,382	1,275	1,233	1,459	1,569
Maximum	2,076	2,236	2,465	2,975	3,211	4,561	6,815	3,052	2,033	1,795	1,775	1,796	2,877
Minimum	606	306	339	1,023	1,180	1,145	1,277	1,277	1,026	782	333	300	840
Std. dev.	433	551	654	669	646	1,074	1,296	375	287	400	508	406	520

Source: HDR, 1989a

river nor have Federal reserved water rights been quantified. Average monthly flows entering the Black Canyon for the no-action alternative are shown in table 3.2.

Table 3.2.--Average monthly flows (ft^3/s) entering the Black Canyon for alternative A (no-action) condition (1952-1983)

	Average monthly flows (ft^3/s)		
Month	Mean monthly	Maximum monthly	Minimum monthly
January	1,382	2,068	598
February	1,337	2,228	300
March	1,180	2,432	300
April	921	2,574	300
May	1,004	2,594	300
June	1,287	3,935	300
July	1,266	6,265	300
August	844	2,248	300
September	579	1,246	300
October	811	1,523	300
November	1,176	1,761	300
December	1,452	1,788	300

Source: HDR, 1989a.

Uncompahgre River

The Uncompahgre River, a major tributary of the Gunnison River, originates in the San Juan Mountains to the south of the study area and flows in a northerly direction to Delta, where it joins the Gunnison River. At Delta, the total drainage area of the river is slightly more than 1,129 square miles. At the USGS gauge near Colona, a small town on the river about 5 miles upstream from the South Canal confluence, the drainage area is about 443 square miles.

The Uncompahgre River is somewhat regulated by Reclamation at the Ridgway Dam. Simulated monthly flows in the river at Colona with Ridgway Dam in operation were developed by Reclamation and are shown in table 3.3.

Returns from irrigation diversions also contribute to the Uncompahgre River. These flows are not monitored or gauged, and it is difficult to estimate their quantity with any accuracy. For this report, the return flow contribution has been estimated to range between 24 to 35 ft^3/s between the South Canal outfall and Montrose (Hokit, UVWUA 1988, personal communication).

Table 3.3.--Simulated flows in the Uncompahgre River below Colona (ft^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	162	154	127	241	424	846	574	300	245	102	91	81	279
1953	83	73	85	145	267	774	446	205	92	59	87	80	200
1954	73	75	72	96	303	318	330	91	76	75	76	75	139
1955	73	71	80	87	198	571	316	285	49	49	72	78	161
1956	73	71	94	141	389	625	312	143	54	55	74	76	176
1957	78	78	76	89	218	847	1,241	537	290	144	163	151	328
1958	139	144	158	434	947	1,334	537	304	76	59	82	83	358
1959	81	75	76	104	319	654	436	150	59	88	76	75	183
1960	70	71	98	274	381	796	494	241	54	59	76	78	225
1961	80	73	81	119	322	746	459	236	126	143	158	93	220
1962	141	150	162	333	516	462	532	324	76	65	69	67	242
1963	67	71	83	86	330	353	319	197	76	59	76	60	149
1964	68	70	85	114	447	666	519	278	173	68	84	88	223
1965	144	138	156	353	388	542	927	348	278	175	142	145	313
1966	144	132	154	354	403	528	369	185	54	59	66	65	210
1967	67	59	60	89	125	336	369	107	76	59	67	65	124
1968	65	61	75	301	291	564	356	376	240	72	104	80	216
1969	144	145	159	354	385	403	421	206	76	155	164	102	227
1970	141	146	158	327	605	643	532	239	400	210	138	146	308
1971	161	139	154	350	354	566	520	269	220	89	131	75	253
1972	68	76	125	141	283	356	364	146	76	78	97	89	159
1973	160	151	174	368	641	946	745	257	266	140	106	86	337
1974	146	150	195	380	521	452	506	166	84	62	79	75	235
1975	142	78	78	151	335	552	1,395	377	204	59	106	109	301
1976	81	82	89	133	234	476	441	155	72	89	71	81	167
1977	81	76	81	139	182	316	231	81	104	59	74	67	124
1978	72	70	80	129	247	571	555	346	89	65	89	93	201
1979	168	160	216	460	503	600	664	275	248	59	96	130	299
1980	91	85	80	309	397	623	542	194	54	62	79	70	216
1981	67	64	70	136	117	480	527	137	76	59	89	72	158
1982	73	70	86	160	373	545	598	457	334	190	164	138	267
1983	139	140	166	348	565	1,381	1,582	563	262	124	114	109	460
Average	104	100	114	226	375	621	567	255	146	90	99	90	233
Maximum	168	160	216	460	947	1,381	1,582	563	400	210	164	151	460
Minimum	65	59	60	86	117	316	231	81	49	49	66	60	124
Std. dev.	38	37	44	121	166	251	309	119	100	45	31	26	76

Source: Reclamation, 1988

Principal tributaries to the river within the study area include Horsefly Creek from the west and Dry Cedar and Cedar Creeks from the east. As with return flows, flows from these streams have not been gauged or monitored. Flows in these streams are dependent upon snowmelt and storm runoff during the early spring and carry irrigation return flows during the late summer and early fall. Because these streams flow intermittently, it has been assumed for this report that their contributions would not be available to meet irrigation or power demands.

Presently, streamflows in the Uncompahgre River between the terminus of the South Canal and the city of Delta are affected by irrigation diversions, return flows from irrigation systems, and small tributary drainages. Major irrigation diversions downstream from the South Canal include the Montrose and Delta (M&D), the Loutzenhizer, and the Selig Canals. (These systems are all part of the UVRP and are described in more detail in this chapter). Additional UVRP canals located farther downstream include the Ironstone, East and Garnet Canals. Mean monthly flows in the river at five key locations between Colona and the Selig Canal are presented in table 3.4.

Table 3.4.--Average monthly flows (ft^3/s) at various locations along the Uncompahgre River (alternative A)

Month	Average monthly flows (ft^3/s)				
	Below Colona	Below South Canal	Below M & D Canal	Entering City of Montrose	Below Selig Canal
January	104	98	70	58	48
February	100	90	62	50	40
March	114	162	135	123	113
April	226	693	436	392	315
May	375	958	578	491	356
June	621	1,092	627	532	365
July	567	1,152	656	567	419
August	255	871	405	326	212
September	146	700	347	269	184
October	90	421	246	195	149
November	99	139	113	105	95
December	90	80	52	40	30
Average annual	233	540	312	263	195

Source: HDR, 1989a.

Periodic floods along the Uncompahgre River have been a problem and have historically disrupted highway and rail traffic and damaged or destroyed irrigation diversion structures and other improvements. Floods in the Uncompahgre Valley generally result from the mountain snowpack rapidly melting from about the middle of May through early July and from general rainstorms that normally occur from July through October. On the long-term average, rainfall flood events occur less frequently than snowmelt events and do not constitute a serious flood threat.

Snowmelt runoff decreases or lessens along the lower Uncompahgre River due to channel storage and the numerous irrigation diversions (U.S. Department of the Army, COE, 1980). Snowmelt flooding is characterized by moderate peak flows, large volume, long duration, and marked diurnal flow fluctuation. Snowmelt runoff may occasionally be augmented by rain. Rainfall flooding is characterized by high peak flows of moderate volume and duration. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions or the ground is frozen and infiltration is minimal. Convective-type cloudburst storms, sometimes lasting for several hours, can be expected to occur in the area during the summer. Runoff from these storms is characterized by high peak discharge, short duration and small volume (U.S. Department of the Army, COE, 1980).

Within the area immediately affected by the development alternatives are several small tributaries to the Uncompahgre River that experience periodic flooding. Several potential penstock routes would cross Cedar Creek and the Montrose Arroyo, a Cedar Creek tributary. Estimated flood discharges in the river, Cedar Creek, and Montrose Arroyo are presented in table 3.5.

Table 3.5.--Peak discharges for area streams (ft^3/s)

	Peak discharges (ft^3/s)			
Stream	10-yr	50-yr	100-yr	500-yr
Uncompahgre River[1]	3,100	4,400	5,000	6,600
Cedar Creek[2]	500	880	1,250	3,200
Montrose Arroyo[3]	300	800	1,100	2,000

Locations: [1] At proposed development powerhouse site.
[2] Upstream of confluence with Montrose Arroyo.
[3] Upstream of confluence with Cedar Creek.

Sources: Uncompahgre River: Corps of Engineers, 1980.
Cedar Creek and Montrose Arroyo: Hydro-Triad, 1979.

IMPACTS OF ALTERNATIVES

The Sponsors have studied four alternatives for developing the hydropower resources of the UVRP. Alternative A has been defined as the no-action alternative. Alternatives B, C and F would develop a hydropower plant having a design capacity of 1,135 ft^3/s and a minimum flow in the Gunnison River of 300 ft^3/s. Alternative E would develop a hydropower plant having a capacity of 950 ft^3/s. Additionally, alternative C would propose to increase the capacity of the Tunnel to 1,300 ft^3/s, and alternative F would provide increased winter flows in the Gunnison River to alleviate ice formation.

FLOODING

Alternative A (No Action)

If no action is taken, flood peaks along the Gunnison and Uncompahgre Rivers would not change. However, the operation of Ridgway Reservoir would slightly reduce flood peaks of the Uncompahgre River. Historically, the UVWUA has reduced diversions through the Tunnel during Uncompahgre River floods so that less water is passed into the Uncompahgre, an operational rule that would continue if no action is taken.

Development Alternatives (B, C, E, and F)

For each of the development alternatives, flooding conditions on the Gunnison River would not change significantly. As long as concurrent flooding on the Gunnison and Uncompahgre Rivers does not occur, some additional flows would be diverted through the Tunnel for power production in addition to irrigation. The quantity of additional flows is not large enough to appreciably reduce downstream flood peaks or water surface elevations on the Gunnison.

If concurrent flooding occurs, the additional flows would not be diverted, and the quantities of water diverted for irrigation and power would be reduced to avoid aggravating flood stages on the Uncompahgre. This reduction would result in the flow continuing through the Gunnison Gorge and into downstream reaches. The amount of flow would not produce appreciable increases in either flood peaks or water surface elevations.

If any of the development alternatives are implemented, each would be operated similarly to the historic operation of the UVRP. River flows at Colona, the Selig and Garnet Canals, and Delta would be monitored by the UVWUA. When river flows exceed the mean annual flood (1,900 ft^3/s), Gunnison River diversions for power in excess of irrigation demands would be reduced until the

1,900-ft³/s criterion is met. If necessary, irrigation diversions would also be reduced. The net result would be that operating the development alternatives would not add to flooding problems on the Uncompahgre River.

In case of a penstock rupture, local flooding would occur but would be quickly controlled by monitoring equipment that would shut down the water supply to the penstock. The entire penstock would contain about 90 acre-feet of water. During the few minutes needed to automatically close the penstock valve at the intake structure, about 10 more acre-feet of water would enter the system. Damage would occur primarily to property adjacent to a penstock rupture; water from a rupture would drain down ditches, washes and drains and ultimately enter Cedar Creek or the Loutzenhizer Canal or Arroyo.

GUNNISON RIVER STREAMFLOWS

Alternative A (No Action)

If no action were taken, streamflows in the Gunnison River would remain similar to present conditions. Potential developments are being considered for the Gunnison River, but none of these presently is permitted or under construction. Model results for mean monthly flows entering the Black Canyon during the 32-year study period are presented in table 3.6.

Table 3.6.--Average monthly flows in the Gunnison River entering the Black Canyon for each alternative (ft³/s)

	Average monthly flows (ft³/s)				
Month	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	1,382	475	471	561	511
February	1,337	499	495	582	534
March	1,180	500	497	568	500
April	921	628	577	642	628
May	1,004	794	694	794	794
June	1,287	1,001	915	1,001	1,001
July	1,266	1,104	1,021	1,104	1,104
August	844	671	527	671	671
September	579	405	353	405	405
October	811	404	348	414	404
November	1,176	406	403	497	406
December	1,452	455	450	601	455
Average	1,103	613	563	654	619
Annual volume (acre-ft)	798,214	443,612	407,729	472,054	447,786
Percent reduction		44.4	49.0	40.7	44.0

Source: HDR, 1989a.

Development Alternatives

In terms of Gunnison River streamflows, the primary long-term impact of all development alternatives would be to reduce the amount of water flowing downstream of the Tunnel. Average monthly flows below the Tunnel for the various development alternatives are summarized in table 3.6, and model results are presented in tables 3.7 through 3.11. As can be seen from this information, the major changes occur during the nonirrigation season because, under existing conditions, Tunnel capacity is being used to divert irrigation water, and little Tunnel capacity remains for additional hydropower diversions.

If recent irrigation trends continue, the actual effects of hydropower operations on July and August flows would be less than are predicted in the tables. The capacity of the Tunnel is greater now than it was in most of the 1952 to 1983 study period, and, therefore, diversions under alternative A may be conservative.

None of the development alternatives would change the operations of the Aspinall Unit; water elevations of Blue Mesa Reservoir and releases from the reservoir would not be affected. Water would not be released from the Aspinall Unit specifically for the hydropower development. Operation of the AB Lateral Facility would not interfere or affect any future operational changes (reoperation) in the upstream Aspinall Unit. Future changes in the operation of the Aspinall Unit may occur in response to environmental, water supply, endangered species, or Reclamation's hydropower needs; these changes would affect downstream flows. If any reoperation resulted in increased summer or irrigation season releases from the Aspinall Unit, these releases would generally be reflected in increased flows downstream from the Tunnel whether or not the AB Lateral Facility was in operation because the Tunnel would already be operating at or near capacity. If any reoperation resulted in increased winter releases from the Aspinall Unit, the releases would most likely be diverted through the Gunnison Tunnel after senior downstream water rights in the Gunnison River have been satisfied. Because the proposed development would not increase the consumptive use of water within the Uncompahgre Valley, this water would be ultimately returned to the Gunnison River at Delta via the Uncompahgre River. Hence, the increased diversions would not result in any net depletion of water from the Colorado River system.

Under all development alternatives, the amount of water diverted from the Gunnison River would be increased, reducing the quantity of flow entering the Black Canyon. During the winter, the volume diverted would increase dramatically, whereas during the summer, the incremental flow diverted for power production would be relatively small. Table 3.12 compares the flow diverted at the

Table 3.7
Flows entering the Black Canyon (ft^3/s).
(Alternative A -- no-action conditions)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	1,881	2,058	2,184	2,574	2,225	3,876	2,489	763	788	1,032	1,427	1,458	1,892
1953	1,227	1,170	1,045	480	614	721	372	755	455	1,093	1,204	1,454	882
1954	709	440	300	300	336	342	342	364	514	398	300	300	387
1955	644	345	305	537	380	430	338	356	302	318	300	1,028	442
1956	1,122	992	860	388	540	559	481	891	300	600	1,262	1,409	784
1957	2,068	2,228	2,432	2,494	2,555	3,935	6,265	2,248	1,162	1,309	1,695	1,771	2,518
1958	1,854	1,930	2,032	1,997	2,594	3,631	1,077	847	354	979	1,144	1,493	1,657
1959	988	723	407	300	349	392	346	793	332	510	644	1,489	607
1960	1,223	1,154	1,140	958	698	799	537	782	362	1,165	1,201	1,388	950
1961	945	656	416	571	437	410	349	799	473	682	716	1,610	674
1962	1,789	1,872	2,033	2,058	1,695	1,759	2,329	761	553	1,280	1,070	1,381	1,548
1963	934	672	476	300	339	339	337	791	493	300	300	770	504
1964	1,086	943	760	424	884	527	330	817	375	822	1,150	1,450	798
1965	1,867	2,045	2,199	2,195	1,945	2,495	3,709	1,486	1,246	1,523	1,733	1,788	2,020
1966	1,327	1,242	1,127	300	739	389	355	750	300	436	953	1,673	799
1967	992	830	436	300	371	469	346	791	305	300	325	1,587	588
1968	1,285	1,243	1,113	311	726	1,274	773	1,254	830	1,228	1,737	1,727	1,125
1969	1,750	1,743	1,042	809	817	688	611	777	809	1,343	1,759	1,777	1,157
1970	1,889	1,983	2,187	1,713	2,124	2,475	2,428	820	1,067	1,423	1,705	1,782	1,799
1971	1,864	1,913	1,966	1,364	1,047	1,225	1,545	779	976	1,321	1,669	1,756	1,450
1972	1,143	1,046	804	300	335	358	332	744	333	531	1,761	1,535	767
1973	1,758	1,747	1,331	1,159	1,474	1,517	1,550	779	655	773	1,747	1,691	1,346
1974	1,208	1,145	1,173	592	1,023	478	376	740	300	300	1,401	1,717	871
1975	1,748	1,743	1,564	1,103	1,046	1,602	2,331	853	838	550	1,469	1,754	1,382
1976	1,099	974	771	300	322	320	310	731	300	300	939	1,402	647
1977	598	300	300	300	303	314	309	373	656	379	315	300	371
1978	1,720	1,741	300	300	733	1,103	816	717	385	698	1,306	1,499	938
1979	1,745	1,746	1,834	1,819	1,967	2,191	1,957	744	403	725	1,270	1,641	1,502
1980	1,749	1,814	1,870	1,589	1,628	1,629	2,227	681	300	890	1,621	1,676	1,472
1981	1,631	1,199	700	323	300	300	300	300	336	450	585	681	589
1982	687	1,514	1,403	488	452	727	689	666	898	1,189	1,558	1,681	993
1983	1,682	1,644	1,265	834	1,115	3,915	3,942	2,064	1,131	1,098	1,379	1,781	1,822
Average	1,382	1,337	1,180	921	1,004	1,287	1,266	844	579	811	1,176	1,452	1,103
Maximum	2,068	2,228	2,432	2,574	2,594	3,935	6,265	2,248	1,246	1,523	1,761	1,788	2,518
Minimum	598	300	300	300	300	300	300	300	300	300	300	300	371
Std.dev.	438	551	672	740	718	1,172	1,382	410	300	394	501	405	542

Source: HDR, 1989a.

Table 3.8

Flows entering the Black Canyon (ft^3/s).

(Alternative B -- 1,135-ft^3/s turbine capacity, no Tunnel modifications)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	754	931	1,075	1,811	1,943	3,426	2,384	645	565	626	611	331	1,257
1953	300	300	300	300	400	478	300	619	300	518	300	327	371
1954	300	300	300	300	300	300	300	300	300	300	300	300	305
1955	300	345	305	300	300	300	300	300	300	300	300	300	308
1956	300	300	300	300	339	300	300	591	300	300	300	300	328
1957	941	1,101	1,330	1,840	2,060	3,318	5,680	1,917	717	649	636	644	1,742
1958	727	803	905	1,325	2,076	3,090	912	606	300	381	300	366	981
1959	300	300	300	300	300	300	300	597	300	300	300	362	330
1960	300	300	300	300	488	429	359	588	300	563	300	300	378
1961	300	300	300	300	300	300	300	601	300	300	300	483	341
1962	662	745	938	1,574	1,516	1,539	2,130	595	300	487	300	300	925
1963	300	300	300	300	300	300	300	595	300	300	325	300	327
1964	300	300	300	300	599	300	300	632	300	300	300	323	356
1965	740	918	1,072	1,473	1,652	2,029	3,259	1,243	702	660	630	661	1,256
1966	300	300	300	300	578	300	300	579	300	300	300	546	368
1967	300	300	300	300	300	300	300	590	300	300	325	460	340
1968	300	300	300	300	541	733	595	900	615	619	610	600	536
1969	623	616	300	425	647	439	423	605	415	476	636	650	521
1970	762	856	1,070	1,263	1,780	2,163	2,251	636	673	658	640	655	1,119
1971	737	786	881	1,055	875	911	1,327	600	635	632	542	629	801
1972	300	300	300	300	300	300	300	568	300	300	634	408	359
1973	631	620	300	528	924	887	1,207	633	433	300	620	564	638
1974	300	300	300	300	803	300	300	583	300	300	300	590	391
1975	621	616	454	630	829	1,006	1,937	693	613	300	373	627	727
1976	300	300	300	300	300	300	300	591	300	300	300	300	325
1977	300	300	300	300	300	300	300	300	300	300	325	300	305
1978	593	614	300	300	398	650	619	600	300	300	300	372	447
1979	618	619	714	1,003	1,524	1,580	1,726	627	300	300	300	514	821
1980	622	687	774	1,153	1,377	1,435	2,133	600	300	300	494	549	870
1981	504	300	300	300	300	300	300	300	300	300	300	300	317
1982	300	398	366	300	300	300	469	447	407	378	431	554	388
1983	555	517	300	300	757	3,419	3,428	1,783	898	576	300	654	1,128
Average	475	499	500	628	794	1,001	1,104	671	405	404	406	455	613
Maximum	941	1,101	1,330	1,840	2,076	3,426	5,680	1,917	898	660	640	661	1,742
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	305
Std.dev.	202	245	317	513	600	1,035	1,255	354	170	142	142	142	373

Source: HDR, 1989a.

Table 3.9
Flows entering the Black Canyon (ft^3/s).
(Alternative C -- 1,135-ft^3/s turbine capacity and 1,300-ft^3/s Tunnel capacity)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	746	923	1,067	1,710	1,778	3,261	2,219	480	400	461	603	323	1,163
1953	300	300	300	300	300	313	300	454	300	353	300	319	320
1954	300	300	300	300	300	300	300	300	300	300	300	300	305
1955	300	345	305	300	300	300	300	300	300	300	300	300	308
1956	300	300	300	300	300	300	300	426	300	300	300	300	311
1957	933	1,093	1,322	1,675	1,895	3,153	5,515	1,752	552	500	628	636	1,644
1958	719	795	897	1,197	1,911	2,925	747	441	300	300	300	358	905
1959	300	300	300	300	300	300	300	432	300	300	300	354	316
1960	300	300	300	300	323	300	300	423	300	398	300	300	321
1961	300	300	300	300	300	300	300	436	300	300	300	475	326
1962	654	737	930	1,409	1,351	1,374	1,965	430	300	322	300	300	840
1963	300	300	300	300	300	300	300	430	300	300	325	300	313
1964	300	300	300	300	434	300	300	467	300	300	300	315	327
1965	732	910	1,064	1,377	1,487	1,864	3,094	1,078	537	552	622	653	1,167
1966	300	300	300	300	413	300	300	414	300	300	300	538	339
1967	300	300	300	300	300	300	300	425	300	300	325	452	326
1968	300	300	300	300	376	568	430	735	450	454	602	592	451
1969	615	608	300	300	482	300	300	440	300	377	628	642	440
1970	754	848	1,062	1,127	1,615	1,998	2,086	471	508	552	632	647	1,026
1971	729	778	873	890	710	746	1,162	435	470	467	534	621	701
1972	300	300	300	300	300	300	300	403	300	300	626	400	344
1973	623	612	300	417	759	722	1,042	468	300	300	612	556	559
1974	300	300	300	300	638	300	300	418	300	300	300	582	363
1975	613	608	446	465	664	841	1,772	528	448	300	365	619	641
1976	300	300	300	300	300	300	300	426	300	300	300	300	311
1977	300	300	300	300	300	300	300	300	300	300	325	300	305
1978	585	606	300	300	300	485	454	435	300	300	300	364	395
1979	610	611	706	891	1,359	1,415	1,561	462	300	300	300	506	753
1980	614	679	766	1,006	1,212	1,270	1,968	435	300	300	486	541	799
1981	496	300	300	300	300	300	300	300	300	300	300	300	317
1982	300	390	358	300	300	300	304	300	300	300	423	546	343
1983	547	509	300	300	592	3,254	3,263	1,618	733	411	300	646	1,043
Average	471	495	497	577	694	915	1,021	527	353	348	403	450	563
Maximum	933	1,093	1,322	1,710	1,911	3,261	5,515	1,752	733	552	632	653	1,644
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	305
Std.dev.	198	241	313	459	549	981	1,203	335	105	81	138	140	345

Source: HDR, 1989a.

Table 3.10
Flows entering the Black Canyon (ft^3/s).
(Alternative E -- 950-ft^3/s turbine capacity, no Tunnel modifications)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	931	1,108	1,252	1,895	1,943	3,426	2,384	645	565	626	788	508	1,338
1953	300	300	300	300	400	478	300	619	300	518	381	504	393
1954	300	300	300	300	300	300	300	300	300	300	300	300	305
1955	300	345	300	300	300	300	300	300	300	300	300	300	308
1956	300	300	300	300	339	300	300	591	300	300	325	459	344
1957	1,118	1,278	1,507	1,840	2,060	3,318	5,680	1,917	717	685	813	821	1,819
1958	904	980	1,082	1,382	2,076	3,090	912	606	300	381	340	543	1,048
1959	300	300	300	300	300	300	300	597	300	300	300	539	346
1960	300	300	300	300	488	429	359	588	300	563	333	438	393
1961	300	300	300	300	300	300	300	601	300	300	300	660	356
1962	839	922	1,115	1,574	1,516	1,539	2,130	595	300	487	300	431	980
1963	300	300	300	300	300	300	300	595	300	300	300	300	327
1964	300	300	300	300	599	300	300	632	300	300	375	500	377
1965	917	1,095	1,249	1,562	1,652	2,029	3,259	1,243	702	737	807	838	1,344
1966	377	300	300	300	578	300	300	579	300	300	300	723	390
1967	300	300	300	300	300	300	300	590	300	300	325	637	355
1968	335	300	300	300	541	733	595	900	615	619	787	777	569
1969	800	793	300	425	647	439	423	605	415	562	813	827	586
1970	939	1,033	1,247	1,312	1,780	2,163	2,251	636	673	737	817	832	1,203
1971	914	963	1,058	1,055	875	911	1,327	600	635	632	719	806	874
1972	300	300	300	300	300	300	300	568	300	300	811	585	389
1973	808	797	387	602	924	887	1,207	633	433	300	797	741	709
1974	300	300	300	300	803	300	300	583	300	300	451	767	419
1975	798	793	631	630	829	1,006	1,937	693	613	300	550	804	800
1976	300	300	300	300	300	300	300	591	300	300	300	452	338
1977	300	300	300	300	300	300	300	300	300	300	315	300	305
1978	770	791	300	300	398	650	619	600	300	300	435	549	502
1979	795	796	891	1,076	1,524	1,580	1,726	627	300	300	420	691	895
1980	799	864	951	1,191	1,377	1,435	2,133	600	300	300	671	726	947
1981	681	300	300	300	300	300	300	300	300	300	300	300	332
1982	300	575	543	300	300	300	469	447	407	422	608	731	450
1983	732	694	433	300	757	3,419	3,428	1,783	898	576	429	831	1,193
Average	561	582	568	642	794	1,001	1,104	671	405	414	497	601	654
Maximum	1,118	1,278	1,507	1,895	2,076	3,426	5,680	1,917	898	737	817	838	1,819
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	305
Std.dev.	285	326	389	532	600	1,035	1,255	354	170	156	209	186	398

Source: HDR, 1989a.

Table 3.11
Flows entering the Black Canyon (ft^3/s).
(Alternative F -- 1,135-ft^3/s turbine capacity, no Tunnel modifications, with de-icing flows)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
1952	754	931	1,075	1,811	1,943	3,426	2,384	645	565	626	611	331	1,257
1953	368	375	300	300	400	478	300	619	300	518	300	327	383
1954	368	375	300	300	300	300	300	300	300	300	300	300	316
1955	368	345	305	300	300	300	300	300	300	300	300	300	314
1956	368	375	300	300	339	300	300	591	300	300	300	300	340
1957	941	1,101	1,330	1,840	2,060	3,318	5,680	1,917	717	649	636	644	1,742
1958	727	803	905	1,325	2,076	3,090	912	606	300	381	300	366	981
1959	368	375	300	300	300	300	300	597	300	300	300	362	342
1960	368	375	300	300	488	429	359	588	300	563	300	300	390
1961	368	375	300	300	300	300	300	601	300	300	300	483	353
1962	662	745	938	1,574	1,516	1,539	2,130	595	300	487	300	300	925
1963	368	375	300	300	300	300	300	595	300	300	300	300	339
1964	368	375	300	300	599	300	300	632	300	300	300	323	367
1965	740	918	1,072	1,473	1,652	2,029	3,259	1,243	702	660	630	661	1,256
1966	368	375	300	300	578	300	300	579	300	300	300	546	380
1967	368	375	300	300	300	300	300	590	300	300	325	460	352
1968	368	375	300	300	541	733	595	900	615	619	610	600	548
1969	623	616	300	425	647	439	423	605	415	476	636	650	521
1970	762	856	1,070	1,263	1,780	2,163	2,251	636	673	658	640	655	1,119
1971	737	786	881	1,055	875	911	1,327	600	635	632	542	629	801
1972	368	375	300	300	300	300	300	568	300	300	634	408	371
1973	631	620	300	528	924	887	1,207	633	433	300	620	564	638
1974	368	375	300	300	803	300	300	583	300	300	300	590	403
1975	621	616	454	630	829	1,006	1,937	693	613	300	373	627	727
1976	368	375	300	300	300	300	300	591	300	300	300	300	336
1977	368	300	300	300	300	300	300	300	300	300	325	300	310
1978	593	614	300	300	398	650	619	600	300	300	300	372	447
1979	618	619	714	1,003	1,524	1,580	1,726	627	300	300	300	514	821
1980	622	687	774	1,153	1,377	1,435	2,133	600	300	300	494	549	870
1981	504	375	300	300	300	300	300	300	300	300	300	300	323
1982	368	398	366	300	300	300	469	447	407	378	431	554	393
1983	555	517	300	300	757	3,419	3,428	1,783	898	576	300	654	1,128
Average	511	534	500	628	794	1,001	1,104	671	405	404	406	455	619
Maximum	941	1,101	1,330	1,840	2,076	3,426	5,680	1,917	898	660	640	661	1,742
Minimum	368	300	300	300	300	300	300	300	300	300	300	300	310
Std.dev.	170	217	317	513	600	1,035	1,255	354	170	142	142	142	369

Source: HDR, 1989a.

Table 3.12.--Comparison of average monthly Tunnel diversions for alternatives (ft^3/s)

Month	Average monthly tunnel diversion for all alternatives (ft^3/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	11	918	922	832	882
February	8	847	850	764	811
March	66	747	750	679	747
April	624	918	968	903	918
May	875	1,084	1,185	1,084	1,084
June	795	1,081	1,167	1,081	1,081
July	914	1,075	1,158	1,075	1,075
August	944	1,117	1,261	1,117	1,117
September	803	976	1,029	976	976
October	464	871	926	861	871
November	56	827	830	736	827
December	8	1,004	1,010	858	1,004
Average annual	467	956	1,007	915	951

Use	Annual volumes (acre-feet) diverted for alternatives				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
Irrigation	336,411	336,411	336,411	336,411	336,411
Power	0	354,602	390,485	324,679	350,429

Source: HDR, 1989a.

Tunnel for each development alternative to the no-action alternative; the mean monthly flows shown for alternative A represent the volumes diverted to meet the irrigation demands in the UVRP. The difference between these flows and those shown for the remaining alternatives represent the additional water diverted for hydropower generation.

In response to comments from the NPS and BLM, Reclamation requested that the Sponsors expand a portion of the hydrologic model to incorporate data from 1984 through 1988; this expansion modeled only the flows entering the canyon. Expanded versions of tables 3.6 through 3.11 are presented in table B.3 in attachment B.

UNCOMPAHGRE RIVER STREAMFLOWS

Alternative A (No Action).--Mean monthly flows along the Uncompahgre River would be similar to those presented in table 3.4. River flows would not be altered, and irrigation diversions would not be significantly increased or decreased.

Winter diversions for livestock watering would be reduced when Reclamation's Lower Gunnison Basin Unit Winter Water Replacement Program (part of the Colorado River Water Quality Improvement Program) is implemented. This reduction of diversions would also occur under development alternatives.

Development Alternatives

On the Uncompahgre River, none of the proposed development alternatives would affect streamflows above the South Canal terminus. However, between that location and the Selig Canal, the amount of water flowing in the river would be reduced. Historically, the irrigation demands for the Selig, Ironstone, East and Garnet canals flowed into the Uncompahgre River and through Montrose via the South Canal. Because each of the development alternatives would divert water for canal demands through the turbines, this reach of the Uncompahgre River would be bypassed.

Mean monthly river flows for each development alternative are compared to the no-action alternative at three locations along this reach in tables 3.13 through 3.15. The flow data shown in these tables include estimated flows entering the river from small tributaries, such as Dry Cedar and Horsefly creeks, or other springs near the river. During the summer and fall, these sources carry return flows from irrigation systems that have not been historically monitored. For this FEIS, these flows were modeled at 24 ft^3/s at the beginning of the irrigation season, increasing to a maximum value of 35 ft^3/s during July and August, and decreasing to 0 ft^3/s in December through March. Considering the diversions that occur upstream of Montrose and the historic ratio of consumptive use to total diversions (estimated at 35 percent in the Upper Gunnison-Uncompahgre Basin Study), these values are conservative and would result in worst-case predictions.

Another factor affecting Uncompahgre River flows between the South Canal terminus and Montrose is the diversions made for winter stock water, which have been made historically but which would be discontinued in the future as part of the Colorado River Water Quality Improvement Program. Eliminating these diversions would add another 50 ft^3/s to the river in this reach during November through March under all alternatives.

Between the Selig Canal and Delta, streamflows in the Uncompahgre River would be increased as a result of any of the development alternatives; the amount of increase would vary according to the alternative. Alternative E would result in the least amount of increased flows, and alternative C would result in the greatest increase. Mean monthly flows for each alternative are compared to the no-action alternative in table 3.16.

Table 3.13.--Comparison of average monthly flows in the Uncompahgre River below the South Canal for each alternative (ft^3/s)

Month	Average monthly flows (ft^3/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	94	94	94	94	94
February	90	90	90	90	90
March	162	104	104	104	104
April	693	368	368	368	368
May	958	581	581	581	581
June	1,092	695	695	695	695
July	1,152	698	698	698	698
August	871	581	581	589	589
September	700	455	455	463	463
October	421	249	249	249	249
November	139	91	91	91	91
December	80	80	80	80	80
Average annual	540	342	342	343	343

Source: HDR, 1989a.

Table 3.14.--Comparison of average monthly flows in the Uncompahgre River below the M&D Canal for each alternative (ft^3/s)

Month	Average monthly flows (ft^3/s)				
	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	66	66	66	66	66
February	62	62	62	62	62
March	135	76	76	76	76
April	436	111	111	111	111
May	578	201	201	201	201
June	627	231	231	231	231
July	656	202	202	202	202
August	405	114	114	122	122
September	347	103	103	111	111
October	246	75	75	75	75
November	113	65	65	65	65
December	52	52	52	52	52
Average annual	312	113	113	115	115

Source: HDR, 1989a.

Table 3.15.--Comparison of average monthly flows in the Uncompahgre River entering Montrose for each alternative (ft^3/s)

	Average monthly flows (ft^3/s)				
Month	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	54	54	54	54	54
February	50	50	50	50	50
March	123	64	64	64	64
April	392	68	68	68	68
May	491	114	114	114	114
June	532	135	135	135	135
July	567	113	113	113	113
August	326	35	35	43	43
September	269	25	25	33	33
October	195	24	24	24	24
November	105	57	57	57	57
December	40	40	40	40	40
Average annual	263	65	65	67	67

Source: HDR, 1989a.

Table 3.16.--Comparison of average monthly flows in the Uncompahgre River below the Selig Canal for each alternative (ft^3/s)

	Average monthly flows (ft^3/s)				
Month	Alt. A	Alt. B	Alt. C	Alt. E	Alt. F
January	44	955	959	868	919
February	40	879	882	796	843
March	113	793	796	725	793
April	315	609	660	595	609
May	356	566	666	566	566
June	365	651	737	651	651
July	419	581	664	581	581
August	212	385	529	385	385
September	184	358	410	358	358
October	149	556	612	546	556
November	95	866	869	775	866
December	30	1,026	1,032	881	1,026
Average annual	195	684	735	643	679

Source: HDR, 1989a.

The decreased flows in the Gunnison River, coupled with increased flows in the Uncompahgre resulting from implementing any of the alternatives, would affect several components of the regional ecosystem. These components include water quality, fisheries, vegetation, wildlife, and the recreational use of both streams. Consequences of implementing any of the proposed development alternatives are described in the following sections of this chapter.

IRRIGATION SYSTEMS

The UVRP, one of the oldest irrigation projects in the United States, was one of the first projects built under the authority of the Reclamation Act of 1902. More than 80,000 acres of irrigated land are included within its boundaries (see figure 1.1). Water supplies are diverted from the Gunnison and Uncompahgre Rivers at seven diversion dams and conveyed to irrigated fields through several hundred miles of canals, laterals and drains. Waters diverted but not consumed are returned to the Uncompahgre and Gunnison Rivers. The UVRP is operated and administered by the UVWUA; project features are owned by Reclamation. This section describes the major canals of the UVRP that would be affected by the proposed alternatives.

EXISTING CONDITIONS

South Canal

The South Canal, the principal conveyance for transporting flows from the Gunnison River into the Uncompahgre River, begins at the West Portal of the Tunnel and runs southwesterly about 11.4 miles to the Uncompahgre River. The canal has a maximum carrying capacity of about 1,010 ft^3/s at the upper end; however, the capacity is reduced to slightly more than 800 ft^3/s near the river.

Flows in the canal are monitored by the UVWUA at a gauging station located about one mile downstream of the West Portal. Two major diversions are made from the South Canal upstream of the gauging station. Flows are diverted into the existing AB Lateral about one-quarter mile downstream from the Tunnel portal. This lateral is a small, unlined channel that flows in a northerly direction about 5 miles, where it discharges into the Loutzenhizer Wash. The lateral provides irrigation water to about 4,000 acres along the east edge of the UVRP.

Additional flows are diverted from the AB Lateral into Cedar Creek, a small tributary of the Uncompahgre River. The purpose of this diversion is to convey additional flows into the Uncompahgre River to meet irrigation demands downstream of the

Selig Canal as well as the demands from irrigators diverting from Cedar Creek itself. For this study, it was estimated that an average of 5 ft^3/s of the flows diverted into Cedar Creek are needed to meet existing water rights along that stream.

Historically, the average annual demands (see table 3.17) placed by the UVRP canal systems have been met through a combination of sources, including Gunnison River diversions, natural flows of the Uncompahgre River, and return flows from irrigation. Because of capacity restrictions in the South Canal, these demands have not always been fulfilled. The Cedar Creek diversion was started to provide capacity for additional flows but has not always been able to provide enough water, even when combined with South Canal flows. When shortages have occurred, diversions into the M&D, Loutzenhizer, and Selig Canals have been proportionately reduced to deliver flows to the Ironstone, East and Garnet systems.

Flows are carried from the South Canal into the West Canal and are described in subsequent sections. Other diversions are made into smaller laterals (designated as the AC, AG, AH and AM) that irrigate about 3,000 acres near the canal. These diversions are recorded, although long-term records are not available. Estimates of flow diverted into these laterals were made using 6 years of ditchrider records provided by the UVWUA.

Added to these flows are estimates of losses due to seepage and evaporation from the South Canal (assumed to be equal to the lateral demands) and estimates of diversions made for the Project 7 Water Treatment facility. For the latter quantity, an average diversion of 5,757 acre-feet per year was assumed for this study. Table 3.18 summarizes the diversions made from the South Canal.

West Canal

The West Canal, built in 1912 as part of the UVRP, is supplied by the South Canal and conveys irrigation flows to about 5,700 acres on the west side of the Uncompahgre River. The canal is about 21 miles long and is generally unlined, although small portions of its length are lined with a trapezoidal concrete section. Flows are recorded by the UVWUA. Maximum mean monthly diversions range from 170 to 180 ft^3/s; mean monthly diversions are shown in table 3.17.

The canal is also used to supply winter stock water to UVWUA members. These supplies are generally provided directly from the Uncompahgre River, rather than the South Canal, using a temporary diversion dam upstream of the South Canal. The UVWUA does not record quantities diverted for this use. For this study, it was estimated that a monthly average of 10 ft^3/s was representative (Jim Hokit, UVWUA, 1988; personal communication).

Table 3.17.--Mean monthly diversions into UVRP Canals (ft^3/s)

Existing Month[1]	Average monthly diversions (ft^3/s) AB Lateral	Cedar Creek	West Canal	M&D Canal	Loutz. Canal	Selig Canal
January	0	0	10	28	12	10
February	0	0	10	28	12	10
March	0	0	10	28	12	10
April	23	13	84	266	58	90
May	46	31	129	427	102	166
June	51	28	134	459	115	192
July	52	33	131	459	114	178
August	51	36	128	429	104	147
September	46	27	118	337	93	109
October	29	14	86	179	63	60
November	0	0	10	28	12	10
December	0	0	10	28	12	10
Average	25	15	72	226	59	83
Annual volume (acre-ft)	18,112	11,077	52,172	163,326	42,925	60,081

[1] Values for April through October are based on UVWUA historical records.

Source: HDR, 1989a.

Table 3.18.--South Canal lateral diversions (ft^3/s)

(ft^3/s) Year September		Diversions (ft^3/s) April	May	June	July	August
1976	10	21	36	42	48	19
1980	5	33	36	39	39	21
1983	12	31	45	43	42	23
1985	5	34	37	39	38	21
1986	5	32	35	38	36	19
1987	6	33	38	37	33	16
Average	7	31	38	40	40	20

Note: Values do not include flows diverted into AB Lateral or Cedar Creek for irrigation.

Source: HDR, 1989a.

Montrose and Delta Canal

The Montrose and Delta (M&D) Canal was privately built but acquired as part of the UVRP in 1908. The canal is about 40 miles long and diverts flows from the Uncompahgre River to more than 25,200 acres along the west side of the valley. The entire canal, 26 feet wide by 5 feet deep, is unlined.

Maximum flows into the system generally range between 550 and 560 ft^3/s, with the majority of diversions occurring in the irrigation season. Approximately 60 percent of these diversions is flow diverted from the Gunnison River via the South Canal and 40 percent Uncompahgre River water. However, only Uncompahgre River flows are diverted into the system during the winter. Generally, these flows are not recorded but have been estimated by the UVWUA's General Manager to range between 25 and 35 ft^3/s. An average winter flow diversion of 28 ft^3/s was used for this FEIS (see table 3.17).

Loutzenhizer Canal

The Loutzenhizer Canal diverts water out of the Uncompahgre River at headgates about two miles downstream from the M&D headgates. The canal, nearly 15 miles long and privately built before the turn of the 20th Century, was acquired by Reclamation for the UVRP in 1908.

The canal, which serves about 6,200 acres on the east side of the valley near Montrose, is unlined and has a maximum bottom width of about 16 feet. As with the M&D, the majority of diversions occur during the irrigation season, using waters provided from the Uncompahgre and Gunnison Rivers. Winter diversions normally range from 10 to 15 ft^3/s, with flows provided solely by the Uncompahgre River. For this FEIS, the winter stockwater diversions were estimated to be 12 ft^3/s. Mean monthly diversions for the canal are shown in table 3.17.

Selig Canal

The Selig Canal irrigates nearly 10,000 acres on the east side of the valley north of Montrose. The canal diverts water from the Uncompahgre at headgates just north of Montrose and runs about 20 miles to the north toward Olathe and Delta. The canal was privately constructed but acquired by Reclamation in 1914. The canal is unlined; although it has a maximum diversion capacity of 320 ft^3/s, its maximum historic diversions have ranged from 190 to 200 ft^3/s. Winter diversions vary between 10 and 15 ft^3/s; for this FEIS, winter diversions were estimated to be 10 ft^3/s.

Other Canal Systems

The UVWUA also operates three other canal systems in the valley that divert flow from the Uncompahgre River downstream from the Selig Canal headgates. These systems are the Ironstone Canal, which irrigates more than 22,500 acres; the East Canal (7,660 acres); and the Garnet Canal (1,600 acres). The maximum diversion capacities at the headgates of these canal systems are 400, 165, and 75 ft^3/s, respectively (USDI, Reclamation, 1984).

In addition to the UVRP canals, several diversions occur upstream of and within the study area. Between the town of Colona and the South Canal, irrigation diversions are made at the Ouray and Reservation Ditches. Between the South Canal and Selig Canal, irrigation diversions are made into the Stark Volkmann, Woodgate-Calloway, Val Verde, and Rice Ditches. Table 3.19 lists the assumed amount of diversions occurring throughout the irrigation season.

Table 3.19.--Assumed diversion patterns of non-UVRP demands between Colona and Selig Canal (ft^3/s)

	Diversion patterns (ft^3/s)					
Location	April	May	June	July	Aug	Sept
Between Colona and South Canal	5	23	28	30	30	15
Between South and Selig Canals	8	33	41	43	43	21

Source: HDR, 1989a.

An additional water-righted demand is listed for the Colorado-Ute Electric Association's (Colorado-Ute) Bullock Station, although this plant has not operated for several years. However, it was included in table 3.14 (and the alternatives analysis) because the water right has not been abandoned. The assumed diversions in table 3.19 include a small portion of the total right for this plant.

Several irrigation diversions on the Gunnison River exist downstream from the North Fork confluence and serve farms and orchards in Delta County. In addition, the North Fork of the Gunnison upstream from the confluence is heavily used for irrigation.

IMPACTS OF ALTERNATIVES

Alternative A (No Action)

If no action is taken, the irrigation system would continue to operate as it has in the past. No changes would occur in the average diversions made into the various canals. Winter stockwater diversions from the Uncompahgre River will be replaced by supplies from domestic water lines under the plans for the Lower Gunnison Basin Unit (Winter Water Program).

Development Alternatives

Implementing any of the development alternatives would not affect the amount of water supplied for domestic purposes or to any of the irrigation laterals or canals operated by the UVWUA. Irrigation demands would have the highest priority and would not be reduced to increase or maintain power production. Irrigation demands made by non-UVRP systems would not be affected by any of the development alternatives. Water would be diverted to these systems in accordance with Colorado water law.

Flows that have historically been diverted through Cedar Creek would be diverted through the penstock for each of the development alternatives. However, adequate flows would be diverted into this stream to meet all water-righted demands that list this stream as their water supply source.

The diversion headgates of the Ironstone, East and Garnet systems are located downstream of the proposed development. Thus, upstream changes would not affect their water supply. Additional bank erosion in the Uncompahgre River could deposit materials behind the diversion dams and in the canals; thus, the proposed bank stabilization program would be necessary to mitigate this problem.

With any of the development alternatives, flows in the Uncompahgre River entering Montrose would be adequate to meet the water rights of the Bullock Station if operations at this plant are restored. The reduced streamflows would not affect the existing limits and conditions in the discharge permit for the Bullock Station [Colorado Department of Health (CDOH), 1989]. However, temperature limits may be harder to meet, particularly in the late summer. Should the plant be restarted, a permit variance or possibly a new permit may be required.

With the development alternatives, water supplies for the M&D and Loutzenhizer Canals would include a larger percentage of Uncompahgre River water. The source of flows would affect water quality considerations. For all development alternatives, diversion demands for these two canals would be met as much as possible from the available supplies in the Uncompahgre River. When the Uncompahgre flows are not sufficient to meet canal demands, Gunnison flows would be conveyed to the systems via the South Canal as they have been historically.

For no-action conditions, about 59 percent of the average annual flow in the Uncompahgre River just below the South Canal terminus comes from the Gunnison River and the remaining 41 percent comes from the Uncompahgre. For all development alternatives, only about 35 percent of the average annual river flow upstream from Montrose would be derived from water imported from the Gunnison. Month-by-month ratios of the Gunnison and Uncompahgre mixtures for no-action and with development alternatives are presented in table 3.20. The implications of these ratios are discussed in the water quality section of this chapter.

Table 3.20.--Comparison of Gunnison River flow to total river flow (ft^3/s) in the Uncompahgre River at the South Canal terminus[1]

	No action flow (ft^3/s)			With development flow (ft^3/s)		
Month	Gunnison River water entering from canal	Total river	Percent from Gunnison	Gunnison River water entering from canal	Total river	Percent from Gunnison
January	3	98	3	0	94	0
February	0	90	0	0	90	0
March	58	162	36	0	104	0
April	466	693	67	142	368	39
May	601	958	63	223	581	38
June	494	1,092	45	97	695	14
July	609	1,152	53	155	698	22
August	641	871	74	350	581	60
September	564	700	81	320	455	70
October	327	421	78	155	249	62
November	48	139	35		91	0
December	0	80	0	0	80	0
Annual average	319	540	59	121	342	35

[1] This water is the irrigation supply for the M&D and Loutzenhizer canals.

Source: HDR, 1989a.

Irrigation diversions downstream from the North Fork confluence should not be adversely affected and would continue to operate in accordance with their water rights. Most developed irrigation rights in the area are senior to the hydropower rights. The water quality for these diversions would decline as discussed later in this chapter. The total dissolved solids (TDS) would increase as less high quality Gunnison River water would be present to dilute flows in the North Fork.

RIVER MECHANICS

EXISTING CONDITIONS

Gunnison River

Between Crystal Dam and the confluence of the North Fork (see figure 3.2), the Gunnison River is deeply incised into the Precambrian schists and gneisses of the Black Canyon Formation except for two short reaches. From Long Gulch to Red Canyon, the east wall of the canyon is composed of the softer Cretaceous sedimentary rocks. At the Smith Fork confluence, the Precambrian rocks dip downward and the Gunnison River flows in a wider canyon formed in the Jurassic Estrada sandstone (lowest formation) Morrison Formation, the Dakota Sandstones (intermediate formation), and the Mancos Shale (highest formation).

In the less erosive Precambrian sections, the Gunnison River Canyon is extremely narrow at river level. Even at a flow of 350 ft^3/s, in many places the river floods the canyon from wall to wall. Where the canyon walls do not restrict the river, the bed width is as much as 200 feet. The river bed is primarily cobbles ranging from 2.5 inches to 10 inches in diameter. These cobbles rarely move and then only short distances during large floods. Because of the upstream reservoirs, very little sediment is transported through the river between Crystal Reservoir and the Smith Fork. Occasional flash floods from side canyons transport a significant amount of silt to the river.

In the narrow sections, the vertical rock walls are the banks. In the steep rapids, one bank is rock and the other is boulders. Where alluvial banks form in slack water areas, the banks are usually only two to three feet high.

Below the North Fork, the river flows westerly toward Delta. In the upper half of this reach, the river has incised its way through the Cretaceous sedimentary rocks in a canyon in a series of sharp, nearly right-angle bends. The valley and channel sinuosity[1] is 1.4. Downstream, the valley walls disappear, leaving the river in a broad valley. In this reach, the river has chosen a somewhat braided pattern; the sinuosity is 1.17. The valley floor slopes steeply toward a narrow belt where the river runs. Within this one-half mile belt, the river has moved laterally rather freely.

In the canyon reaches below the North Fork, the river ranges from about 120 to more than 400 feet wide. The widest parts have islands or large middle bars, and the narrowest sections occur at bends. In the broad valley downstream from the canyon, the average width is about 350 feet but varies from 200 to 1,000 feet.

As in the reaches above the North Fork, the river bed is primarily composed of well-rounded platy cobbles. The banks are primarily alluvial, but in places the river flows against the Mancos Shale.

The cobbles on the bed of this section of the river rarely move, except for short distances during large floods. The sands and gravels move on the bed and are suspended during spring runoff and during high flow. The sediment moving through the reach is supplied from the North Fork, other small tributaries, and eroding banks. The local streams draining the Mancos Shale bring in mostly clay with their infrequent runoff. Almost all of this fine sediment is carried through directly to the Colorado River. The sediment load from both the North Fork and the Gunnison River above the North Fork is not large (Stevens, 1988).

Uncompahgre River

Between the South Canal terminus and the city of Delta, the Uncompahgre River flows through a broad valley cut into the Mancos Shale by a geologically earlier and much larger river. Overall, the sinuosity of the present channel is estimated to be 1.25. As wide as one mile, the valley bottom is made up of alluvium. Near Montrose is a deposit of Wisconsin glacial outwash.

Much of this section of the Uncompahgre River is extremely unstable [Stevens, 1988, and the Soil Conservation Service (USDA, 1988)]. However, a few sections have been protected by the UVWUA, the Colorado Department of Highways, and others. Meander scrolls, oxbow lakes, abandoned and active side channels, braided sections, meandering reaches and manmade cutoffs exist in

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[1] The ratio of the actual length of a river reach to the straight-line distance between the beginning and end of the reach.

this section. The river varies in width from 60 feet in the stable sections to as much as 450 feet in some parts of the unstable sections.

Studies indicate that the Uncompahgre River bed below the Selig Canal is well armored with cobbles (HDR, 1989b). Samples of the river pavement have a mean diameter (D50) of about 4 inches (100 millimeters [mm]), which will resist movement at flows below 2,000 ft^3/s. In stable sections of the river, the banks are well defined and more than 6 feet high. In other sections, however, the river is eroding the high bank but is not carrying enough material to build a new bank on the opposite side, leaving a poorly defined, low bank and allowing vegetation to encroach. The bank materials are somewhat finer than the river pavement (D50 = 20 mm) and consist of cobbles, gravel, and sandy material.

About 37,000 linear feet of the river banks between the proposed tailrace and Delta have been protected against erosion. Near homes, bridges, and other structures, one or both banks are protected with large sandstone boulders hauled in and dumped as riprap. Riprap levees have been built on the upstream approaches to bridges to direct flood waters. At some bends, gravel and riprap levees have been constructed to protect adjacent property. Other methods of existing protection include anchored trees and old car bodies.

The river transports all sizes of sediment from clays only microns in diameter to medium-sized cobbles 6 inches in diameter. Almost all the clay and sand particles move through the reach, spending only a short time on the channel bed. The gravels and cobbles move primarily along the bed and are deposited upstream from diversion dams and in the first reaches of the irrigation canals. Ridgway Reservoir is expected to trap a large amount of the sediment derived from the Upper Uncompahgre River Basin.

IMPACTS OF ALTERNATIVES--GUNNISON RIVER

Alternative A (No Action)

If no action were to occur, conditions in the river would continue as they have since the Aspinall Unit was completed. Sediment transport would be minimal, and small amounts of bank erosion would occur below the North Fork. Developments in the North Fork catchment are having, or will have, their effect below the confluence. For example, Reclamation's Paonia Reservoir captures spring snowmelt, reducing some flood peaks. Overall, the Gunnison River between the North Fork and Delta will gradually become narrower and more stable due to these developments.

Development Alternatives

Stevens (1988) reported on the effect of the development alternatives to the morphology of the Gunnison River downstream from the Tunnel; with development, the morphology would not change. The reduced flows would increase the exposure of the river bed between the Tunnel and the North Fork confluence, which would encourage riparian vegetation to grow. However, this growth is not expected to be significant. Low flow cycles experienced since Blue Mesa Dam closed have apparently not resulted in significant riparian invasion. This would indicate that periodic low flows alone (at least 2 years or less in duration) may not be sufficient to trigger colonization. Although such conditions would increase in frequency with the project, average postproject flows would still be well beyond these low levels, and scouring floods would be relatively unaffected. Perhaps more importantly, the principal project-related flow changes would occur in the winter when vegetation is dormant and seeds are generally nonviable. Riparian invasion is unlikely during these seasons. Vegetation that does invade the channel is expected to be scoured away during floods, which would be largely unaffected by development. After high flow periods, the river would appear the same as without development.

The small quantities of sediment contributed by local tributaries within the Monument would not be affected by development. Geologic formations in most of the Monument provide much less sediment than the sedimentary formations found in the Gunnison Gorge downstream from the Monument, with the exception of Red Rocks Canyon at the lower end. These sediment loads would occur during high runoff conditions in the tributary. Depending upon flow conditions in the river's mainstem, these sediments may or may not be moved downstream. If low flow conditions exist, the sediments would be deposited near the confluence of the tributary with the mainstem. However, sediments would subsequently be moved downstream during flood events on the mainstem.

The lowered winter flows would reduce the river's potential to move sediment, and sediment would remain in the river longer. Under the no-action alternative, average winter flows would remove a greater portion of silt and sand than winter flows under development alternatives. Flushing flows (of more than 2,000 ft^3/s) would not decrease significantly in frequency.

In the reach between the North Fork and the Gunnison River's confluence with the Uncompahgre River at Delta, the channel is more susceptible to morphological changes. Erosion in this area would be reduced with development because the volume of flow would be reduced by increased Tunnel diversions.

In the reach between the North Fork and Delta, impacts to the Gunnison River resulting from increased diversions are reduced by the inflows of water from the North Fork. However, the Gunnison River is more susceptible to change downstream from the North Fork than upstream.

The flow diversions to the proposed development would result in more of the bed of the river section between the North Fork and Delta being exposed for longer periods. The invasion of riparian vegetation onto exposed bars would rapidly follow, but no significant change would occur in the amount or type of sediment supplied to the reach. The new river morphology would be the result of the balance between the invasion of riparian vegetation during low flows and the scouring and removal of this vegetation during floods. As large floods are not affected by the proposed development, the net result would be the same as for the river upstream from the North Fork, i.e., more vegetation during low flows and no changes after large floods.

The overall effect of any of the proposed development alternatives would be to increase the stability by reducing the potential for bank erosion of the Gunnison River below the North Fork.

IMPACTS OF ALTERNATIVES--UNCOMPAHGRE RIVER

Alternative A (No Action)

If no action were to occur, the impact of Ridgway Reservoir would be to produce a more stable, slightly narrower river in the reaches between the dam and the study area. The sediment supply would be less since the reservoir would trap much of the sediment from the upper catchment and the imported Gunnison River water is relatively free of sediment. Within the study area, bank erosion would persist, requiring periodic activities to protect channel banks in critical urban and rural areas. The bank protection would be completed by landowners, local governments, and in some areas, the UVWUA. These activities are expected to consist of the construction of rock jetties and hard points, with occasional riprap installation over channel banks. Significant amounts of channel bed degradation are not expected to occur within the reach between the South Canal outfall and the city of Delta.

If no action is taken, the Uncompahgre River between the Selig Canal and the city of Delta would continue to erode its banks. However, the rate of erosion would be less than it has been in the past due to Ridgway Dam being completed.

Development Alternatives

The stabilizing effect of Ridgway Reservoir would occur and, in addition, all development alternatives would decrease the amount of water in the river between the South Canal terminus and the proposed tailrace. As a result, bank erosion in this reach would decrease or cease altogether in some places. Flows would tend to meander more around the existing bars and islands. The sediment supply would be reduced. The river bed would remain stable since the flows are too small to move the cobbles. Scouring potential would be slightly decreased, so more riparian wetland vegetation would accumulate in the river bottom, trapping the finer sediments and slowly building up new banks.

Between the South Canal and the AB Lateral tailrace, the combined long-term impact of the development alternatives and Ridgway Reservoir would be to produce a more stable, slightly narrower (approximately 25 percent), more sinuous river.

Implementing the proposed alternatives would greatly increase the volume of water in the river between the proposed tailrace and the city of Delta, leading to subsequent increase of flow velocity and annual duration (volume). This increase probably would not result in significant degradation of the riverbed. The mean particle diameter of the bed materials is approximately 100 mm (4 inches). Computations (HDR, 1989b) indicate that a particle about 60 mm (2.36 inches) in diameter would be required to resist flows of 2,000 ft^3/s. Field sampling of the pavement materials indicates that 84 percent of sample stones are larger than 60 mm. Using the method of competent bottom velocity (USDI, Reclamation, 1960), the pavement is sufficient to resist mean velocities of as much as 7.4 feet per second. Under average flow conditions with development, the average mean velocity in the river between the tailrace and Delta is about 4.4 feet per second. Under dominant (bank full) flow conditions (2,000 ft^3/s), the average mean velocity is about 6.0 feet per second.

The primary, direct impacts of hydropower alternatives would be to increase the potential for severe bank erosion during the first several years of project operation. The mean particle size of the bank materials is approximately 20 mm (0.79 inch). Using the competent bottom velocity method mentioned earlier, this size would resist movement at channel velocities as much as about 3.3 feet per second. At velocities greater than 3.3 feet per second, movement would begin, and bank erosion would occur. If additional bank stabilization measures were not installed, the river would gradually widen from its present width of about 66 feet to about 200 feet, causing damage to homes, businesses, structures, and property that are near the riverbanks. The Sponsors would mitigate this potential impact by installing 52,740 linear feet of bank protection measures between the tailrace and Delta (see figure 2.8), including 24,550 feet of riprap revetment and 28,190 feet of streambank vegetation. The amount of bank protection measures that would have to be constructed by landowners would be reduced, perhaps significantly. Technical design aspects of these measures are discussed in chapter 2.

With the bank protection measures in place, significant impacts to the morphology of the Uncompahgre River would be reduced. The revetment measures would be located along banks near existing homes and structures that are presently not protected and also along banks that are immediately near cultivated fields. A total of 50 sites are planned for protection using these measures.

The streambank vegetation measures would be located in rural areas where the banks are immediately adjacent to wetlands, and where feasible, in areas where the risk of economic losses is lower. A total of 16 sites are planned for protection using this measure, consisting of a mixture of vegetative species, with grasses (switchgrass, wheatgrass, and reed canary grass) to be planted in the banks and a variety of shrubs and woody species (for example, willow and cottonwood) planted above the banks. The final mixture would vary according to the existing species and would be designed to improve site habitat conditions. The final mixture design would be prepared in consultation with the landowners, the CDOW, the FWS, and the Colorado State Forester. In addition to the vegetation, this measure would also include placing river cobble, extracted from existing stockpiles at Selig and Ironstone canals, along the toe of the banks to prevent bank failure.

After facility operation begins, the Sponsors would maintain the installed bank protection measures as part of a five-part program of postdevelopment activities to ensure mitigation of erosion impacts related to the facility (described in chapter 2). If additional stabilization measures are required, they would be installed by the Sponsors. In this case, riprap revetment probably would be installed using a design template identical to that shown in figure 2.7. Vegetative treatment could also be used, depending upon the location.

Installation of the proposed stabilization measures is expected to have short-term impacts during construction and long-term, operation-related impacts (see pertinent sections of this FEIS). The riprap protection would be designed to withstand the 10-year flood level, although the project would cease operations when Uncompahgre River flows exceeded 1,900 ft^3/s. Riprap would be designed to withstand considerably greater flows. The protected areas would be less susceptible to flood-induced erosion damage than under no-action conditions.

WATER TEMPERATURE

Although temperature is usually considered to be a water quality criterion, it is discussed separately from other water quality considerations in this section. Remaining water quality issues such as water chemistry and dissolved oxygen are discussed later in this chapter.

EXISTING CONDITIONS--GUNNISON RIVER

Water temperature plays an important role in biological activity in the Gunnison River. In the summer, water temperature affects the amount of dissolved oxygen present in the river, which in turn affects the fishery. The metabolism, growth, and production of fishes, especially cold water species such as trout, are also affected by high water temperatures. In the winter, if water temperatures become too cold, ice forms. If this ice were to completely cover the river, species using the river during the winter months, including river otters, eagles, and waterfowl, could be affected. Ice covers, if they occur, would have little direct effect on the fishery of the river. Ice jams, however, can cause riverbed and bank scouring as well as flooding.

Summer Conditions

Water temperatures in the Gunnison River between Crystal Reservoir and the confluence with the North Fork of the Gunnison River are largely a function of the temperature of releases made from Crystal Reservoir. A substantial amount of historical water temperature data is available for the Gunnison River below Crystal Reservoir and at the North Fork confluence. The USGS maintains a gauging station just downstream from the East Portal of the Tunnel that gathers both streamflow and water quality data. Temperature data collected at this station from 1980 through 1986 are summarized in table 3.21. The minimum and maximum measured water temperatures at the East Portal of the Tunnel between 1980 and 1986 were 1.5 degrees Celsius (°C) [34.7 degrees Fahrenheit (°F)] on February 4, 1982, and 14.5 °C (58.1 °F) on August 5, 1981; September 16, 1983; and September 14, 1984. Water temperature during the summer is generally highest at the East Portal during August when flows are lowest.

During the summer of 1988, Reclamation, the FWS, and the CDOW collected daily temperature data at various locations along the Gunnison River between the East Portal and the city of Delta. Maximum temperature data are summarized in table 3.22. River flows during this period generally ranged between 330 and 400 ft^3/s. As can be seen from table 3.22, maximum temperatures near the Ute-Duncan Trail remained below 15.5 °C (59.9 °F) and below 19 °C (66.2 °F) above the North Fork confluence.

Table 3.21.--Water temperature statistics for the Gunnison River at USGS Station below East Tunnel Portal (1980-1986)

Water temperatures	°C
Average temperature	8.8
Maximum temperature	14.5
Minimum temperature	1.5
Median temperature	10.0
Standard deviation	4.0

Source: USDI, USGS (1987).

Table 3.22.-- Maximum water temperatures (°C) observed on the Gunnison River (1988)

Location/Agency	Date	Daily average (maximums,°C)[1]	7-day average (maximums,°C)[1]
Gunnison Tunnel	June 29	10.0	9.8
(FWS)	July 5,6,7	10.0	9.9
Duncan-Ute Trail	July 8	15.3	14.8
(CDOW)	July 14	15.2	15.0
	July 30	15.2	15.0
	August 14	15.3	15.0
Above North Fork	June 22	18.9	-NA[2]-
confluence	June 23	18.4	-NA-
(Reclamation)	June 24	18.3	-NA-
	July 9	18.3	17.4
Above North Fork	June 22	18.5	16.9
confluence	June 23	18.8	17.3
(FWS)	June 24	19.0	17.7
	July 9	18.5	18.1
Austin	June 22	21.5	-NA-
(Reclamation)	July 31	21.7	20.7
	August 3	21.4	20.8
	August 4	21.1	20.9
Below Delta	June 22	21.3	19.3
(FWS)	June 23	21.3	19.7
	June 24	21.5	20.3
	July 2	21.0	20.6

[1] Daily averages and 7-day averages are the maximum values recorded during 1988.

[2] -NA- implies initiation of data sampling occurred less than 7 days before date indicated; hence, 7-day averages are not available.

Source: USDI, Reclamation, 1988.

Maximum summer water temperature between the North Fork and Delta has periodically exceeded 20 °C (68 °F). Water temperature data collected by the USGS at its Gunnison River station near Delta indicated a maximum water temperature of 22 °C (71.6 °F) on June 29, 1981. As indicated by a June mean monthly flow of 234 ft^3/s at the East Portal gauging station, low flows characterized 1981. North Fork flows were also low during 1981.

Additional water temperature data were collected near Austin and at Delta during the summer of 1988. River flows during the sampling period were generally lower than historic averages.

These data indicated a maximum daily average temperature of 21.7 °C (71.1 °F) near Austin that occurred on July 31. Maximum instantaneous temperature recorded also occurred on July 31 and was 24.8 °C (76.6 °F). Maximum instantaneous water temperature in the summer of 1989 here was 23.8 °C (74.8 °F). Water temperatures of more than 20 °C (68 °F) are not uncommon during low flow years. Nehring (1982) reported water temperatures during 1981 exceeding 20 °C (68 °F) near Delta during much of July and August. Bio/West, Inc. (1981) confirmed Nehring's observations, reporting afternoon river temperatures near Delta of 22 to 23 °C (71.6-73.4 °F) during June through August 1981.

Winter Conditions

Winter water temperatures on the Gunnison at the East Portal gauging station are similarly a function of the temperature of water released from Crystal Reservoir. Under typical conditions, water leaves the reservoir at temperatures from 2° to 5 °C (35.6° to 41.0 °F) during the winter. Because of the variation in flows and ambient temperature, the location of 0 °C water and the formation of ice historically have migrated longitudinally within the river. Based on model studies performed by Ashton (1987 and 1988), the location of 0 °C water or ice formation fluctuates from below Delta upstream to an area beyond the North Fork confluence during extreme cold spells (see figure 3.4).

Ashton's work is based on an assumed 2 °C water temperature for releases from Crystal Reservoir. Observations in January 1988 showed actual Crystal release temperatures between 1° and 3 °C as measured 1 mile downstream from the dam. The approach used by Ashton consisted of dividing the Gunnison into four reaches, calculating the area exposed to the atmosphere in each reach, and balancing the energy contained in the release flow against the

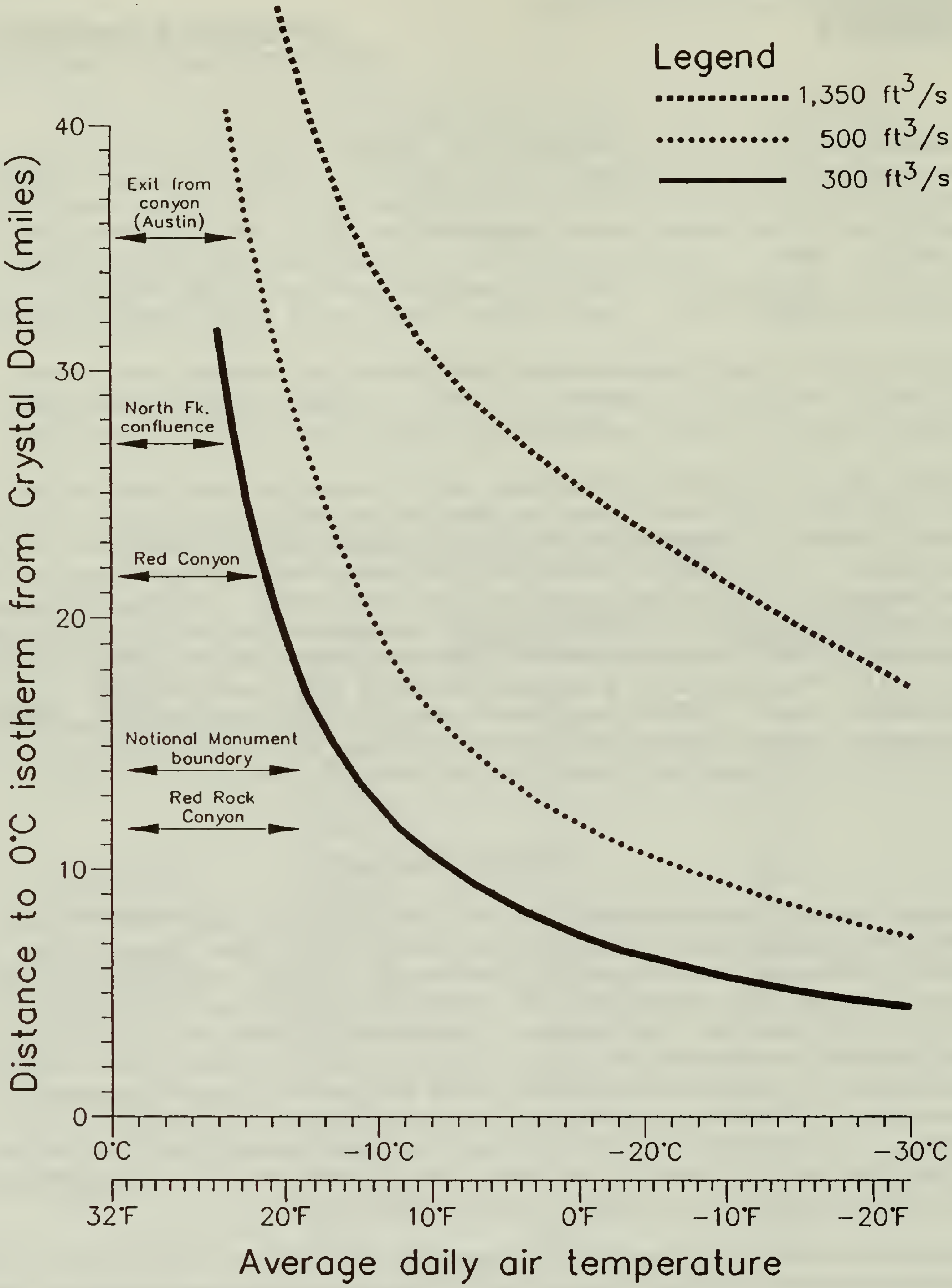

Figure 3.4. Theoretical location of the 0°C isotherm on the Gunnison River (Ashton, 1987).

heat loss from the water surface. Ashton's work showed that ice formation, represented by the location of 0 °C water combined with very low air temperatures, would begin upstream of the North Fork under low flow conditions. For example, at a mean air temperature of -10 °C (14 °F), the 0° isotherm would be located 34 miles downstream of Crystal Reservoir for a flow of 1,350 ft^3/s, 19 miles downstream for a flow of 500 ft^3/s, and 12 miles downstream for a flow of 300 ft^3/s. These distances represent the location of 0 °C water, not the development of an intact ice formation covering the river from bank to bank.

In slightly supercooled waters, minute ice crystals called frazil ice can adhere to the river bottom and form anchor ice or form clusters or floes that rise to the surface as floating frazil ice. Frazil ice forms in open reaches of a fast-flowing river after the water has cooled to 0 °C. Under certain conditions, an ice cover builds from the floating frazil ice and may bridge the river completely (Ashton, 1986).

Ashton's mathematical models (1987 and 1988) were formulated to show the relationship between the approximate location of 0 °C water downstream from Crystal Reservoir in relation to flow. However, these curves do not represent the relative upstream edge of an ice cover. Thus, Ashton also modeled two scenarios to predict the location of the ice cover edge.

The first scenario assumed minimum flow releases from Crystal Reservoir (300 ft^3/s), a water temperature of 1.5 °C (34.7 °F) for releases from the reservoir, and the average of morning and evening air temperatures taken at Crystal Reservoir (-7.8 °C or 17.8 °F). The results of this simulation indicate that, at minimum river flows and very cold ambient air temperatures, the theoretical location of an intact ice edge would fluctuate between Red Canyon and the North Fork. Under these conditions and a flow of 500 ft^3/s, the ice edge approached the North Fork confluence. At higher flows, the ice edge was considerably downstream regardless of the weather conditions (see figure 3.5).

The second modeled scenario represented an average-case scenario based upon average water releases. Data for the average case winter consisted of a water temperature of 2.5 °C (36.5 °F) for releases from Crystal Reservoir and actual air temperature data from the Redlands Mesa Agricultural Station (28 °F average), located about 5 miles to the north of the North Fork confluence. Ice cover usually develops downstream from Delta. Figure 3.6 shows the predicted location of the upstream edge of the ice cover during a typical winter at various flows. During a typical winter, the model predicts that the ice cover could approach but would not move upstream of the North Fork confluence even at 300 ft^3/s. At 500 ft^3/s, the ice edge is predicted to occur at the downstream edge of the Canyon.

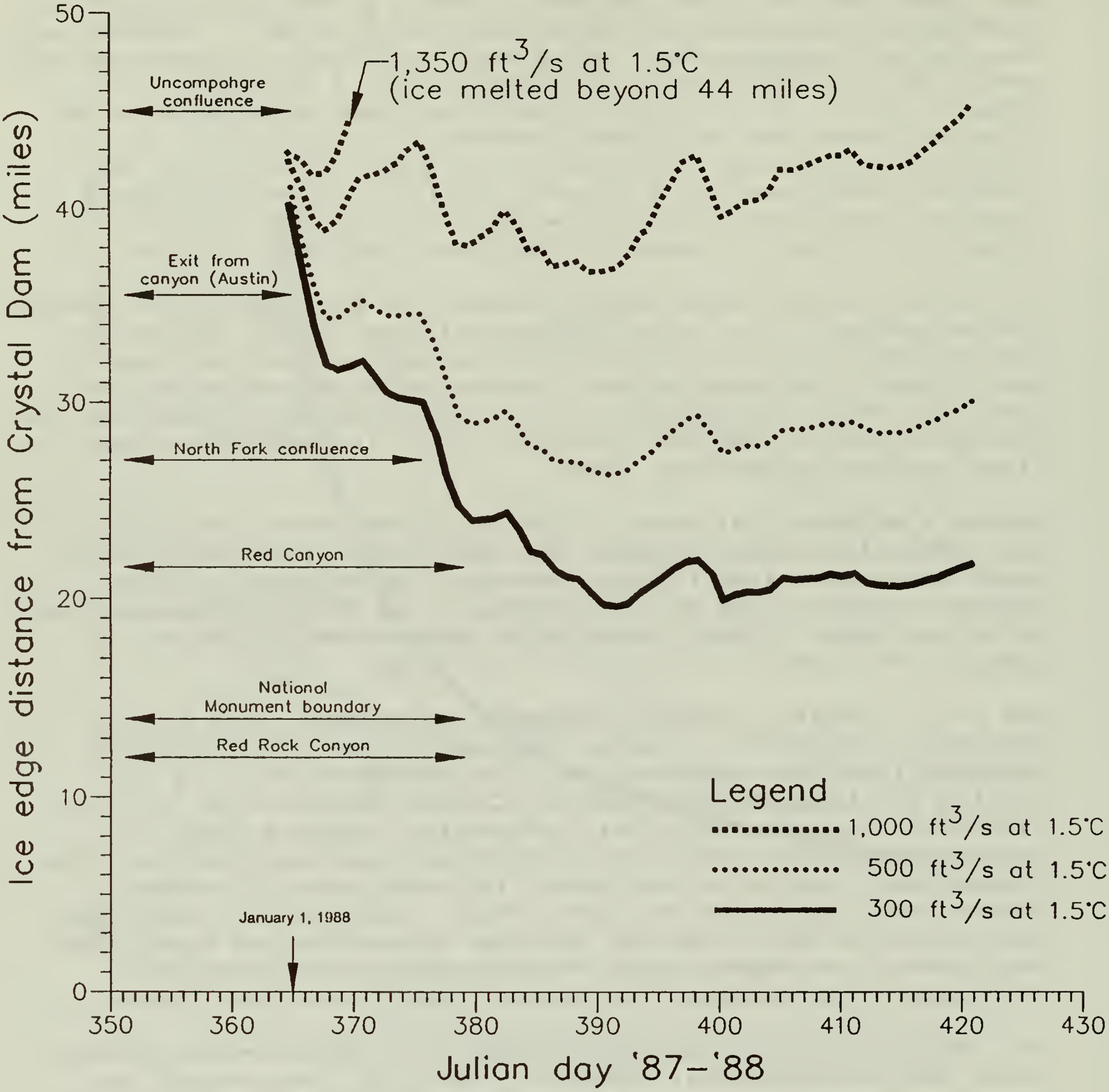

Figure 3.5. Modeled location of ice edge under extreme conditions on the Gunnison River (Ashton, 1987).

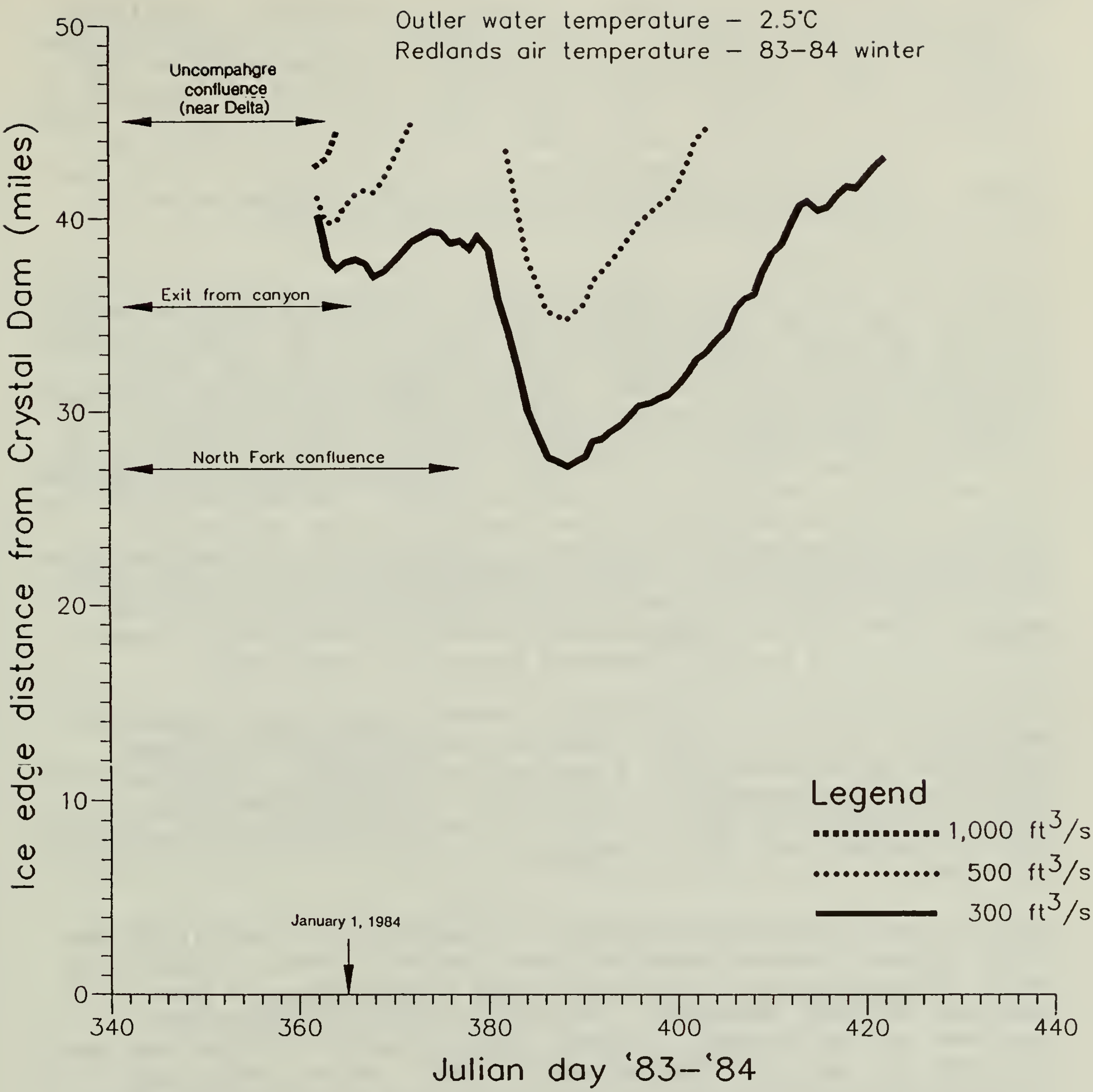

Figure 3.6. Modeled location of ice edge under average conditions on the Gunnison River (Ashton, 1987).

From January 20 to 21, 1988, Reclamation performed a field test to determine the location of ice formation in the Gunnison River under reduced flow from Crystal Reservoir. Releases from the reservoir were reduced from 1,300 ft^3/s to 500 ft^3/s. Minimum air temperatures at Crystal Dam ranged from -22.2 °C to -8.9 °C (-8 °F to +16 °F), while highs ranged from -5.6 °C to -2.2 °C (22° to 28 °F). Minimum air temperatures near the North Fork confluence ranged from -17.8 °C to -6.7 °C (0° to 20 °F). Temperature of water released from Crystal Reservoir ranged from 1 °C to 2 °C (34 °F to 35 °F).

During the test, 1 to 2 feet of bank ice formed along the edge of the Gunnison River above the North Fork, and some floating slush ice was observed in the open water. Sheet ice formed around exposed rocks in the channel. Small amounts of frazil ice began forming in the slower water along the banks, but none was observed in midchannel where water velocities were estimated at 2 to 3 feet per second. By midday, nearly all floating slush ice and anchor ice were gone. During the test, the Gunnison River at Austin (10 miles downstream from the North Fork confluence) contained increased bank ice and a large amount of floating slush ice in the open channel. The ice development was greatest at Delta where sheet ice formed around obstructions and on calm water. Under similar temperature conditions and river flows of 1,300 ft^3/s, ice was not observed above the North Fork.

During the winter of 1988-1989, releases from Crystal Reservoir were below 350 ft^3/s. Ice conditions were monitored between Christmas and February 28, a period that included unusually cold conditions. As measured at the Tunnel, Crystal Reservoir releases ranged from 2.5 °C (36.5 °F) to 0.4 °C (32.7 °F). During most of January and all of February, releases were below 2.0 °C (35.6 °F).

Surface ice bridged approximately 10 percent (2.5 miles) of the river between Crystal Reservoir and the North Fork. Frazil ice began forming in the river within the Black Canyon of the Gunnison National Monument, and anchor ice occurred as far upstream as the Monument. Anchor ice formed in riffles and runs at night and usually disappeared by noon. Shore (bank) ice occurred along the length of the river, and floating ice was common. These observations generally agree with Ashton's models (1987 and 1988) that predicted 0°C water temperatures to occur in the lower reaches of the Monument under certain temperature and flow conditions.

Downstream from the North Fork, similar conditions occurred, although two extensive areas of surface ice bridges occurred -- one just upstream from the Relief Canal Diversion Dam (between Austin and the North Fork confluence) and one upstream from the Hartland Diversion Dam (approximately 2 miles upstream from Delta). Floating frazil ice added to these ice bridges and created an extensive ice jam above the Hartland Diversion. This jam caused the river to rise and fall approximately 3 to 5 feet and appeared to result in ice scouring of the channel. River flows in the winter of 1989-1990 remained around 300 ft^3/s, but ice formation was less than during the previous winter, probably due to less extreme cold weather.

EXISTING CONDITIONS--UNCOMPAHGRE RIVER

Temperature data collected by the USGS at the Colona and Delta gauging stations indicate maximum summer temperatures of 20 °C (68 °F) on August 31, 1983, and 24 °C (75.2 °F) on July 10, 1986, respectively. Winter icing on the Uncompahgre River is common because of the low winter flows. Temperature statistics at the two gauges are presented in table 3.23. Releases from Ridgway Reservoir are cooler in the summer and slightly warmer in the winter than historic flows, an effect that should not be seen downstream from Montrose.

Table 3.23.--Water temperature statistics for Uncompahgre River at USGS Stations near Colona and Delta for 1980 through 1986

Statistic	Colona °C	Delta °C
Average temperature	9.8	12.6
Maximum temperature	20.0	32.0
Minimum temperature	0.0	0.0
Median temperature	10.0	7.5
Standard deviation	5.4	6.9

Source: USDI, USGS, 1987.

IMPACTS OF ALTERNATIVES--GUNNISON RIVER

Alternative A (No Action)

If no development is undertaken, no significant change from historic conditions in temperature patterns and seasonal flow variations along the river would be expected. Icing conditions would occur but would be uncommon.

Development Alternatives, Summer Conditions

Implementing any of the development alternatives would reduce the flow in the river during the summer. The amount of reduction would vary depending upon the alternative selected, but average river flows would range between 637 ft^3/s for alternative C and 730 ft^3/s for alternatives B, E and F from July through September. If no action were taken, the average flow during this period would be 897 ft^3/s.

Water temperature during the summer is not expected to change significantly immediately below Crystal Reservoir. Downstream, water temperature would increase. As indicated previously, maximum summer water temperatures near Austin during the low flow years of 1981 and 1988 ranged from 20 to 25 °C (68 to 77 °F). In both of these years, the river flows were lower than the average flows expected with development but about equal to those which would be expected under dry conditions. Thus, diverting water from the Gunnison River for hydropower, regardless of the alternative, should not result in water temperatures higher than the conditions observed during these low flow years. However, because the flows with development would be low more frequently (see tables 3.8-3.11), higher temperatures would become more frequent. Mean monthly flows between 300 and 500 ft^3/s from June through September would occur 38 percent of the time under alternative A; approximately 51 percent under alternatives B, E, and F; and approximately 73 percent under alternative C. The impacts of changing summer water temperatures are discussed later in this chapter.

Development Alternatives, Winter Conditions

Small changes (1 °C to 2 °C) in water temperature would be anticipated as a result of development. From December through February, generally the coldest period of the year, mean monthly flows in the river would average 476, 471, and 499 ft^3/s for alternatives B, C and F, respectively, and 581 ft^3/s for alternative E. For all alternatives, the minimum instantaneous flow of 300 ft^3/s would occur much more frequently (see tables 3.7-3.11). Mean monthly winter flows would be below 500 ft^3/s less than 10 percent of the time for alternative A and 45 to 60 percent of the time for all other alternatives.

In general, the potential for ice formation and accumulation exists within the Gunnison River at flows below 500 ft^3/s during periods of low temperatures. Ice conditions (previously described) seen during the winter of 1988-1989 would be more frequent under alternatives B and C, and to a lesser extent under alternatives E and F.

Average monthly flows from December through February for alternative F are slightly higher (499 ft^3/s) than those for alternatives B and C, as alternative F would provide deicing flows of approximately 600 ft^3/s for a period adequate to remove ice cover from the river. Therefore, alternative F would result in the periodic recession of the ice edge downstream to locations near those identified for alternative E. The effects of ice formation are discussed later in this chapter.

IMPACTS OF ALTERNATIVES--UNCOMPAHGRE RIVER

Alternative A (No Action)

If no action is taken, river temperatures in the Uncompahgre River would remain unchanged from present patterns. During the summer, temperatures would be affected by the amount of water withdrawn for irrigation. Consequently, average temperatures would continue to increase downstream. During the winter, the low flows present in the river would most likely develop an intact ice cover in slow-moving areas toward Delta.

Development Alternatives

Under all development alternatives, the amount of flow in the Uncompahgre River would be reduced between the South Canal and the tailrace during the irrigation season. Flows in the river would be substantially increased year-round downstream from the tailrace.

Reducing flows in the reach between the South Canal and Montrose would result in higher water temperatures during the summer. Because river flow would still be high (see tables 3.13 and 3.14) between the South and the Loutzenhizer Canals, this change would not be significant except on the reach between the Loutzenhizer Diversion and the proposed tailrace; in this reach, summer water temperatures would probably increase. During the winter, the flow profiles in the river between the South Canal and the tailrace do not change; hence, water temperatures would not change.

Downstream from the tailrace, water temperatures would be expected to decrease during the summer because of relatively cooler Gunnison River water flowing through the powerplant. During the winter months, water temperatures would increase. Flow tests were conducted by the Sponsors in January 1982. Approximately 300 ft^3/s was diverted through the Tunnel and South Canal over a 12-day period to determine the potential for ice formation in the Uncompahgre River. Visual observations indicated that no intact ice cover developed in the river between the South Canal and Delta (UVWUA, 1984).

WATER QUALITY

Water quality of the Gunnison and Uncompahgre Rivers can be characterized by addressing the physical (e.g., turbidity) and chemical (e.g., hardness) parameters of the respective streams. Water quality data for the Gunnison and Uncompahgre Rivers were obtained from several sources, including the Environmental Protection Agency (EPA), USGS, Bureau of Land Management (BLM), and Reclamation's own data. From these data, a general characterization of the water quality in the affected rivers can be developed. These qualities are important because they determine the type and density of organisms present and the possible consumptive and nonconsumptive uses for the river water. Water quality standards for the rivers are established by the CDOH, Water Quality Control Commission (WQCC). This section presents information regarding the water chemistry of the Gunnison and Uncompahgre Rivers within the reaches affected by development alternatives.

EXISTING CONDITIONS

Gunnison River Between Crystal Reservoir and North Fork

The quality of water in the Gunnison River downstream from Crystal Reservoir can be determined from studying data taken by the USGS at the gauging station downstream from the East Portal of the Tunnel and from occasional data collected by the USGS during 1981, 1984, and 1985 near Delta upstream from the Uncompahgre River confluence. These data were obtained primarily by measurement once each month during the winter, with multiple monthly measurements during the summer.

A good indicator of the dissolved salts content of water is its specific conductance; as the specific conductance increases, the water quality decreases. Generally, approximate TDS can be estimated by multiplying the specific conductance by 0.66 (USDI, USGS, 1985). Specific conductance data for the two stations are summarized in table 3.24. Flow, specific conductance, and temperature versus time for all data collected between 1980 and 1986 for the East Portal and Delta gauging stations are shown in figures 3.7 and 3.8.

Figure 3.7 shows temperature increasing through the summer at the Tunnel gauging station, reaching a mean monthly maximum in August. Specific conductance shows little seasonal variation and is positively correlated with the concentration of total ions (positively and negatively charged molecules) in solution; specific conductance is an indirect measure of salinity and water quality. The lower the concentration of dissolved substances

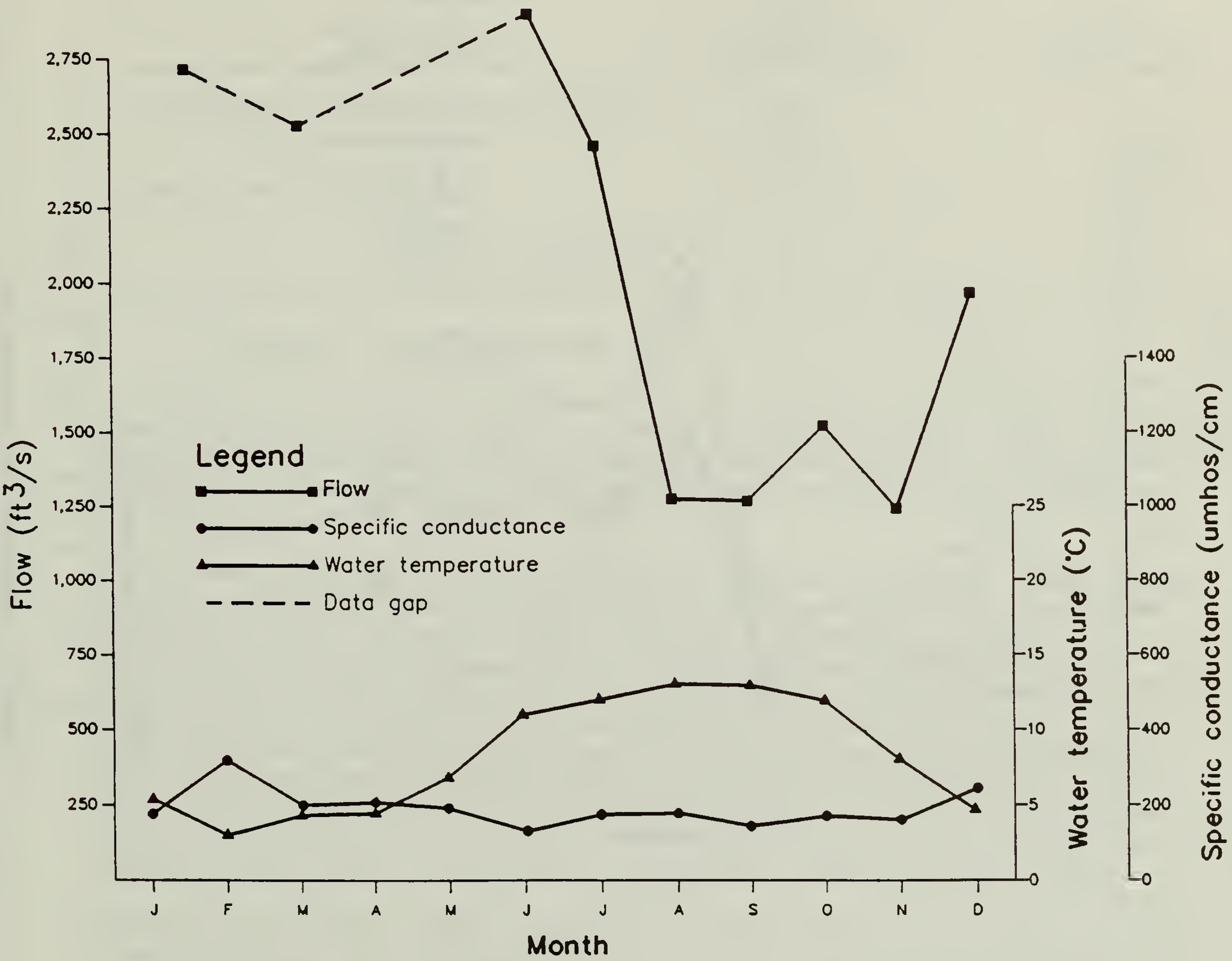

Figure 3.7. Mean monthly specific conductance, water temperature and flow (Gunnison River at the East Portal).

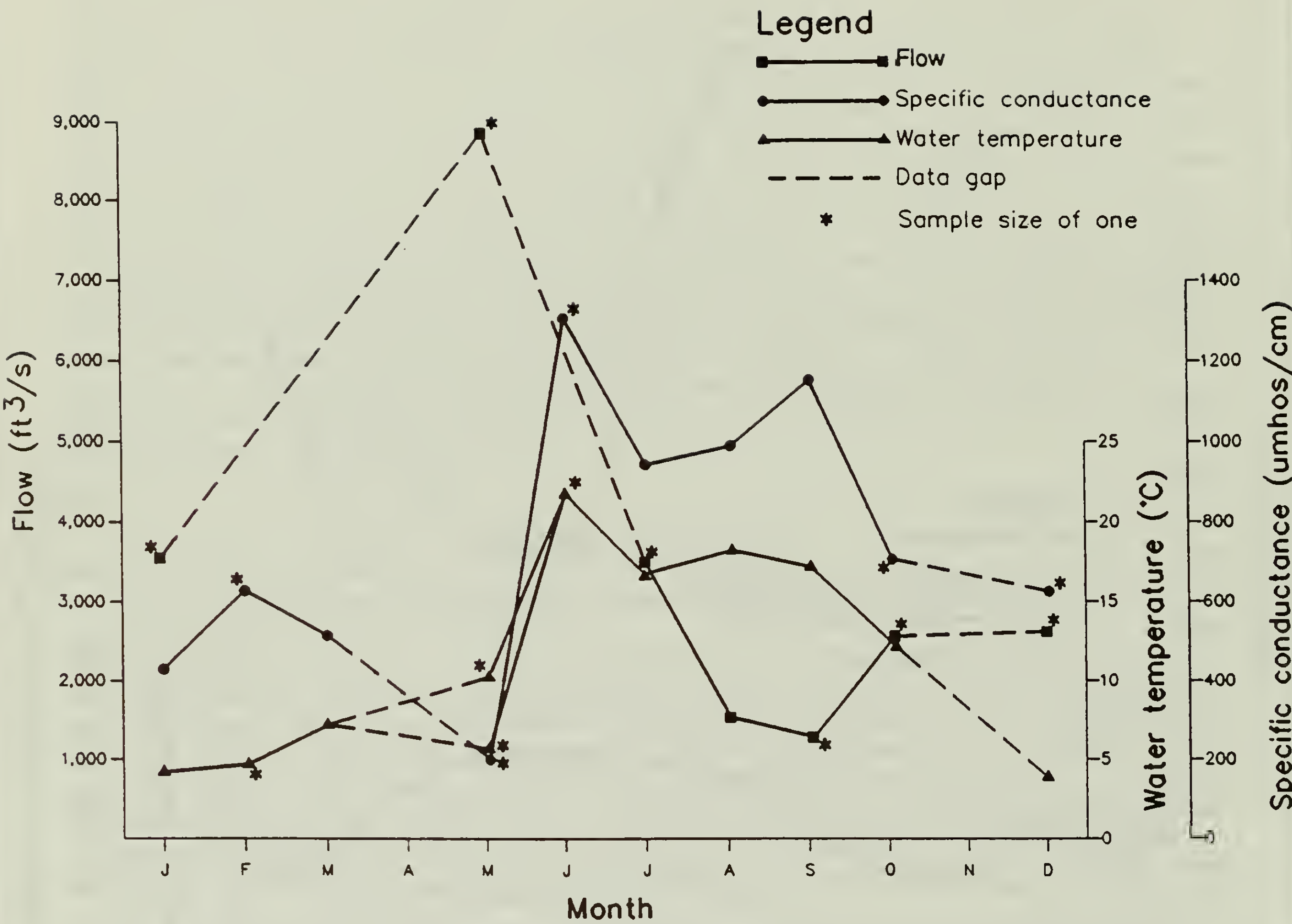

Figure 3.8. Mean monthly specific conductance, water temperature and flow (Gunnison River at Delta).

Table 3.24.--Summary of specific conductance data for the Gunnison River at two USGS gauging stations (1980 - 1986)

Statistic	Below Tunnel (µmhos/cm)	Near Delta (µmhos/cm)
Number of samples	67	20
Average	189	735
Maximum	320	1,500
Minimum	70	235
Median	185	735
Standard deviation	45	381

Source: USDI, USGS, 1985.

like calcium (Ca++), magnesium (Mg++), sulfate (SO_4^{--}) and chloride (Cl-) ions, the more pure the water (Wetzel, 1983). Table 3.24 indicates a low specific conductance and excellent water quality at the East Portal gauging station.

Additional water quality information for the Gunnison River from Crystal Reservoir to the North Fork confluence is the result of research on the effects of mainstream dams on the physio-chemistry of the Gunnison River (Stanford and Ward, 1983). Stanford and Ward published information about longitudinal physiochemical changes in water quality beginning at the headwaters of the Gunnison River and ending at the confluence of the Gunnison and Colorado rivers. During the period when their data were collected (September 1979 through October 1980), flows at the East Portal gauging station ranged from a low of approximately 770 ft^3/s to a high of 2,125 ft^3/s (USDI, USGS, 1987).

Stanford and Ward (1983) indicate a longitudinal increase in ion concentration (sum of Mg++, Na+, and SO_4^{--}) from the headwaters of the Gunnison to the confluence with the Colorado River (see attachment C), a commonly observed phenomena for rivers in general. They also reported a seasonal change in ion concentration, inversely related to flow. The trend was most obvious at sampling locations least affected by water released from reservoirs. Their data show that the Aspinall Unit reservoirs tend to reduce seasonal changes in ion concentrations and in other indicators of water quality such as specific conductance. These data suggest that water quality within the upper portion of the Gunnison River immediately below Crystal Reservoir is a function of the limnology of and releases from the Aspinall Unit reservoirs.

The ionic composition of the Gunnison River between Crystal Reservoir and the North Fork indicates little influence from irrigation return flows entering from the Smith Fork. The most important factor seems to be the limnology (see Glossary) of Crystal Reservoir. Stanford and Ward (1983) found that calcium dominated the ionic composition of the river system upstream of the Black Canyon of the Gunnison National Monument, while sulfate, an ion indicative of irrigation return flows, dominated in the lower reaches of the Gunnison River. The concentration of the nutrient nitrate-nitrogen tended to decline through the Monument, presumably the result of autotrophic (see Glossary) processes (see attachment C). Conversely, sulfate and dissolved and particulate organic carbon tended to increase (see attachment C). These factors perhaps suggest the importance of the North Fork, which tends to exhibit poorer water quality.

Ground-water inflows seem to contribute little to the water quality characteristics within the Monument because of the granitic bedrock (Stanford and Ward, 1983). Based on the Stanford and Ward data (1983), mean annual sulfate (as sulfur), nitrate (as nitrogen), dissolved organic carbon, and particulate organic carbon concentrations at the Tunnel were approximately 10.8 mg/l, 0.47 mg/l, 2.5 mg/l and 0.21 mg/l, respectively.

Dissolved oxygen is important because it is required for metabolic processes (see Glossary). Oxygen requirements for sport fish like trout are usually higher than for nongame fish such as suckers. The saturated, dissolved oxygen concentration at the East Portal gauging station can be calculated if certain assumptions are made involving altitude (atmospheric pressure), water temperature, presence or absence of salts, and degree of biological activity. Assuming an altitude of 5,000 feet, a water temperature of 14 °C (57.2 °F), no dissolved solids (essentially no salinity), and no biological activity, a saturated, dissolved oxygen concentration of 8.0 mg/l is obtained (EPA, 1985a). This theoretical value is well above the limits specified by WQCC (see table 3.25). Actual 1988 measurements by Reclamation in the Gunnison River above the North Fork on July 11, August 9 and September 16 indicated dissolved oxygen of 12.1, 11.2 and 10.8 mg/l, respectively. These high levels were probably due to a high level of photosynthesis[2] in the river.

Within Colorado, the WQCC has the authority and responsibility to maintain and improve water quality. The WQCC uses a water quality classification system based on recreation, aquatic life, existing high quality waters, domestic water supply, and agriculture. Recreation Class 1 indicates that activities such as swimming are suitable for a particular body of water.

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[2] The process by which plants form the sugar glucose from carbon dioxide of air and water by using chlorophyll and light.

Table 3.25.--Water quality standards and classifications for pertinent reaches of the Gunnison River

Stream segment	Classification[1]	Numerical and physical standards (mg/l)	
Gunnison River from Crystal Dam to a point 1 mile below Smith Fork confluence	High Quality, Class 2	Existing conditions	
Gunnison River from a point 1 mile downstream of confluence with Smith Fork to immediately above confluence with Uncompahgre River	Recreational Class 2 Aquatic Life - Class 1 Cold Water Supply Agriculture	Dissolved oxygen (D.O.)	= 6 7 spawning
		pH	= 6.5-9.0
		Fecal Coliform	= 2000/100 ml
		Temperature	= 68 °F maximum for aquatic life in Class 1, cold water biota
		NH3	= 0.02 unionized
		Residual C12	= 0.003
		Cyanide (free)	= 0.005
		S as H2S	= 0.002 undiss.
		Boron	= 0.75
		Nitrate (NO_2)	= 0.05
		Nitrate (NO_3)	= 10.0
		Chloride (Cl)	= 250.01
		Sulfate (SO_4)	= 250.0
		Arsenic	= 0.05
		Cadmium	= 0.0004
		Chromium (tri)	= 0.05
		Chromium (hex)	= 0.025
		Copper	= 0.012
		Lead	= 0.005
		Iron (sol)	= 0.3
		Iron (tot.)	= 0.05
		Manganese (sol.)	= 0.05
		Manganese (tot.)	= 1.0
		Mercury	= 0.00005
		Nickel	= 0.05
		Selenium	= 0.01
		Silver	= 0.0001
		Zinc	= 0.05

[1] See narrative for detailed explanation.
Source: WQCC, 1988.

Recreation Class 2 signifies stream segments where primary contact recreation does not exist and cannot reasonably be expected to exist in the future. Boating would be considered an acceptable activity under this classification.

Water bodies classified as Aquatic Life Class 1 cold water support cold water animal species. Although water temperature may not limit the distribution of cold water animal species, other factors such as low flow or chemical contamination may result in a designation as Aquatic Life Class 2 cold water. The purpose of this classification system is to provide a reasonable degree of public safety and to provide for the propagation of fish and other aquatic life.

Table 3.25 presents the classification and numeric water quality standards for pertinent reaches of the Gunnison River. Where applicable, the numeric water quality standards are upper limits for regulatory purposes and do not represent observed concentrations. The Gunnison River between Crystal Reservoir and 1 mile downstream of the Smith Fork is classified as High Quality Class 2--Existing Conditions, a classification that establishes the existing water quality as the numeric standards.

Gunnison River Below the North Fork Confluence

Water quality within the Gunnison River declines below the confluence with the North Fork, primarily because of irrigation return flows. Stanford and Ward (1983) reported a substantial increase in the sulfate concentration in the Gunnison below the North Fork confluence (see attachment C). Sulfate concentrations greater than 3,000 mg/l may be characteristic of the irrigation and side return flows (Stanford and Ward, 1983). They reported a large increase in annual particulate organic carbon below the North Fork confluence, while the mean annual concentrations of dissolved organic carbon and nitrate increased slightly.

The decline in water quality below the North Fork confluence is reflected by the increased specific conductance at Delta (see table 3.24). Also, specific conductance and water temperature increase seasonally at the Delta gauge more dramatically than at the East Portal gauge (see figure 3.8). The Gunnison River from 1 mile below the Smith Fork to the Uncompahgre River in Delta is classified by the WQCC as Recreational Class 2, Aquatic Life Class 1 cold.

Uncompahgre River

Water quality in the Uncompahgre River is poor compared to the Gunnison River. Table 3.26 provides specific conductance data collected by the USGS at two gauging stations on the Uncompahgre

Table 3.26.--Summary of specific conductance data at two USGS gauging stations on the Uncompahgre River (1980-1986)

Statistic	Near Colona (µmhos/cm)	Near Delta (µmhos/cm)
Number of samples	82	67
Average	605	1,256
Maximum	1,450	2,500
Minimum	170	30
Median	630	1,200
Standard deviation	272	535

Source: USDI, USGS, 1987.

River for the water years 1980 through 1986. The upstream gauge is at Colona, about 12 miles southeast of Montrose, and the downstream gauge is at Delta. At each of the gauging stations, specific conductance and temperature vary seasonally. Water temperature is generally greatest during August at the Colona gauge and July at the Delta gauge. Mean monthly flow, specific conductance and temperature versus time for all data collected between 1980 and 1986 for the Colona and Delta gauging stations are shown in figures 3.9 and 3.10.

Water temperature data collected by the USGS at the Colona and Delta gauging stations indicate maximum summer temperatures of 20 °C (68 °F) on August 31, 1983, and 32 °C (89.6 °F) on July 10, 1986, respectively. Greater suspended solids and chemical oxygen demand probably result in lower dissolved oxygen in the Uncompahgre River than in the Gunnison River.

A substantial decline in water quality occurs between Colona and Delta. The data presented in table 3.26 show a large increase in specific conductance between these gauging stations. The inverse relationship between streamflow and specific conductance is the same relationship observed on the Gunnison River at Delta (see figures 3.9 and 3.10). Specific conductance is less during May and June, the months with the greatest flows. Poor water quality in this reach of the Uncompahgre River is apparently the result of excessive amounts of dissolved solids from irrigation return flows. Limited water quality data for Spring Creek and the Loutzenhizer Arroyo show that these streams carry relatively large amounts of SO_4^{--} and Cl^-.

Seepage from the Uncompahgre River channel into the Mancos Shale seems to be limited, contributing little to salinity in the Uncompahgre River. Salinity estimates made by the Colorado River Water Quality Improvement Program indicate that the present salt loading to the Colorado River from the Uncompahgre Valley is

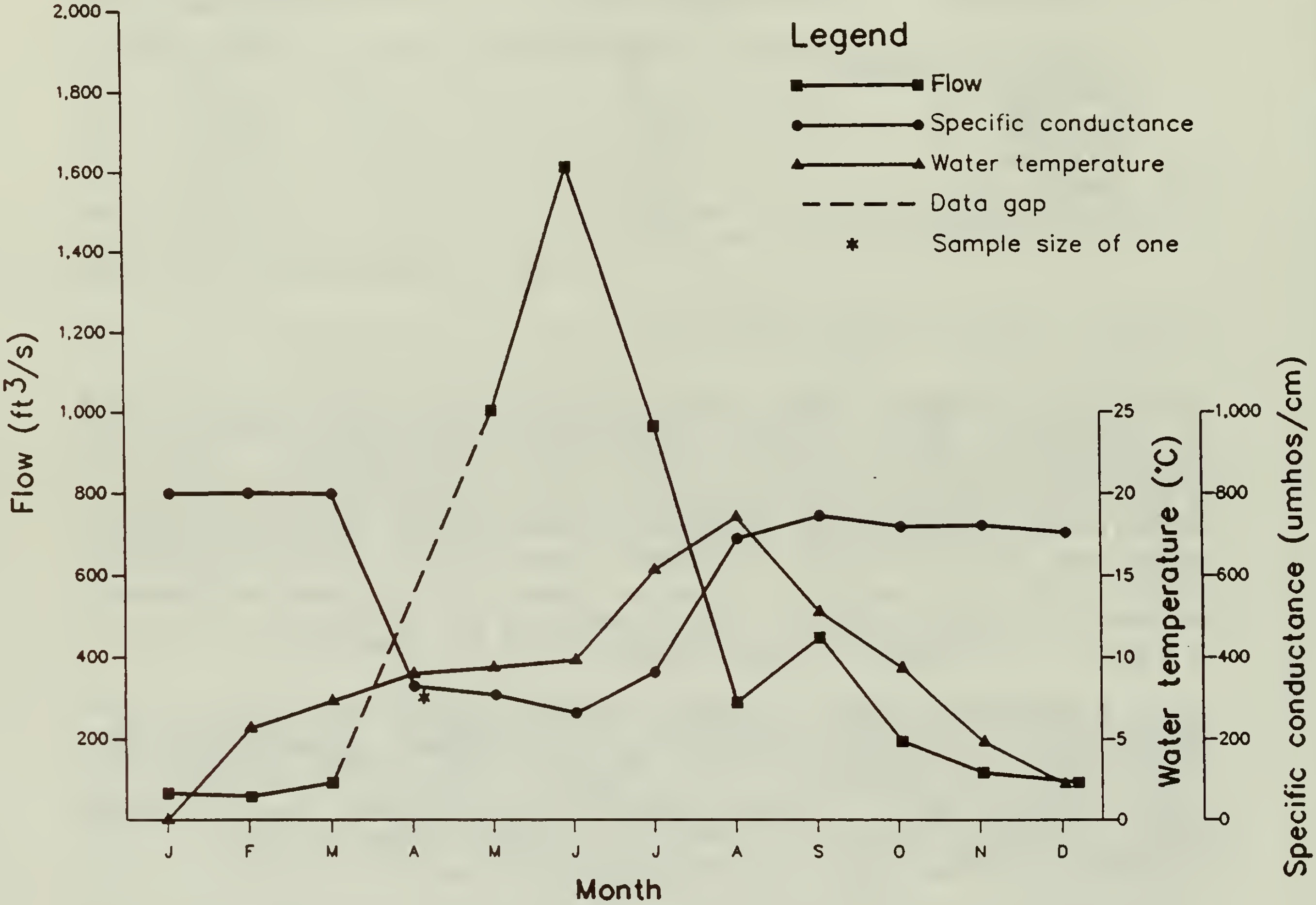

Figure 3.9. Mean monthly specific conductance, water temperature and flow (Uncompahgre River at Colona).

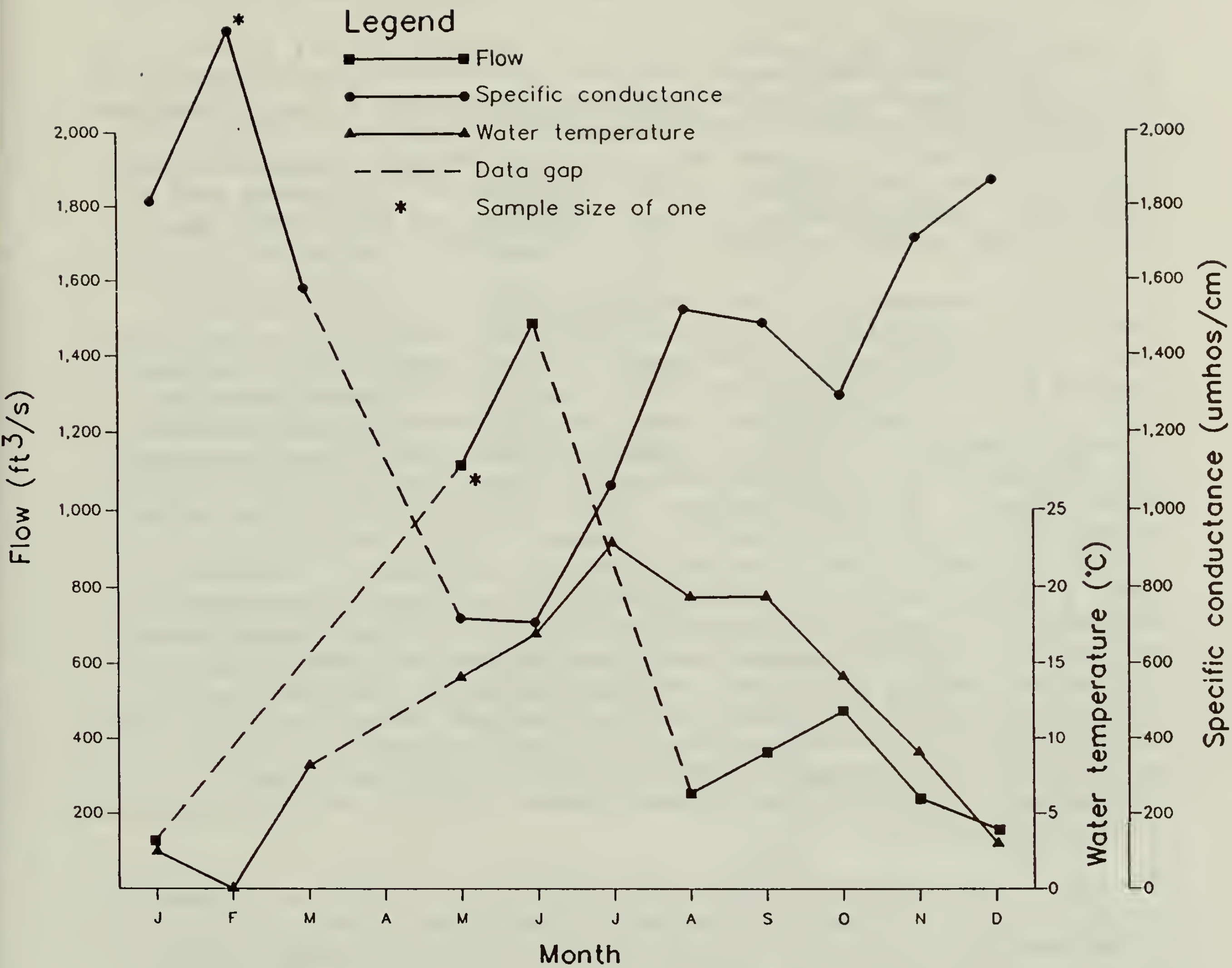

Figure 3.10. Mean monthly specific conductance, water temperature, and flow (Uncompahgre River at Delta).

531,000 tons per year, based on a total outflow of 281,000 acre-feet (USDI, Reclamation, 1984). This loading is almost entirely due to tributary inflow and irrigation return flows.

The Uncompahgre has a large effect on Gunnison River water quality at their confluence because of the substantial amount of dissolved substances carried by the Uncompahgre River. Stanford and Ward (1983) showed large increases in nitrate, sulfate, particulate organic carbon and dissolved organic carbon in the Gunnison River below Delta (see attachment C). Nitrate and SO_4^{--} carried by the Uncompahgre River probably are the result of agricultural practices within the Uncompahgre Valley.

The upper Uncompahgre River and some of its tributaries are presumably contaminated by mine drainage, resulting in relatively high concentrations of trace metals in the Uncompahgre River. Studies by Reclamation have indicated that concentrations of zinc, mercury, and cyanide, based on a flow-weighted average, may exceed acceptable levels for aquatic life, while the concentration of selenium and manganese may at times exceed safe drinking water levels. By the time the river reaches Colona, the water volume and alkalinity levels increase, both of which help to dilute and precipitate the heavy metal compounds. Starting in 1988, Ridgway Reservoir began settling out trace metals and sediment, thus reducing concentrations at Colona. Selenium concentrations increase downstream from Colona as a result of irrigation return flows and reach peak levels near Delta. Although the WQCC considers the Uncompahgre River from its source to its confluence with Red Mountain Creek upstream of Ouray acceptable for a domestic water supply, the river is not considered acceptable for domestic water supply use downstream to Delta (WQCC, 1988).

The WQCC classifications for the Uncompahgre River are presented in table 3.27. Below Red Mountain Creek, the river is classified as Recreational Class 2 (Agriculture and Aquatic Life Class 1 cold) to the Highway 550 bridge south of Montrose. The Aquatic Life designation becomes Class 2 warm water here, indicating no significant cold water sport fishing between this point and the Uncompahgre River's confluence with the Gunnison River at Delta.

IMPACTS OF DEVELOPMENT ALTERNATIVES

Implementing the development alternatives would not result in the discharge of any new or additional pollutants to the waters of either the Gunnison or Uncompahgre Rivers. Consequently, potential water quality impacts resulting from development would be related solely to diverting additional water for hydropower. Agricultural diversions, the Aspinall Unit reservoirs and Ridgway Reservoir presently play a major role in influencing water

Table 3.27.--Water quality standards and classifications for pertinent reaches of the Uncompahgre River

Stream segment	Classification[1]	Numeric and physical standards (mg/L; same as Gunnison River shown in table 3.26), except:	
Uncompahgre River from source to a point immediately above confluence with Red Mountain Creek	Recreational - Class 2 Aquatic life - Class 1 Cold Water supply Agriculture	Copper Nickel Iron (total) Zinc Cadmium	= 0.02 = 0.05 = 1.0 = 0.24 = 0.001
River from point above confluence with Red Mountain Creek to U.S. Highway 550 south of Montrose	Recreational - Class 2 Aquatic life - Class 1 Cold Agriculture	Chromium (tri) Copper Iron (total) Lead Nickel Selenium Zinc	= 0.1 = 0.065 = 0.1 = 0.04 = 0.05 = 0.02 = 0.225
River from Hwy 550 south of Montrose to confluence with Gunnison River	Recreational - Class 2 Aquatic life - Class 2 Warm Agriculture -	D.O. NH3 (unionized) Cadmium Chromium (tri) Copper Lead Nickel Selenium Silver Zinc Iron (total) Nitrite	= 5.0 = 0.1 = 0.005 = 0.1 = 0.03 = 0.05 = 0.2 = 0.035 = 0.00015 = 0.1 = 2.3 = 0.5

[1] See narrative for detailed explanation.
Source: WQCC, 1988.

quality within the Uncompahgre and Gunnison Rivers. Potential impacts from the proposed alternatives would be in addition to the present influence from these sources.

ALTERNATIVE A (NO ACTION)

If no development occurs, water quality in the Gunnison River would not change significantly. However, water quality would continue to be affected by the releases from Crystal Reservoir, agricultural runoff from tributary streams, and irrigation diversions. Sediment loads delivered from the Smith Fork and the North Fork of the Gunnison River would also continue to affect the Gunnison River's water quality.

GUNNISON RIVER BETWEEN CRYSTAL RESERVOIR AND NORTH FORK

Development Alternatives

The principal effect of all of the development alternatives outlined in chapter 2 would be to reduce the amount of water in the Gunnison River between the Tunnel and Delta. In water quality terms, the diminished flows reduce the amount of water available for diluting elements that downgrade water quality.

As discussed previously, water quality immediately below Crystal Reservoir is a function of the quality of water released from the reservoir. Water quality within Crystal Reservoir varies seasonally as upstream reservoirs and Crystal receive inflow and thermally stratify and destratify. These changes are probably also reflected below Crystal Reservoir. Between Crystal Reservoir and the Tunnel, an area unaffected by the project, no change in water quality is anticipated. The release of water from Crystal Reservoir would continue to dictate water quality. Seasonal variation in specific conductance would remain muted, and water temperature should remain warmest during August.

The data presented earlier in this chapter showed an inverse relationship between flow and specific conductance. As river flow increased, specific conductance decreased and water quality improved, suggesting that the significance of potential impacts resulting from additional water diversion would depend on the type of water year (whether it is was low, moderate, or high flow).

Because poor quality water (compared to the Gunnison River) does not enter the Gunnison River between Crystal Reservoir and the Smith Fork in sufficient amounts, water quality is not predicted to deteriorate between Crystal Reservoir and the Smith Fork. However, during periods of moderate (600 to 1,000 ft^3/s) or high flows (greater than 1,000 ft^3/s), slight increases in the concentration of ions, particulate and dissolved organic matter, and other measures of water quality would occur below the Smith and North forks. However, even with development, water quality during moderate-to-high flow years would remain excellent in this reach. Sediment in flows to the river would be transported out of the system slower during low flow periods. With development alternatives, this would be the most significant during the winter when flow changes would be the greatest.

During periods of low to moderate flows (300 to 600 ft^3/s), the concentrations of ions, particulate and dissolved organic matter, and other water quality measures would increase because of the reduced amount of flow available for dilution. The changes would be within the range experienced since the Aspinall Unit was completed, and the water quality would remain good within this reach.

In 1988, when flows downstream from the Tunnel were usually below 400 ft^3/s, the concentration of ions (as measured by TDS) in the river upstream of the North Fork confluence remained low; TDS were below 300 milligrams per liter (mg/l). Development would not change the fish species assemblage presently inhabiting the river, and water use presently allowed would not be affected. Additional diversions would not be made during low flow periods (300 ft^3/s), so water quality would not be affected. The present WQCC classification of High Quality Class 2 Existing Conditions is unlikely to be affected by project development.

In general, alternative C (which would increase the capacity of the Tunnel) would result in the greatest amount of water diverted compared to alternatives B, E and F (see tables 3.8 through 3.11). The additional diversion would occur primarily during November through April, months typified by higher flows. Alternatives B and F should result in similar water quality, based on the quantity of water remaining within the Gunnison River. Alternative E would have a turbine design flow less than the other development alternatives and would therefore divert the least amount of water. In turn, this would provide the greatest amount for diluting the poorer quality Smith Fork flows.

GUNNISON RIVER BELOW NORTH FORK

Development Alternatives

Water quality impacts increase moving downstream from the North Fork, which exhibits considerably poorer water quality than the Gunnison River. The dissolved solids concentration is much higher than the Gunnison, although the amount of flow contributed by the North Fork is smaller compared to Gunnison flows. Without development, these higher concentrations result in longitudinal trends in water quality discussed previously. However, with development, the reduced flows would result in less water for dilution for longer durations.

During the summer of 1988, flows in the North and Smith Forks and Gunnison Rivers were substantially below their respective historic averages. Specific conductances measured by Reclamation indicated values of 222 micromhos per centimeter (µmhos/cm) in the Gunnison River above the North Fork confluence, 1,297 µmhos/cm in the North Fork and 649 µmhos/cm in the Gunnison near Austin. These values represent historical averages, and flows were equivalent to those expected with development during dry conditions. Hence, although the dilution capability of the Gunnison River would be reduced with development alternatives, the reduction would not result in water quality parameters outside of those historically experienced. However, conditions such as occurred in 1988 would be more frequent with the development alternatives. The length of time in the spring or after summer thunderstorms that the river would remain cloudy or turbid due to North Fork inflow would be extended, and TDS concentrations would increase. In the summer of 1988, TDS concentrations exceeded 1,000 mg/l in the North Fork and were recorded at around 530 mg/l on the Gunnison River near Austin. The reduced flows should not change the type of species presently inhabiting the river and would not change the allowable usage, including irrigation. Of the development alternatives, alternative E would provide the greatest amount of water for dilution of North Fork flows.

UNCOMPAHGRE RIVER

Alternative A (No Action)

If no development occurred, water quality in the Uncompahgre River would be changed by the operation of Ridgway Reservoir. Trace metal concentrations within the Uncompahgre River, the result of runoff from mine tailings within the headwaters, should be reduced within the reservoir. Trace metals typically adsorb on the surface of clay and other soil particles. With the decline in water velocity at the upstream end of the reservoir, clay and other soil particles would be deposited, thus settling trace metal contaminants. Consequently, the waters released from the reservoir would be expected to be relatively free from suspended sediments and the associated trace metal contaminants.

The release of water low in suspended sediments from Ridgway Reservoir would result in an initial period of degradation and scour within the river channel for a few miles downstream from Ridgway Dam. This action would slightly degrade the quality of water released from Ridgway as the result of increased sediments and turbidity.

Implementing the Lower Gunnison Basin Unit winter water replacement program (began in January 1990, to be completed in 1995) will also affect water quality in the Uncompahgre River. This (Colorado River Basin) salinity control project will decrease the inflow of dissolved salts and would also increase the amount of streamflow in the river during the winter by replacing stockwater supplies diverted from the river with supplies provided through rural water systems.

Development Alternatives

The principal effect of all of the development alternatives would be to reduce the amount of water in the Uncompahgre River between the South Canal and the tailrace and to increase the amount of water in the river between the tailrace and Delta. In water quality terms, the diminished flows would reduce the amount of water available for dilution of elements that downgrade water quality, but the increased flows downstream from the tailrace would improve water quality, provided measures to limit erosion would be undertaken.

Each of the alternatives would decrease the amount of water entering the Uncompahgre River through the South Canal, primarily between March and November. During the nonirrigation period, flows through the South Canal have been historically curtailed; this pattern would continue with development (except in emergency situations). Therefore, water quality impacts caused by the reduced flows would be evident only during the irrigation season.

Because the proposed method of operation for each of the alternatives is similar, the flows in the Uncompahgre River between the South Canal and the tailrace would be similar. Average monthly flows would be reduced by approximately 180 to 400 ft^3/s with the project alternatives, representing a loss during the irrigation season of approximately 123,460 acre-feet of higher quality Gunnison River water.

Using average specific conductance values at Colona and the Tunnel and ignoring the effects of Ridgway Reservoir, the dissolved solids in the water just below the South Canal would be about 233 mg/l if no development occurred. Using these same assumptions, the dissolved solids concentration with development would nearly double during the irrigation season as a result of less flows in the reach between the Loutzenhizer Canal and the proposed tailrace. Although this would represent a significant increase in concentration, it would not result in an increase of total salt loading to the Colorado River system. Further, it would not change the WQCC stream classification because Ridgway Reservoir would be expected to improve the river quality by reducing heavy metals and suspended solids at Colona. Heavy metals may still continue to occur in the river due to metals occurring in the sediments upstream from Montrose. Thus, the net impact resulting from reduced flows from the Gunnison and South Canal would be expected to be less significant.

Selenium and heavy metals are antagonistic, reducing each other's toxicity. The Uncompahgre River gains selenium between Colona and Delta, and heavy metal pollution is declining there due to Ridgway Reservoir. Thus, under all alternatives, including the no-action alternative, it is possible that selenium would become more of a factor in the river. The development alternatives would provide less dilution of selenium between the South Canal and the proposed tailrace and more dilution between the tailrace and Delta; however, the impacts of this occurrence are unknown.

Diversion of water from the Gunnison River under alternative A provides approximately 59 percent of the flow in the Uncompahgre River upstream from Montrose annually. The AB Lateral Facility would reduce this to 35 percent annually. Therefore, Gunnison River water would annually provide approximately a 35 percent reduction in trace metal concentrations immediately below the South Canal with AB Lateral implemented. This is a net reduction in dilution, however, and water quality would decline. This assumes no beneficial effect with respect to trace metal reduction associated with Ridgway Reservoir.

Ridgway Reservoir will essentially function as a large detention basin. Detention basins are capable of removing 40 to 80 percent of trace metals present in incoming water (Walker, 1987). The efficiency of Ridgway Reservoir should be considerably better because of the larger size and greater hydraulic residence time compared to wet detention basins typical of urban areas. Because considerable inflow occurs between Ridgway Reservoir and the South Canal, Ridgway Reservoir is not acting as a detention basin for the entire watershed upstream of the South Canal. Regarding trace metals other than selenium, attachment F (tables 1 and 2) indicates that annual concentrations remain approximately the same or decline between Ridgway and Delta. This suggests improving effects from water being introduced from the Gunnison River, a phenomena that would continue by implementing the project. Exceeding water quality standards or Safe Drinking Water Maximum Contaminant levels would not occur because of implementing the facility.

Increased flows in the Uncompahgre River downstream from the tailrace would not add significantly to the deep percolation into the Mancos Shale formation and would have little or no impact on salinity contributions to the river. The decrease in salt loading from lining the enlarged section of the AB Lateral, from the decrease in the amount of water flowing through the South Canal, and from reducing irrigation season diversions into Cedar Creek is estimated to be 3,044 tons per year based on seepage rate estimates (USDI, Reclamation, 1984 and 1988).

Water quality within the 25 miles of the Uncompahgre River below the AB Lateral plant tailrace would be affected. Water diverted for hydropower would not be exposed to soils and, therefore, would not acquire the water quality characteristics of irrigation return flows. All development alternatives would increase erosion between the tailrace and Delta. Alternative E would result in the least streambank erosion because of lower flows through the tailrace, reducing the potential for sediment entrainment from bank erosion. Without the bank stabilization program, the sediment load would increase significantly for an undetermined number of years. Bank stabilization would be a required feature of the project as discussed in chapter 2 and in attachment A.

Installing the revetment would result in temporary increases of suspended sediments and turbidity in the Uncompahgre River. These increases would be the result of excavation required for constructing the revetment toes and for grading streambanks at each installation.

Installation of the proposed measures would not create long-term impacts to the water quality of the Uncompahgre River. Erosion would be reduced, effecting a gradual improvement of suspended solids and turbidity.

Water quality classification and associated discharge permit standards may change if water quality is substantially improved in the Uncompahgre River. After the hydropower project had operated for 3 to 5 years, the CDOH would contact the CDOW for a water quality and fish and wildlife analysis. If habitat and an associated cold water trout fishery were developed, the CDOH could reclassify the river to a higher standard. However, wastewater treatment discharge conditions would not necessarily be changed because increased flows would provide additional dilution (J. Scherschlight, personal communication, 1987).

FISHERIES

EXISTING CONDITIONS

Gunnison River

Before the Aspinall Unit, the Gunnison River was characterized by wide fluctuations in streamflow. The extremes of high spring flows an low summer and fall flows were believed to contribute significantly to poor salmonid reproduction and survival before Aspinall construction. Historical accounts (Wiltzius, 1978) indicate that very few salmonids, including the Colorado River cutthroat, inhabited the Gunnison River downstream from the Tunnel. The native cutthroat was removed from the Gunnison River in the early 1900's (Wiltzius, 1978). Excessive spring flows presumably resulted in increased mortality of rainbow and brown trout swim-up fry, while low summer flows (less than 200 ft^3/s) led to unsuitable water temperatures. Attachment B (which has been revised from the DEIS) contains historic flow records for the Gunnison River downstream from the East Portal of the Tunnel.

Since the Aspinall Unit was completed, relatively stable, cold water flows from Crystal Reservoir have resulted in an excellent trout fishery downstream of the dam. For fishery collections in the Black Canyon of the Gunnison National Monument and downstream areas in the period before and following operation of the Aspinall Unit, refer to Wiltzius (1978). Kinnear and Vincent (1967) document fish populations in the Monument before the Aspinall Unit. Stanford and Ward (1981, 1983, 1984, and 1989) discuss the limnology and ecology of the Gunnison River. They suggest that the Aspinall Unit reservoirs have caused a downstream shift (reset) of optimum trout production conditions and other physical and biological processes from the area impounded by Blue Mesa Reservoir to the Gunnison Gorge. In addition, the CDOW has completed extensive research on the river from 1979 to 1988 (Nehring, various dates; Nehring and Anderson, various dates; and Nehring and Miller, 1987).

The CDOW has designated the nationally renowned 28-mile Black Canyon reach as wild and Gold Medal water, meaning natural reproduction sustains the fishery and that trophy fish are present. Species abundance above the North Fork may be represented in decreasing order as: rainbow trout > brown trout > flannelmouth, longnose, white and hybrid suckers > mottled sculpin, common carp and longnose dace. Presumably immigrants from Crawford and Paonia reservoirs, infrequent species include northern pike, yellow perch, and green sunfish and bass. The trout comprise about 54 percent of the fish population, sucker species 36 percent, sculpin 9 percent, and the remaining species 1 percent (Nehring, 1987a).

The native fish species such as the bluehead and flannelmouth sucker, longnose dace, and mottled sculpin are not important from a sport fishery standpoint but are an important part of the overall ecosystem. These species tolerate a relatively broad range of environmental conditions such as temperature, dissolved oxygen, turbidity, and velocity. The native roundtail chub has been severely reduced in the Gunnison Gorge as a result of cold water releases from the Aspinall Unit. No threatened or endangered fish species exist in the Gunnison River upstream from Delta; however, the endangered Colorado squawfish and the razorback sucker occur downstream. Wiltzius (1978) indicated that there was no evidence that endangered fish species had ever occurred in the Black Canyon of the Gunnison National Monument.

Growth, density, biomass and production are typical measures of the quality of a fishery. Table 3.28 presents data collected by CDOW with respect to density and biomass of trout species for various portions of the Gunnison River. These data indicate a general decline in the density and biomass of rainbow and brown trout between the Duncan-Ute Trail and the North Fork-Austin areas. This trend may or may not be indicative of total fish biomass within the Gunnison River but probably reflects

Table 3.28.--Gunnison River standing crop and biomass estimates (August-September 1986)

Description of study area and fishing regulations	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	N/ha	kg/ha	Trout/ha >35 cm
Duncan-Ute Trail--	3,220	31.0	10.0						
4 trout/day; 1 over				Brown	4,688	±2,013	469	69.8	17
16 inches; catch-and-				Rainbow	2,748	±1,549	275	132.8	175
release, 12-16 inches									
				Total	7,447	±2,319	745	202.6	191
Smith Fork-North Fork--	6,440	31.0	20.0						
4 trout/day; 1 over				Brown	2,554	±1,152	128	33.3	32
16 inches; catch-and-				Rainbow	3,596	±3,640	180	98.8	156
release, 12-16 inches									
				Total	5,903	±1,994	295	132.2	171
North Fork-Austin--	12,900	45.7	59.0						
8 trout/day; limited				Brown	3,243	±1,103	50	13.1	15
access; heavy siltation				Rainbow	2,524	±1,665	37	12.5	23
				Total	5,880	±2,965	85	25.6	37

Source: Nehring, 1987b.

interactive effects of fishing harvest and the lack of natural reproduction downstream from the North Fork confluence. Total trout (rainbow and brown) density and biomass during 1986 were 745 fish per hectare (ha) and 203 kilogram (kg) per ha, respectively, in the Duncan-Ute Trail area, compared to 85 fish per ha and 26 kg per ha, respectively, in the North Fork-Austin area. Trout density estimates presently range from 2,223 to 2,470 trout per ha (900 to 1,000 trout/acre) in the less accessible Black Canyon, compared to 741 to 988 trout per ha (300 to 400 fish/acre) in the area above the North Fork confluence (USDI, Reclamation, 1988; Nehring, 1988c).

Additional rainbow and brown trout biomass data collected from 1981 to 1988 by CDOW are presented in table 3.29. These data show brown trout biomass ranging from 25.8 to 170.2 kg per ha and rainbow trout biomass ranging from 50.5 to 243.0 kg per ha during the study period between Duncan-Ute Trail and Smith Fork-North Fork area (Nehring, 1988c). Nehring and Anderson (1983) reported that stable flows from October 1980 through March 1981 led to highly successful incubation and hatching of brown trout eggs. Lower stable flows of 200 to 400 ft^3/s through September 1981 provided excellent spawning and incubation for rainbow trout. Strong year classes in the early 1980's were the result of favorable flow conditions.

Because of the trout's importance as a sport fish, the majority of the fisheries data on the Gunnison River are for trout, and less data are available for nongame fish. Nehring and Anderson (1982) and Nehring (1981) report data on the occurrence of nonsport fish in the Gunnison River. Wiltzius (1978) presents data on nongame fish within the Black Canyon of the Gunnison National Monument and downstream areas. Sucker density is greater downstream from the North Fork than upstream. Sucker density is presently estimated at 1,000 fish per mile above the North Fork (Nehring, 1987b, and USDI, Reclamation, 1987a).

Rainbow and brown trout growth within the Gunnison River is excellent. Rainbow trout in the Duncan-Ute Trail and Smith Fork and North Fork areas exceed 41 cm (16 inches) during the fourth year of growth. The data in table 3.30 show trout lengths in relation to age, allowing inference of trout age based on length. For example, a rainbow trout during its third year of growth would be anticipated to reach approximately 39.5 cm (15.5 inches) in the same area.

With the development of the Gold Medal fishery above the North Fork, trout populations have improved below the North Fork. Table 3.31 presents the results of a 1981 CDOW survey conducted between the North Fork confluence and the Austin Bridge. These data indicate a greater number of nongame fish than game fish. The abundance of species may be represented as: bluehead sucker > flannelmouth sucker > western white sucker > rainbow trout >

Table 3.29.--Rainbow and brown trout population statistics for the Gunnison River for 1981-1988[1]

Species	Size (cm)	Density (number/ha) 1981	1982	1983	1984	1985	1986	1987	1988
		Duncan - Ute Trail Area (2 miles - 3.2 km - 10 ha)							
Brown	15 & up	869	603	586	541	330	469	1,236	936
Brown	30 & up	194	141	139	58	58	112	228	141
Brown	35 & up	71	43	39	18	13	31	72	44
Brown	40 & up[2]	119	97	81	59	32	37	211	44
Rainbow	15 & up	339	392	427	217	346	275	1,110	1,054
Rainbow	30 & up	140	181	253	162	333	193	273	245
Rainbow	35 & up	84	97	146	110	261	190	194	245
Rainbow	40 & up[2]	600	423	651	401	892	1,447	1,573	1,153
		Biomass (in kg/ha)							
Brown		201.2	143.8	134.5	54.6	53.6	69.8	170.2	117.7
Rainbow		110.7	110.3	149.8	84.5	164.5	132.8	236.9	243.0
		Smith Fork - North Fork Area (4 miles - 6.4 km - 20 ha)							
Brown	15 & up	115	186	407	351	249	128	319	255
Brown	30 & up	14	40	128	61	55	76	105	60
Brown	35 & up	8	16	34	22	26	38	53	23
Brown	40 & up[2]	69	120	216	128	126	165	447	152
Rainbow	15 & up	355	228	268	275	205	180	608	452
Rainbow	30 & up	16	66	169	206	193	162	246	229
Rainbow	35 & up	10	16	51	140	140	155	190	80
Rainbow	40 & up[2]	234	192	222	626	770	1,895	2,504	491
		Biomass (in kg/ha)							
Brown		25.8	48.0	104.5	41.8	45.4	33.3	65.0	41.7
Rainbow		50.5	51.3	81.3	99.4	91.3	98.8	185.7	109.7

[1] Data based on population estimates and the length-frequency distribution of unmarked trout captured.

[2] Total fish for the study section.

Source: Nehring, 1988c.

Table 3.30.-- Average length (cm) at age for rainbow and brown trout for the lower Gunnison River, 1981-1988

Age	1981	1982	1983	1984	1985	1986	1987	1988
Brown Trout (North Fork-Austin)								
1+	----	----	----	----	----	21.7	26.4	25.8
2+	----	----	----	----	----	30.9	32.9	30.5
3+	----	----	----	----	----	36.4	37.6	40.0
4+	----	----	----	----	----	39.3	40.2	42.7
5+	----	----	----	----	----	40.9	41.8	41.0
6+	----	----	----	----	----	42.7	42.7	49.0
Rainbow Trout (North Fork-Austin)								
1+	----	----	----	----	----	21.5	36.5	24.8
2+	----	----	----	----	----	32.4	34.4	30.5
3+	----	----	----	----	----	38.7	38.2	37.4
4+	----	----	----	----	----	41.2	39.7	36.4
5+	----	----	----	----	----	43.0	42.4	35.3
Brown Trout (Smith Fork-North Fork and Duncan Ute)								
1+	25.0	23.6	21.5	15.9	19.2	23.4	19.3	20.3
2+	33.9	32.8	29.6	26.1	26.2	30.0	30.7	27.9
3+	39.1	41.8	37.8	32.5	31.8	35.1	37.6	34.3
4+	45.0	47.5	43.7	38.8	36.5	40.0	39.6	38.5
5+	----	52.0	44.0	46.0	38.0	43.7	40.1	45.8
6+	----	----	----	----	----	51.0	45.7	----
7+	----	----	----	----	----	----	48.0	----
Rainbow Trout (Smith Fork-North Fork and Duncan Ute)								
1+	20.5	20.9	19.5	17.2	22.6	23.1	20.8	19.1
2+	34.5	32.1	28.6	23.6	26.9	33.3	32.5	28.5
3+	41.7	38.6	38.0	31.8	33.7	37.6	39.5	36.1
4+	46.2	44.4	40.3	39.9	38.8	40.8	41.0	41.7
5+	----	48.4	47.0	45.1	44.9	42.6	45.3	43.9
6+	----	----	----	43.0	44.0	45.5	44.5	45.1
7+	----	----	----	----	----	----	47.9	44.5

Source: Nehring, 1988c.

Table 3.31.--Species list and percent composition of fishery in Gunnison River below North Fork confluence

Species	Percent composition
Bluehead sucker	25
Flannelmouth sucker	19
Western white sucker	18
Rainbow trout	16
Longnose dace	6
Brown trout	5
Carp	4
Sucker hybrids	4
Fathead minnow	2
Mottled sculpin	1
Longnose sucker	<1
Roundtail chub	<1

Source: Nehring and Anderson, 1982.

longnose dace = brown trout > others. The total trout population downstream from the North Fork was recorded at an all-time high in 1988 with an estimated 14,600 trout, compared to total trout population estimates of 5,900, 5,900, and 11,700 for 1982, 1986, and 1987 (Nehring, 1988c).

Total trout biomass estimates in the reach below the North Fork were 32.2, 25.6, 51.4 and 57.2 kilograms per hectare (kg/ha) for 1982, 1986, 1987, and 1988, respectively. The population data for 1988 were collected following a summer of unusually low flow and high water temperatures. The CDOW believes that recent population increases in this reach are due largely to high numbers of young trout moving out of upstream reaches where high spawning success occurred in 1986 and 1987 (Nehring, 1988c). Farther downstream, suckers and minnow species tend to dominate the Gunnison River between Delta and its confluence with the Colorado River near Grand Junction.

A number of factors could potentially limit trout populations within the Gunnison River, including water quality, predation (which includes fishing), prey density, and suitable habitat. The decline in water quality below the North Fork contributes to the decrease in trout density and biomass. Reduced reproduction may result from siltation and high spring flows. Summer water temperatures near Austin commonly exceeds 20 °C. However, Nehring and Anderson (1982) reported healthy, robust rainbow and brown trout during 1981 when water temperature exceeded 20 °C during much of July and August, and trout density and biomass were at an estimated all-time high in the low water year of 1988 (Nehring, 1988c). In July and August of 1981, flows averaged less than 300 ft^3/s, and in 1988, between 300 and 400 ft^3/s.

Prey are not believed to presently limit the growth of fish in the Gunnison River. Bio/West, Inc. (1981), sampled macroinvertebrates (primarily aquatic insects) near Delta during 1981, identifying 25 species of macroinvertebrates in riffle habitat and 18 species in run habitat. Backwater areas were also sampled. The riffles were dominated by mayflies, caddisflies and midges (see attachment C). Beetle larvae and stoneflies were also abundant. The species abundance in runs generally mimicked that found in the riffles. Midges and oligochaete worms dominated the backwater areas. Bio/West, Inc., also reported diatoms as the dominant phytoplankton (floating, minute plants). [For information on periphyton density (plants attached to rocks, etc.), see attachment C.] Invertebrates were commonly found in the stomachs of suckers, the red shiner and the roundtail chub (Bio/West, 1981) suggesting a healthy lower trophic structure. Stanford and Ward (1983 and 1984) reported very high invertebrate biomass estimates on the Gunnison River near the North Fork confluence and provided detailed information on stonefly populations (1989). Additional invertebrate information is contained in Wiltzius (1978).

Angling had a significant impact on the structure of the game fish population before specialized fishing regulations on the Gunnison River. These regulations are briefly summarized in table 3.28 and consist of harvest restrictions on the number of fish within certain size categories. Table 3.32 summarizes rainbow and brown trout exploitation or harvest rates for two sections of the Gunnison River in the early 1980s before special regulations. Nehring (1983) indicated nearly twice the exploitation rate of trout on the North Fork-Smith Fork section of the river compared to the Duncan-Ute Trail area, the difference being greater in 1988 (Nehring, 1988c).

Table 3.32.--Annual rainbow and brown trout exploitation or harvest rates for two sections of Gunnison River (in percent)

		Harvest rate (%)	
Year	Species (trout)	Duncan/Ute Trail	Smith Fork/North Fork
1982	Rainbow	31.7	54.7
	Brown	21.1	41.3
1986	Rainbow	8.2	20.7
	Brown	7.3	27.6
1988	Rainbow	3.1	37.1
	Brown	3.7	31.9

Source: Nehring, 1983, and 1988c.

Restrictive regulations have had a positive impact on the fishery (Nehring and Anderson, 1985a). Harvest rates have declined, although catch rates have increased recently due to special regulations. Therefore, angling probably played less of a role in the structure of the fish community in the late 1980s than before size-oriented regulations. Predation by snakes, otters, eagles and other animals could also affect the fishery but are probably not significant factors when compared to the effect of habitat conditions, and, to a lesser extent, fisherman harvest.

During the summer of 1989, a series of severe thunderstorms caused flash floods in the Gunnison River between the Black Canyon of the Gunnison National Monument and Delta. Large amounts of sediment and debris entered the river. The immediate results were a large fish kill of both trout and nongame fish. CDOW surveys showed a substantial decline in the number of trout in the Gunnison Gorge area. At the Duncan-Ute trail area, rainbow trout populations declined 76 percent from 1988 levels and 46 percent from the 9-year average population. Overall brown trout populations declined 28 percent from 1988 and 3 percent from the 9-year average. Spawning bars and other areas were heavily silted. During the floods, the Gunnison River was flowing between 300 and 400 ft^3/s, which was not a sufficient flow to dilute or remove the sediment. In the long term, a flushing flow would be necessary to clean the sediment from the pools and other areas of the river. By the spring of 1990, much of the silt had been removed from riffles and runs, but substantial deposits remained in ponds and other slack-water areas.

Habitat

The presence or absence of suitable habitat for trout reproduction and spawning, a function of flow, is perhaps the most important factor influencing trout populations in the Gunnison River because this river is managed as a wild trout fishery and is not dependent on hatchery stocking. Table 3.33 provides a description of life cycles for rainbow and brown trout in the river. Brown trout spawn the river between mid-October and mid-November (Nehring, 1988b). Incubation of the eggs requires approximately 100 to 120 days, with hatching occurring in late March. These sac fry spend several weeks within the gravel substrate of the river before sac absorption, swim-up, and active food foraging. Conversely, rainbow trout begin actively spawning around April 1. The onset of spawning may vary by 2 to 3 weeks, depending upon the water temperature (warmer water results in earlier spawning). Rainbow spawning generally ceases in May, followed by a 30- to 60-day incubation period (average, 45 days) and a 1- to 3-week period between the time of hatching and swim-up. Therefore, stable flows sufficient to prevent redd desiccation from mid-October through late February to late March

Table 3.33.--Rainbow and brown trout life histories on Gunnison River

Life history progression				
Spawning -->	Hatching ----------------------		> Swim-up fry -->	Fingerling
		Brown Trout		
(Oct. 15 to Nov. 15)	(March 1 to April 15)	4-6 weeks in gravel	(April 15 to May 15)	(July 1)
		Rainbow Trout		
(April 1 to May 15)	(June 1 to 15)	2-3 weeks in gravel	(June 15 to July 1)	(July 30)

Source: USDI, Reclamation, 1988.

seem best for natural reproduction and recruitment for brown trout. Stable flows from April 1 to July 1 are also required to maximize spawning success for rainbow trout.

In 1973, CDOW began efforts on the Taylor River to determine the impact of flow regimes on trout population dynamics. During the late 1970s and early 1980s, the FWS initiated a major effort to increase the amount of information related to streamflow and fish population dynamics. Their effort resulted in a habitat evaluation methodology called the Physical Habitat Simulation Model (PHABSIM) and numerous other computer habitat models designed to derive the wetted perimeter for a stream and the weighted usable area (WUA) for various life stages of trout.

The PHABSIM model compares habitat within a stream or river, expressed as a mathematical function of flow, depth and substrate to the fish's preferred habitat. Preferred habitat is expressed as a mathematical function based on field measurements of flow, depth, substrate and simultaneous collection or observation of fish. The function is termed a preference curve and is theoretically independent of the specific stream. Nehring and Anderson (1985b) and Nehring and Miller (1987) verified the PHABSIM model for the Gunnison River from 1981 through 1986.

Figures 3.11 and 3.12 illustrate the amount of available adult rainbow trout habitat (expressed as WUA) that presently exists in the Gunnison River as measured in two river reaches. Adult summer habitat conditions above the North Fork appear best at flows ranging from 400 to 1,000 ft^3/s, while winter habitat conditions are best at flows ranging from 300 to 400 ft^3/s. The WUA-flow relationship is similar for the Duncan Trail area, only a much broader range of flows is optimum. Figure 3.13 indicates that spawning conditions for both rainbow and brown trout above

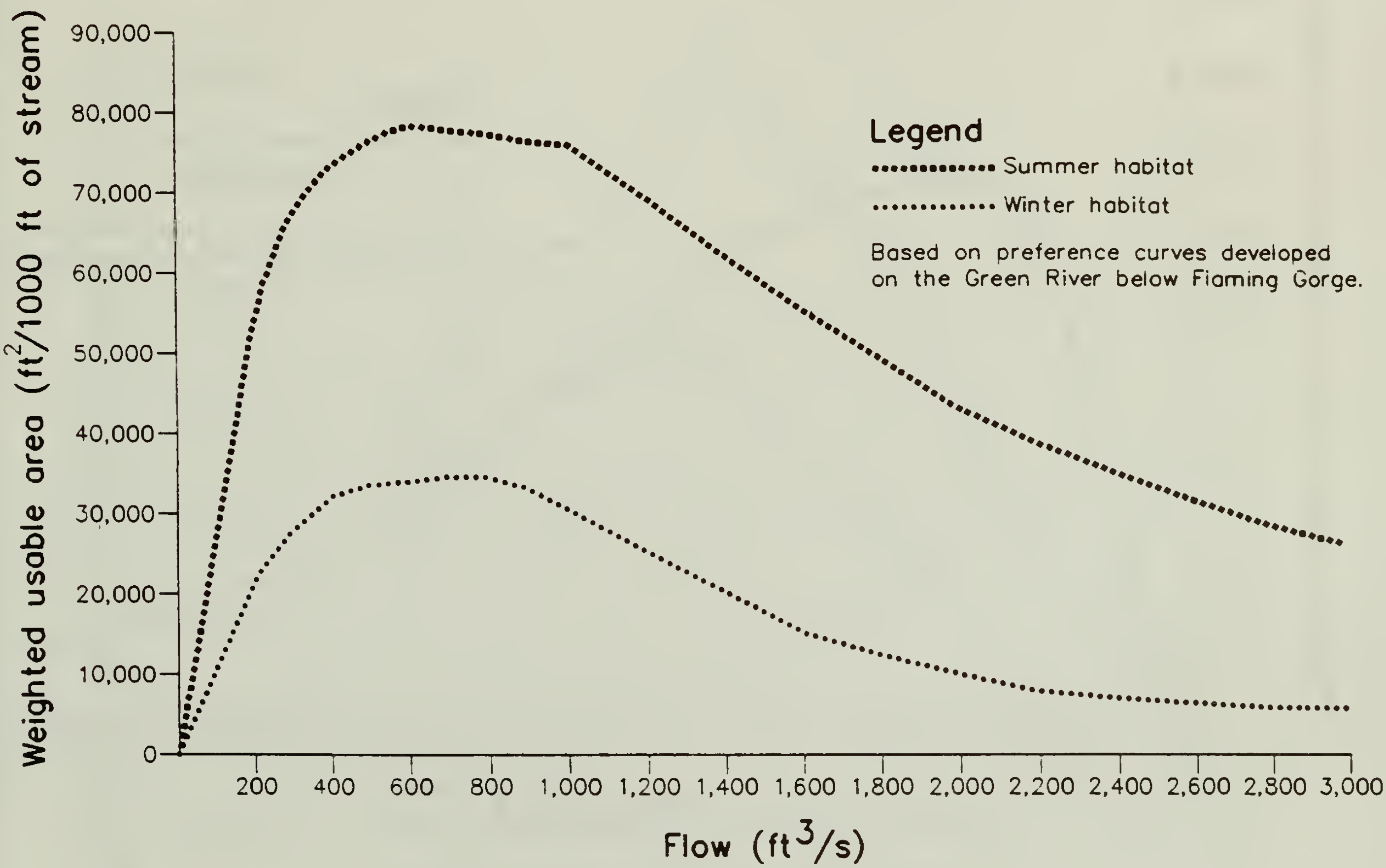

Figure 3.11. Adult rainbow trout habitat (Gunnison River at Duncan Trail).

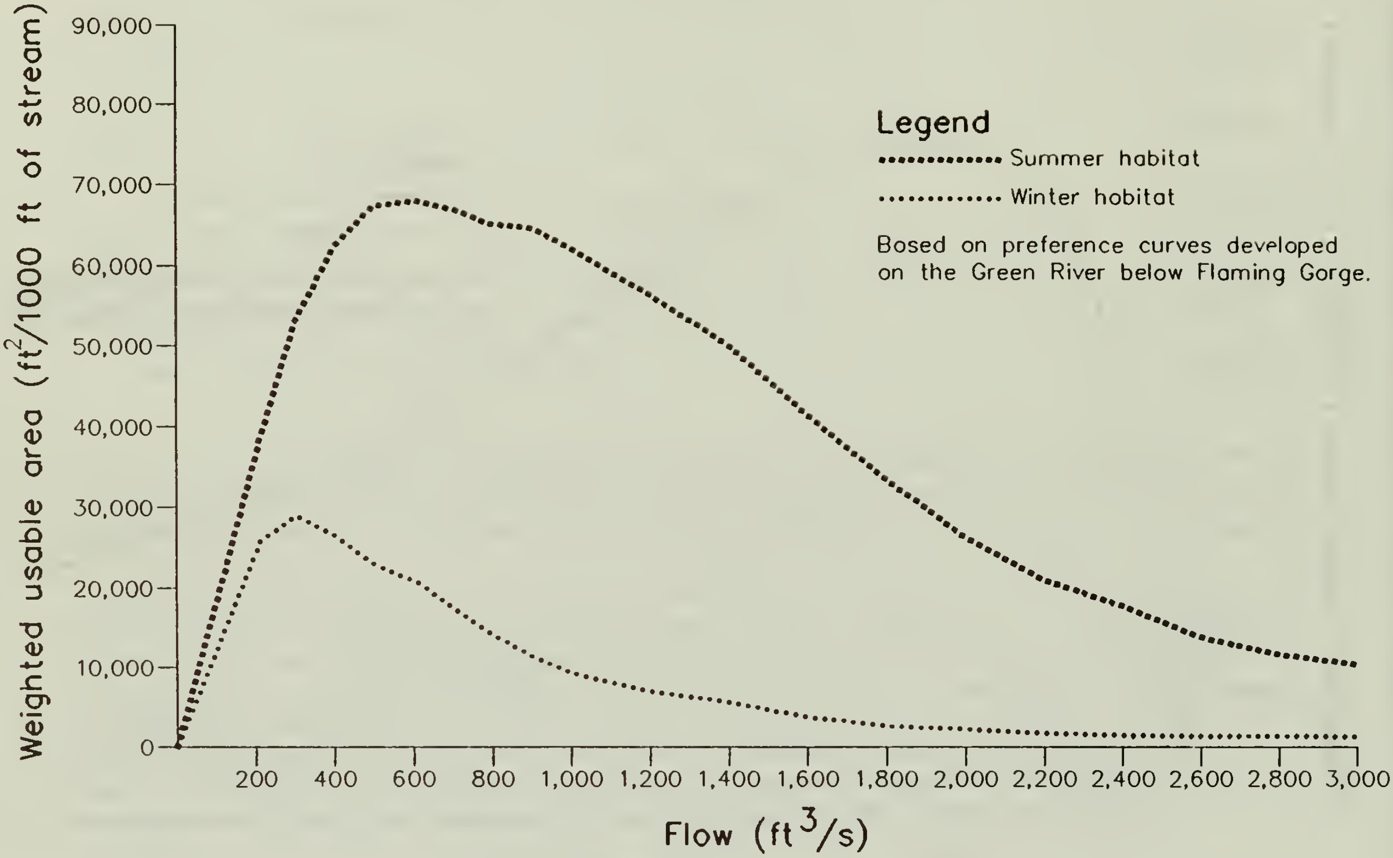

Figure 3.12. Adult rainbow trout habitat (Gunnison River above the North Fork).

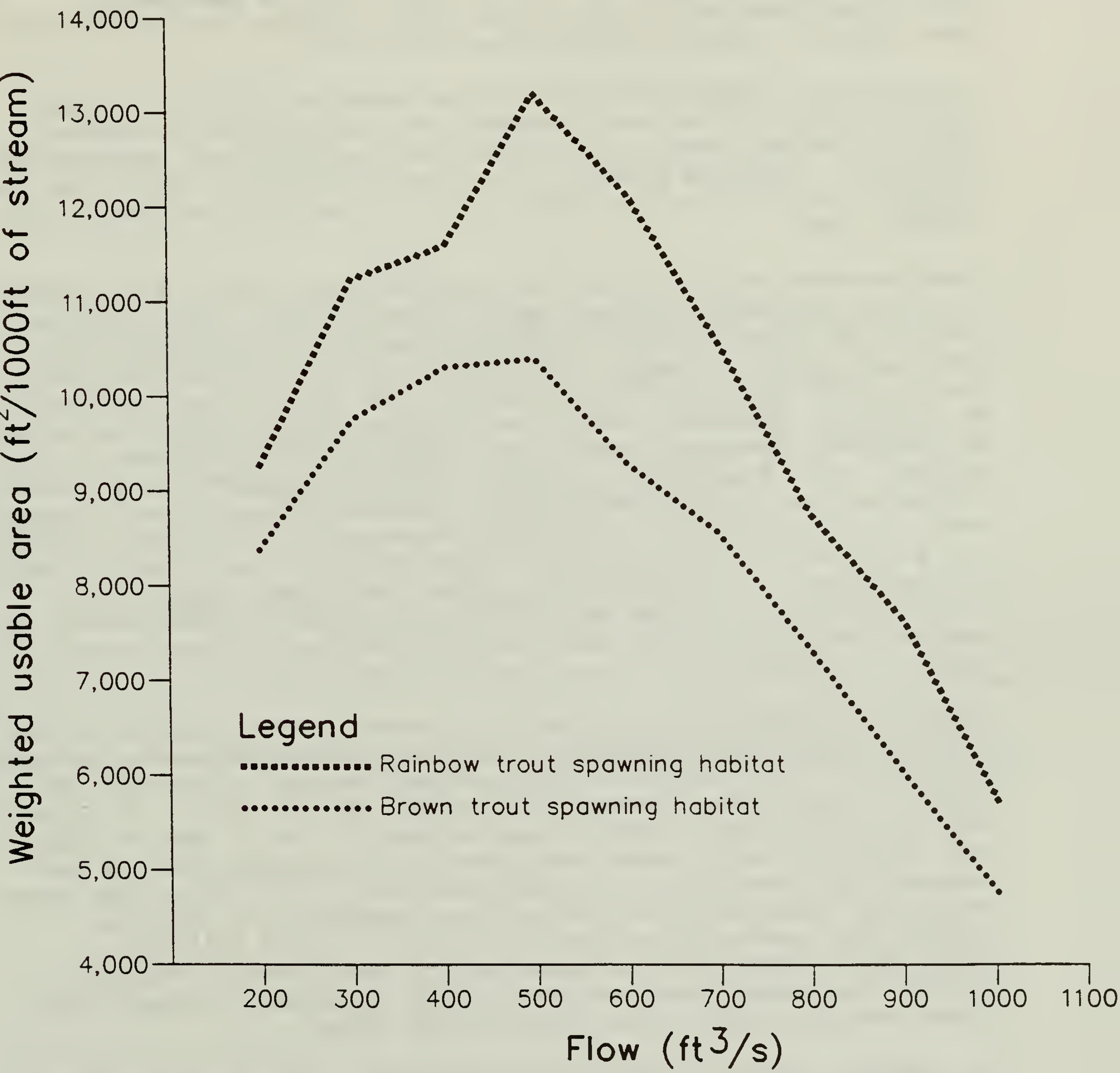

Figure 3.13. Rainbow and brown trout spawning habitat (Gunnison River above North Fork).

the North Fork are optimum at 500 ft^3/s. Spawning habitat appears to be limited at the Duncan Trail site, with a maximum of 700 square feet per 1,000 lineal feet of river, but follows the same general trend by peaking near 500 ft^3/s.

If brown trout eggs are laid in the spawning gravels at high flows during October and November and these flows are subsequently reduced, many of the redds can be left dry, destroying the eggs. The same potential for egg destruction exists for the rainbow trout during the spawning and incubation period of April through June.

June through early July is the most critical period for rainbow trout and mid-April through May for brown trout. The critical trout life stage in most large Southwestern streams and rivers is the swim-up fry or emergence stage. Near-zero water velocity habitat must be present upon swim-up, or the fry may be destroyed by current. PHABSIM predictions related to the amount of swim-up fry habitat correspond well with field observations (Nehring and Miller, 1987; and Nehring, 1988b). Nehring and Miller's study indicated that rainbow and brown trout age 1-year class strength has a strong positive correlation with monthly flow WUA (PHABSIM) and a negative correlation with mean monthly flow from the year of emergence. In other words, trout year class strength is directly related to the amount of fry habitat available when fry emerge from the gravels and inversely related to mean monthly flow.

Figure 3.14 generally represents a channel cross-section on the Gunnison River within the Gunnison Gorge in relationship to flow. Figure 3.15 indicates that the greatest amount of swim-up fry habitat occurs when flows are below 400 to 500 ft^3/s. At flows of 800 to 1,500 ft^3/s, there is approximately 1 to 2 feet of near-zero velocity water along each bank that produces fair to poor swim-up fry conditions. At approximately 1,500 ft^3/s, the river begins to leave the main channel and inundate the riparian vegetation, producing a high flow window (1,500 ft^3/s to 2,000 ft^3/s) with improved swim-up fry conditions. However, sudden flow reductions are more likely to occur at these high flows and can isolate the fry from the river.

In summary, studies have shown that various flow-related factors greatly influence the Gunnison River fishery:

1. A flow of 200 ft^3/s is an adequate minimum, but substantial habitat gains occur between 200 and 300 ft^3/s. Available trout habitat drops dramatically below 200 ft^3/s.

2. Stable flows during the spawning and incubation period are needed to protect the eggs.

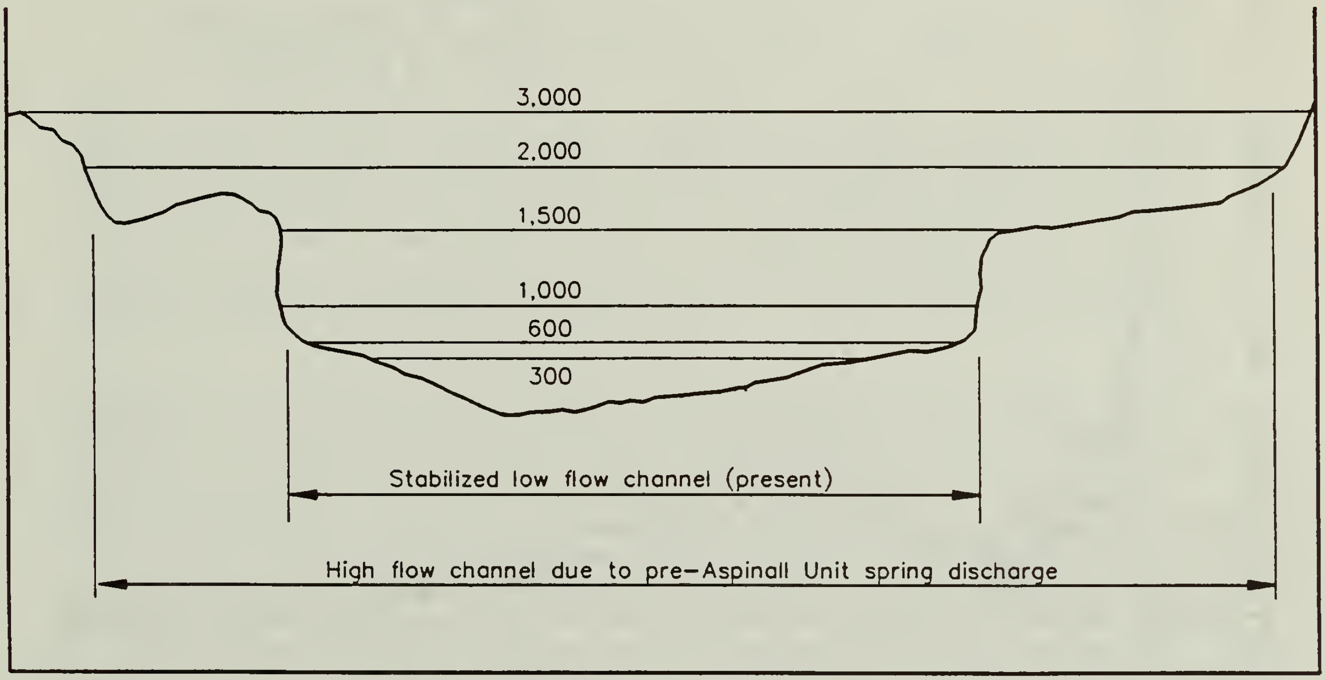

Figure 3.14. Stylized channel cross section (Gunnison River in the Gunnison Gorge, in ft^3/s).

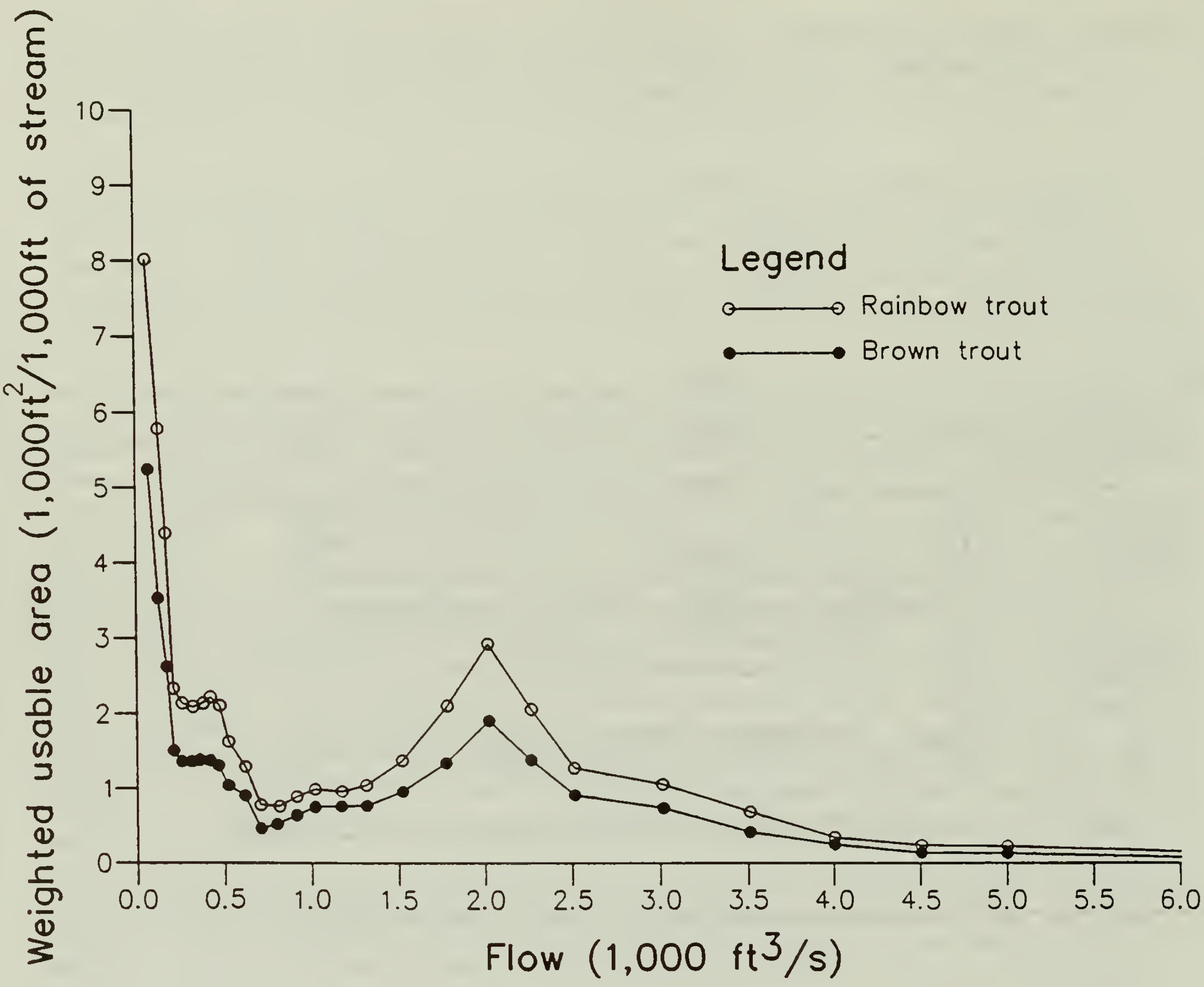

Figure 3.15. 2- 4-week-old fry habitat (swim-up fry) on the Gunnison River (Nehring and Miller, 1987).

3. Medium-to-low stable flows provide the best survival conditions for trout swim-up fry. The 45-day time period (June 1 through July 15) is probably the most critical period in the Gunnison River for rainbow trout reproductive success. The April 15 through June 15 period is critical for brown trout. If significant flow changes are necessary, gradual incremental changes help prevent the total loss of an entire year class of trout.

4. Sudden inflows of sediment during flash floods cause fish kills until the sediment-laden inflow is diluted.

Stanford (1989) has studied the Gunnison River. He estimated that the existing biophysical conditions would be most reasonably protected by both maintaining flows around 600 ft^3/s with as little fluctuation as possible and by minimizing periods of 300 ft^3/s flows (less than 30 days in any 5-year period). Stanford was concerned that a significant shortening of the discontinuity distance[3] would occur if flows were maintained closer to 300 ft^3/s than 600 ft^3/s.

Studies on the Gunnison River previously cited indicate that optimum flows for adult trout are around 500 ft^3/s and the 600-ft^3/s flow stated above would also be excellent. Optimum flows for juvenile and fry, however, are closer to 300 ft^3/s. Also, as can be seen from tables 3.6 through 3.11, minimum flows of 300 ft^3/s are reached under the no-action and development alternatives more often than the recommended 30 days in a 5-year period. Meeting the flow of 600 ft^3/s consistently would result in greater drawdowns on Blue Mesa Reservoir with associated recreation and fishery impacts. At 300 ft^3/s, adult trout habitat conditions are still above 80 percent of the optimum seen at 500 to 600 ft^3/s.

South Canal

The fishery in the South Canal is seasonal, dependent on the movement of fish through the Tunnel. Flows within the South Canal do not occur during the winter because no irrigation demand exists. Because the South Canal is partly located on private land and because it has hazardous sections, it historically has been closed to public fishing.

[3] Discontinuity distance is the distance from a dam to where in the river gradient biophysical conditions resemble those that existed in an upstream area before the river was regulated.

Uncompahgre River

The sport fishery resource of the Uncompahgre River has historically been poor because of high turbidity, heavy siltation, poor substrate condition, poor water quality, poor pool quality, bank instability, high spring flows, and extremely variable summer flows. The fishery habitat in the Uncompahgre River below Colona can be characterized as 24 percent riffle, 75 percent run (72 percent deep-fast, 2 percent deep-slow, 1 percent shallow-slow), and 1 percent pool. The lack of pool and slow deep-run type areas limit the amount of habitat available for adult trout that prefer velocities around 1 foot per second in the summer and 0.5 foot per second or less in the winter. Poor water quality is probably the biggest factor in the low productivity of the Uncompahgre River. With the development of Ridgway Reservoir, the potential for a better sport fishery exists, and the CDOW is now stocking the Uncompahgre River upstream from Montrose.

The CDOW indicates that siltation is the primary limiting factor in the Uncompahgre River (CDOW, 1976 and 1983). The heavy siltation load may reduce primary production (algae and aquatic plants) and secondary production (macroinvertebrates), potential prey organisms for fish. However, this does not appear to be the case above Montrose, as macroinvertebrate populations appear to be in good condition. Below Montrose, however, macroinvertebrate populations are severely reduced. Siltation may also destroy trout eggs, larvae, and fry by suffocation, limiting trout production.

Seven species of fish are commonly found in the Uncompahgre River below Colona: white, bluehead, and flannelmouth suckers; mottled sculpin; speckled dace; and brown and rainbow trout. Suckers and sculpin dominate the river in numbers and presumably in biomass. Rainbow trout are common in the Uncompahgre River for several miles below the South Canal outfall that discharges cold water of high quality from the Gunnison River. The presence of Ridgway Reservoir may also expand the trout population in the river. Most of the rainbow trout in this section originate from the Gunnison River through the Tunnel and South Canal. In general, however, both rainbow and brown trout are uniformly distributed in small numbers between Colona and Montrose. Very few young trout have been collected in this reach, indicating little or no natural reproduction. Below Montrose, both trout species are extremely limited.

IMPACTS OF DEVELOPMENT ALTERNATIVES

Gunnison River

As previously discussed, a number of measurements, including species composition, density, biomass, secondary production and WUA, may be used to quantify a fishery's quality. These same measurements may be used to assess impacts on the fishery from the various development alternatives; however, predicting the degree of impact (e.g., rainbow trout biomass would increase or decrease by a specific percentage) is difficult.

The loss of fish species from the Gunnison River as a result of development would be unlikely. Also, impacts on endangered or threatened fish species downstream are not predicted (see attachment F). Negative impact of the development on the species composition and relative abundance (percentage composition) of fish in the Gunnison River downstream of the Uncompahgre River confluence is also unlikely because the amount of water downstream of the confluence would be unaffected by development. However, a shift in the relative abundance of fish species may occur in the Gunnison River above the confluence. Rainbow and brown trout may comprise a greater percentage of the population after the project is completed, the result of increased trout reproduction because of a higher frequency of low and moderate flows. Flows of 300 ft^3/s between Crystal Reservoir and the North Fork are important during certain periods because of the amount of suitable habitat available for newly hatched swim-up fry. Nehring and Miller (1987) consider fry survival as the critical bottleneck in trout population dynamics within the Gunnison River. Although trout species may become more important numerically than nongame species such as suckers, a decline in sucker numbers or biomass is not anticipated.

Water Temperature

As compared to the no-action alternative, one consequence of the development alternatives would be an increase in the frequency of 300-ft^3/s flows in the Gunnison River between Crystal Reservoir and the North Fork confluence. Figure 3.3 shows an increase of approximately 43 percent in the occurrence of mean daily flows of 300-ft^3/s as a result of the alternatives. Water temperature in the Gunnison would also change with the increase in the frequency of 300-ft^3/s flows. During the winter, the frequency of water temperatures near 0 °C (32 °F) upstream of the North Fork and the formation of frazil and sheet ice would increase. Conversely, water temperature during June through August would be likely to increase, especially below the confluence with the North Fork where the influence of Crystal Reservoir on river limnology is less dramatic.

The increased frequency of 0 °C (32 °F) water during the winter between Crystal Reservoir and the North Fork theoretically could affect the fishery in three ways: (1) increased mortality of brown trout eggs deposited during the previous fall; (2) increased time required for development of brown trout; and (3) decreased growth of game and nongame fish resulting from more frequent occurrence of cooler water temperatures.

Increased mortality of brown trout eggs deposited in redds during fall spawning theoretically could result from anchor ice development or increased scouring by frazil ice. However, according to Behnke (1986), this situation seems unlikely because presently brown trout quite successfully inhabit upper reaches of the Gunnison River where climatic conditions are considerably more severe. Similarly, brown trout are present in a large portion of Colorado at considerably higher elevation and in the North American continent at northern latitudes where climatic conditions are considerably more harsh than in west-central Colorado (Behnke, 1986). According to Behnke, these empirical data should lessen concern that reduced winter flow to 300 ft^3/s in the Black Canyon of the Gunnison would increase the mortality of incubating eggs from ice or the associated effects of lower water temperature. Brown trout are apparently quite adept at selecting redd locations that maximize the probability of egg survival.

Behnke (1986) briefly summarized the attempts of two other scientists to duplicate brown and brook trout redd selection in Wyoming streams exposed to severe winter conditions. Reiser and Wesche (1977, as cited by Behnke, 1986) constructed artificial redds in the Laramie River at sites with ideal hydraulic parameters and placed eggs in these redds. All of the eggs froze in the artificial redds. Survival to hatching only occurred when eggs were planted in natural redds previously constructed by female trout. Physical conditions within the stream bed, such as upwelling of ground water or flow conditions, are apparently critical to egg survival.

A delay in hatching brown trout eggs in the spring may also result from decreased flow in the Gunnison River. Because of additional water diversion for the project, the winter water temperature may decrease by 1 to 2 °F (Behnke, 1986). This would presumably occur further downstream near the North Fork confluence, since water temperature immediately below Crystal is a function of releases from Crystal Reservoir. Behnke (1986) estimated a 7- to 10-day delay in the hatching of brown trout eggs with a decrease in water temperature by 1 to 2 °F for a period of 90 to 100 days. This delay seems insignificant when compared to the natural variability in the normal time of hatching for brown trout in the Gunnison River. Nehring (1988b) observed newly hatched brown trout fry during 1987 as early as

April 11 and as late as June 12. He concluded that brown trout emergence is spread over a 30- to 40-day period in any single year and perhaps historically over a 60-day period.

Increased water diversion for hydropower, resulting in decreased water temperature during the winter and increased water temperature during the summer, could affect the growth rates of game and nongame fish species. As previously discussed, the changes in water temperature in the Gunnison River should be most apparent a substantial distance downstream from Crystal Reservoir, perhaps near the North Fork confluence. The alternatives would result in a mean monthly reduction in flow of 170 (alternative B, E, and F) to 310 ft^3/s (alternative C) in the Gunnison River from June through August. The reductions would primarily occur in high and moderate water years and not in low water years. The result would be a warming of the Gunnison River. Water temperature presently increases from 7 to 16 °C (45 to 60 °F) during July and August between Crystal Reservoir and the North Fork confluence. These temperatures are in the range considered optimal for trout growth and are also suitable for nongame fish species present. With a reduction in mean monthly flow of approximately 200 ft^3/s during the summer below the Tunnel, temperatures near the North Fork confluence may increase by 2 to 4 °F.

The greater occurrence of extended minimum flows of 300 ft^3/s in the Gunnison River after the project is completed would increase the frequency of warmer water temperatures near the North Fork. Nehring (1988c) cited research on trout growth-temperature interrelationships by Elliot (1975a and b) that

> ...strongly supports the hypothesis that water temperatures in the Gunnison Gorge above the North Fork confluence even in a low water year such as 1988 are about as close to optimum conditions as one could probably expect to find in a regulated stream.

Nehring (1982) reported healthy, robust trout near Austin during the summer of 1981, a year when flows approached 230 ft^3/s at the East Portal of the Tunnel and water temperatures routinely exceeded 20 °C (68 °F) at Austin (see table 3.24). North Fork inflows were also considerably reduced during 1981 compared to historic flows. The average weekly water temperature during 1988, also a low flow year, did not exceed 18.1 °C (64 °F) above the North Fork confluence but did reach 20 °C (68 °F) at Austin. Maximum instantaneous water temperature near Austin reached 24 °C (75 °F) during 1988. Nehring (1988c) observed that rainbow and brown trout are growing faster in the North Fork to Austin reach of the river than trout upstream of the confluence despite the low flows and elevated water temperatures seen in 1988.

Although increased summer water temperatures would occur, decreased growth and increased trout mortality would probably not occur under the development alternatives. The Gold Medal and wild trout status should be unaffected. If increased temperatures became a problem, effects would most likely be seen downstream from the North Fork confluence.

Measurements taken by Reclamation near the North Fork and Austin during 1988 showed dissolved oxygen concentrations in excess of 10 mg/l. These concentrations are suitable for maintaining a trout fishery and should be maintained under development conditions.

Macroinvertebrate populations could be affected by the increased diversion of water through the Tunnel by reducing wetted perimeter. Ice is also known to reduce the winter macroinvertebrate populations in Colorado rivers and streams where winters are harsh and ice development extensive (Burkhard, personal communication, 1987). If ice jamming or severe anchor icing occurred to the extent that resulted in significant streambed scouring, macroinvertebrate density and biomass and even fish could be adversely affected. During the 1988-1989 winter, such conditions developed along about 2 miles of the Gunnison River in an area about 2 miles upstream from Delta.

Several investigators have indicated that anchor and frazil ice may increase the number of organisms in the drift by dislodging them from the substrate (Reimers, 1957). However, most studies have concluded that the reduction in total numbers of macroinvertebrates was negligible (Benson, 1955; Brown, Clothier, and Alvord, 1953; and Needham and Jones, 1959).

The break up of extensive ice jams with its subsequent grinding and scouring can severely reduce the macroinvertebrate populations in a river. As described previously, this type of ice jam occurred above the Hartland Diversion Dam near Delta, downstream from the better trout areas in the river.

Benson (1955) concluded that it was doubtful that anchor ice could smother trout eggs under conditions where the ice was intermittent because the ice generally had a rather porous texture. He did suggest that trout swim-up fry would be vulnerable at the time of emergence if ice were present; however, this would not occur on the Gunnison River.

The occasional high winter mortality of trout populations associated with ice conditions apparently is not due to a lack of food or low water temperatures, but rather more likely caused by catastrophic events such as dewatering of stream sections by ice jams (Benson, 1955). This type of extensive ice buildup was not observed in the Gunnison Gorge during the low water winter of 1988-1989. Sheet and shelf ice offer cover to trout along otherwise open stretches of river (Maciolek and Needham, 1952).

Impacts to the game and nongame fishery of the Gunnison River resulting from changes in water temperature seem unlikely, especially considering that the minimum postdevelopment flows and maximum water temperatures would not differ substantially from the low flow conditions observed during 1977, 1981 and 1988. During these low flow years, trout populations remained healthy and viable. Higher trophic organisms such as trout are a direct indicator of the health of the ecosystem. If reduced flows and the accompanying changes in water temperature affected macro-invertebrate populations, these impacts should have been reflected by decreased growth or increased mortality in the fish population. This apparently was not the case, as trout production was excellent.

Alternative F would periodically increase flows during January and February to remove ice buildup within the Gunnison River. Flows would be increased to approximately 600 ft^3/s by reducing diversion through the Tunnel and be maintained for a sufficient time period to remove ice buildup. This temporary increase in flow should have little impact upon the Gunnison River fishery. Spawning by brown trout is complete, and swim-up fry are not present in the river during this period. Adjusting to the temporary increase in flow should be easily made by adult fish. In fact, the temporary increase in flow may have no positive or negative impact on the fishery. Assuming redd selection by brown trout optimizes egg survival by selecting a location unlikely to freeze under extreme conditions (see previous discussion), the additional flows would provide little additional benefit.

Habitat

The use of PHABSIM to investigate relationships between fish habitat and flow has been the subject of considerable discussion, primarily oriented toward whether fish habitat expressed as WUA and biomass are correlated. The data presented previously showing the strong positive association between PHABSIM estimates of WUA and actual trout biomass data suggest that the model works quite well in making predictions about the condition of a fishery in relation to flow.

Although PHABSIM may be used to investigate the historical relationship between flow and (indirectly) the viability of a fish population, it may also be used to indicate potential impacts from flow diversion on the fishery. These impacts may be either beneficial or adverse. A potential impact to the fishery from the project may result from decreased flows in the Gunnison

River. Figures 3.16 and 3.17 represent a habitat time series for spawning, incubation, fry, and adult rainbow trout life stages for the Gunnison River near the Duncan-Ute Trail.

Except for alternative A, each of the alternatives results in similar available habitat for the various life history stages. Available habitat under alternative A (no-action) conditions is generally less. This pattern is consistent at the Duncan-Ute Trail and North Fork sites; hence, only the Duncan-Ute Trail PHABSIM results are presented in the figures. The North Fork area contains more spawning habitat than the Duncan-Ute area. An increase in spawning habitat under development alternatives is also seen in the North Fork area.

The Duncan-Ute Trail section contains large pool-run-riffle complexes and is characteristic of the river in the Gunnison Gorge. The North Fork section demonstrates a broader, flatter channel configuration, characteristic of the river between the Smith Fork and North Fork confluence. About 70 percent of the river downstream of the Tunnel exhibits the Gunnison Gorge characteristic of deeply incised canyon walls, while the remaining 30 percent is typical of the North Fork location.

In evaluating the results of the PHABSIM model, consideration must be given to the best flow for the each of the life stages. For the fish population as a whole, the best flow occurs when reproduction, survival and growth are optimized. However, the best flow for the specific life stages may differ; for example, the best flow conditions for rainbow trout adults are not necessarily the best conditions for swim-up fry or spawning trout. Therefore, the question of which life stage limits the potential of the fishery becomes important. The PHABSIM results must also be interpreted considering knowledge about the fishery gained through collecting field data and observations.

As stated previously, the swim-up fry or emergence stage is probably the most critical life stage for rainbow and brown trout in the Gunnison River. In most instances, Nehring believes that the limiting life stage for both rainbow and brown trout is the swim-up fry stage (Nehring, 1988b). In some cases, the available spawning habitat may be limiting. To assess swim-up fry habitat, Nehring developed a graph of fry habitat versus discharge for the swim-up fry stage (figure 3.15) that shows that low stable flows around 300 ft^3/s from April through July produce the best conditions for the fragile emergence stage. High stable flows around 2,000 ft^3/s also produce excellent emergence conditions as flow moves into the low-lying riparian vegetation (figure 3.14). Between 650 and 1,500 ft^3/s, swim-up fry conditions are fair to poor. However, flows exceeding 500 to 600 ft^3/s are not as favorable for trout spawning habitat (see figure 3.13). Nehring

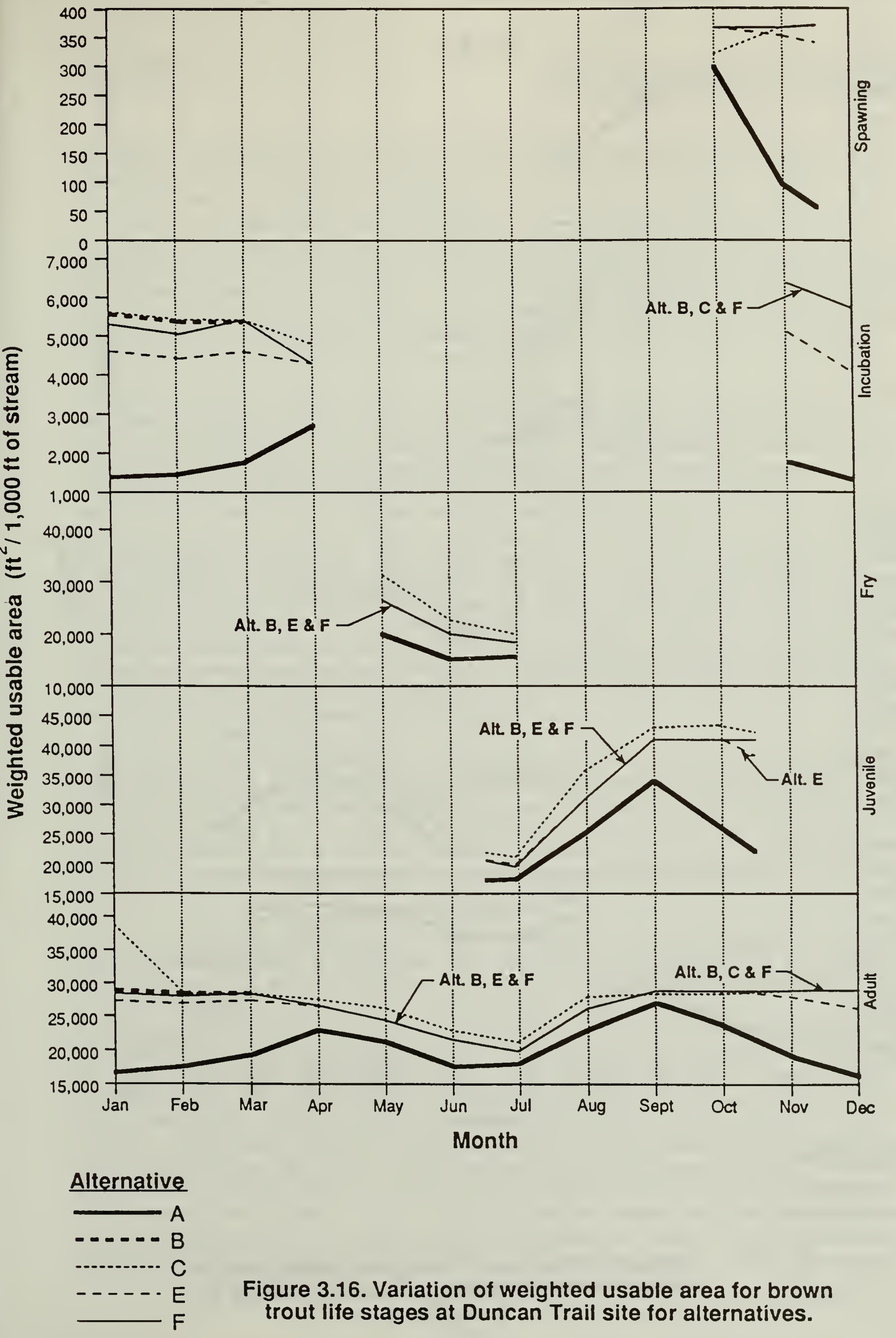

Figure 3.16. Variation of weighted usable area for brown trout life stages at Duncan Trail site for alternatives.

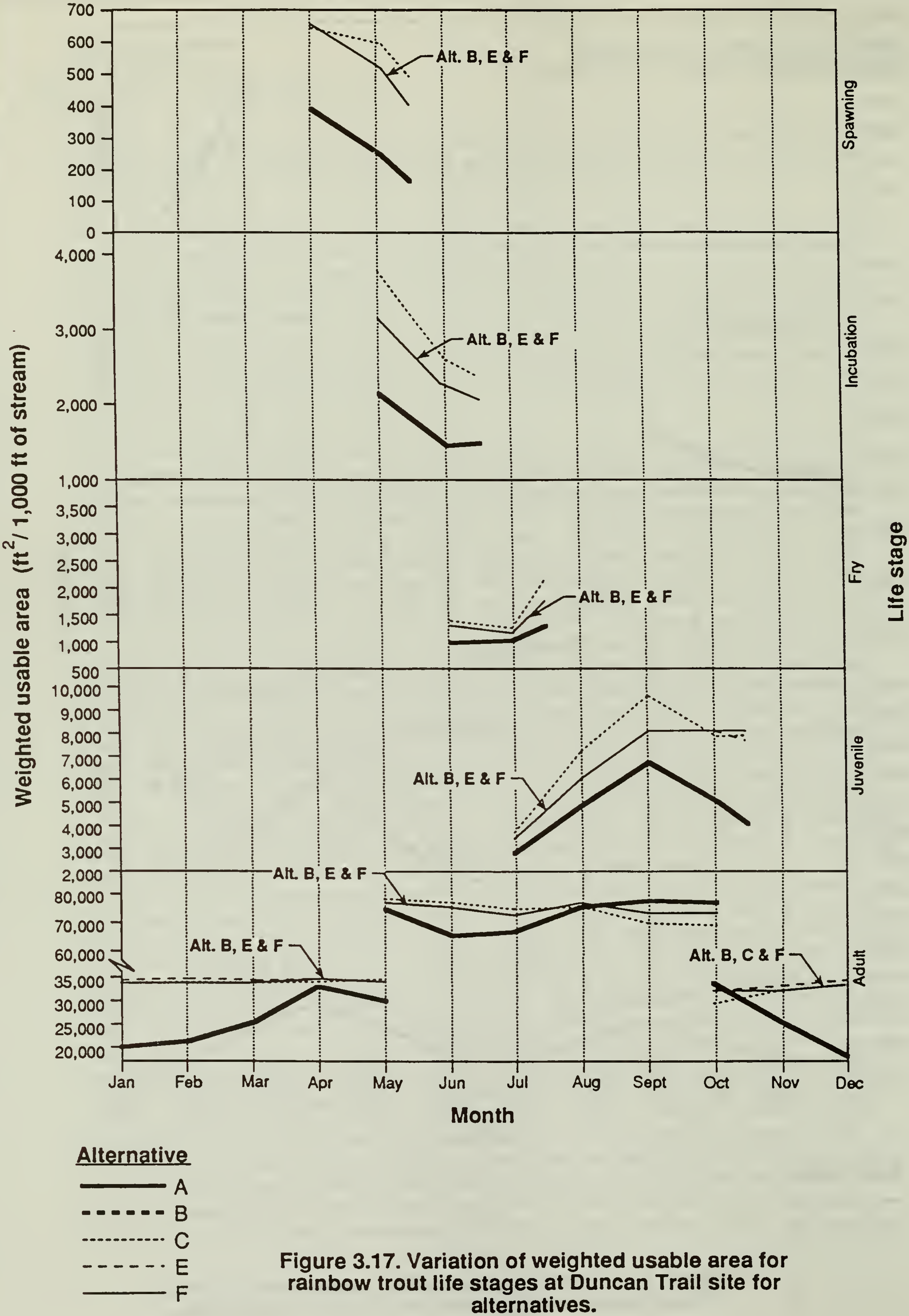

Figure 3.17. Variation of weighted usable area for rainbow trout life stages at Duncan Trail site for alternatives.

(1988b) recommends an optimum flow of 300 ft^3/s between the beginning of May and mid-July for brown and rainbow trout swim-up fry habitat in the Black Canyon.

Compared to the years since Aspinall Unit construction, the frequency of flows near 300 ft^3/s below the Tunnel would increase with development. Therefore, the swim-up conditions would remain adequate and could improve. The PHABSIM model indicates that alternative A provides the least amount of fry habitat, while alternative C provides the most.

Moderate water years where flows between May and July range between 300 and 600 ft^3/s are probably the most important from the standpoint of trout reproduction. With development alternatives, the frequency of these moderate flow conditions during May through July would increase from 60 percent to 70 percent. Mean monthly flows during these months would decrease by approximately 200 ft^3/s in May, 270 ft^3/s in June, and 150 ft^3/s in July because of increased diversion into the Tunnel. This flow reduction would have a positive impact by reducing many May-through-July flow periods into the flow range of 500 to 800 ft^3/s, a range that produces fair swim-up fry conditions. Also, flows in this range would be decreased into the 300- to 500-ft^3/s range, producing excellent swim-up fry conditions. During high water years such as 1983, the swim-up fry habitat and the resulting trout recruitment would remain only fair.

Incubation and spawning habitat for rainbow trout will probably increase by 60 to 78 percent under development alternatives. The PHABSIM model indicates an even greater improvement in brown trout spawning and incubation habitat. Based on the PHABSIM modeling results, a flow of approximately 500 ft^3/s is best for brown trout spawning habitat on the Gunnison River near the North Fork.

Nehring (1988b) recommends a minimum flow of 300 ft^3/s between mid-October and mid-November and between the beginning of April and mid-May to provide spawning habitat for brown trout and rainbow trout, respectively. Nehring also recommends an optimum flow of 1,200 ft^3/s between mid-October and mid-November and 1,000 ft^3/s between the beginning of April and mid-May to provide spawning habitat for brown trout and rainbow trout, respectively, because some of the higher elevation gravel bars are under water at these river stages. However, as previously discussed, these higher flows are not optimal for other life stages such as swim-up fry and adults. Also, eggs laid in these higher elevation gravel bars are subject to dewatering if flows in the Gunnison River drop. Thus, for ultimate reproductive success, it is probably better for the trout to spawn on the lower elevation gravel bars that are less subject to dewatering. PHABSIM results indicate that little difference exists in incubation and spawning WUA for each of the development alternatives. Again, existing conditions (alternative A) provide the least amount of habitat.

The relatively long incubation period for brown trout (October to March) is a critical period. If brown trout eggs are deposited in the spawning gravels during relatively high flows in October and November and flows are subsequently reduced during the incubation period, many redds can be left dry, destroying the eggs. Nehring (1988b) summarized information about redd dewatering. The summary was based on the research of a number of scientists who reported that redd dewatering for up to 8 hours or more for several days to weeks did not have a detrimental impact on egg and embryo survival provided: (1) intra-gravel humidity levels were maintained at 100 percent saturation; and (2) maximum and minimum intra-gravel temperature extremes did not reach the lethal limit. Redd dewatering during the winter is likely to result in freezing the developing embryo.

The CDOW indicates that most redds in the Gunnison River constructed during flows of 1,000 to 2,000 ft^3/s remain wet at flows above 600 ft^3/s. The project would reduce the number of times flows would drop substantially between fall brown trout spawning and spring hatching. Without development, 1,000- to 2,000-ft^3/s flows in October and November dropped 5 times to below 600 ft^3/s by March over the 32-year study period. If the development were in place, this reduction would not have occurred. In fact, it appears that flows in November, the primary brown trout spawning period, would always be in the 300- to 700-ft^3/s range, near optimum for brown trout spawning. Lower stable winter flows at near optimal spawning and incubation levels resulting from development should enhance brown trout reproduction in the Gunnison River. During 5 years of the 32-year period, however, simulated flows dropped from 600 ft^3/s to 300 ft^3/s after brown trout spawning, significantly reducing the amount of suitable habitat. Eggs laid at 600 ft^3/s could be dewatered at 300 ft^3/s, reducing successful reproduction. However, the increased fry survival at 300 ft^3/s should help offset the loss of eggs during these years.

Nehring (1988b) recommends minimum and optimum flows of 300 ft^3/s and 500 ft^3/s, respectively, for brown and rainbow trout adults. In general, CDOW believes that adult habitat is not limiting populations on the Gunnison River. Therefore, a moderate change in the available trout habitat resulting from the project is not anticipated to significantly affect the existing trout population. Figures 3.16 and 3.17 show differences in adult habitat for each of the development alternatives. A gain of adult habitat is shown in most months, but adult rainbow trout habitat show a reduction of approximately 5 percent during August and September. Brown trout habitat increases during the entire year.

As discussed under the existing conditions, excessive siltation can have significant adverse impacts on both the nongame and trout fishery in the Gunnison River. When flash floods occur, impacts are lessened if flows in the Gunnison River are high and the sediment is diluted and carried out of the system faster. Because the AB Lateral Facility would reduce flows in the Gunnison River, the situation could be aggravated. Flash floods from thunderstorms occur in this region during mid-June to mid-September when fishkills historically have been reported. Tables in the streamflow section of this chapter show that the river flows are least affected by the AB Lateral Facility during this period because the Tunnel then operates at or near capacity, particularly during low water years. For May through September, for example, flows would be below 500 ft^3/s approximately 38 percent of the time under alternative A, 50 percent under alternative E, and 69 percent under alternative C.

Thus, the existing problem with periodic siltation would continue under all alternatives; however, it would be aggravated by additional development. The greatest problem would occur under alternative C, the least under alternative A. Fall and winter flows would be reduced with the development alternatives, reducing the river's ability to remove the sediment. However, these flows (even under alternative A) are not high enough to be considered flushing flows to cleanse the river. Winter flows of more than 2,000 ft^3/s would occur only 6 percent of the time under alternative A and would not be predicted to occur at all under development alternatives. Summer flows of more than 2,000 ft^3/s would occur approximately 18 percent of the months under alternative A, 14 percent under alternative E, and 9 percent under alternative C.

The above habitat analyses suggest that physical trout habitat in the Gunnison River below the Tunnel might be enhanced if the facility were developed. The beneficial effect on trout habitat associated with lower flows in the Gunnison River has been previously suggested by others who have studied the possible effects of flow modification on the river trout fishery (Kinnear and Vincent, 1967; Nehring and Anderson, 1983; Behnke, 1984). Kinnear and Vincent studied habitat within the Black Canyon of the Gunnison National Monument and discussed the habitat-type changes with differing flows. Should trout habitat improve substantially, other factors such as prey availability or overcrowding may become important in regulating trout population in the Gunnison. However, the river's reduced ability to remove sediment would periodically reduce the quality of habitat for fisheries.

A summary of minimum and optimum flow needs for various life stages of brown and rainbow trout is shown in table 3.34. These flows are compared to the average flow conditions that would occur with each of the alternatives.

Table 3.34.--Minimum and optimum flow recommendations, by time period, species and life stage, compared to average monthly flows for AB Lateral Project alternatives (ft^3/s)

Species	Life stage	Critical time period	Minimum flow[1]	Optimum flow[1]	Alternative A	B	C	E	F
Brown	Spawning	10/15 - 11/15	300	1,200	994	405	376	455	405
	Incubation	11/01 - 04/01	300	1,200	1,306	467	463	562	481
	Hatching	03/15 - 05/15	300	1,200	1,007	637	586	661	637
	Fry	05/01 - 06/15	300	300	1,098	863	768	863	863
	Juvenile	06/15 - 10/15	300	300	936	723	636	725	723
	Adult	04/01 - 09/30	300	500	984	769	682	771	769
		10/01 - 03/31	300	500	1,228	458	446	539	470
Rainbow	Spawning	04/01 - 05/15	300	1,000	949	683	616	693	683
	Incubation	04/15 - 06/15	300	1,000	1,053	804	720	807	804
	Hatching	06/01 - 07/01	300	1,000	1,287	1,001	915	1,001	1,001
	Fry	06/15 - 07/15	300	300	1,276	1,053	968	1,053	1,053
	Juvenile	07/15 - 10/15	300	300	812	604	516	606	604
	Adult	04/01 - 09/30	300	500	984	769	682	771	769
		10/01 - 03/31	300	500	1,228	458	446	539	470

[1] Source: Nehring, 1988b.

The year-round water diversion from the Gunnison River through the Tunnel could increase the loss of fish from the Gunnison River. Although unquantifiable and probably confined to the 1-mile reach between Crystal Reservoir and the Tunnel, these losses might be important regarding the angling success in this easily accessible and heavily fished reach. These losses could be partially offset by gains made by increasing the amount of trout habitat as a result of reduced flows. Because trout are more dormant in the winter, fewer individuals will probably move toward the Tunnel intake than in the summer, resulting in low trout numbers traveling through the Tunnel in winter. A fish barrier on the AB Lateral inlet to keep fish in the South Canal would be installed as part of the development. The barrier, with 1.5- to 2-inch bar spacing, would be designed to minimize adult fish entrainment, and the Sponsors would coordinate its design with the CDOW.

South Canal

Reclamation and the UVWUA restrict access to the South Canal because of public safety; however, the canal is used by local residents as a fishery. Fish populations are characterized by fish moving through the Tunnel. Under all development alternatives, the fish population in the South Canal will probably remain comparable to or will increase relative to the no-action alternative.

Fish passing through the Tunnel and excluded from the Project intake by bar racks would remain in the South Canal. During summer as under present conditions, these fish would either remain in the canal or continue on to the Uncompahgre River. During the winter, excluded fish would remain in the pool created by the new radial gate installed at the AB Lateral headgate. Sponsors would coordinate with Reclamation and the CDOW to schedule periodic flushing of this pool or other measures to preserve these fish.

The small resident population of trout in Cedar Creek, a tributary of the Uncompahgre River, should not be affected by reduced diversions of South Canal flows to the creek. Reduced use of the creek as a canal could improve habitat conditions. However, agricultural runoff, highly variable water temperatures, and other factors would continue to prevent a viable fishery.

Uncompahgre River

Each of the alternatives would decrease the amount of water entering the Uncompahgre River from the South Canal and increase the amount of water entering the Uncompahgre River from the tailrace. Decreased flow to the Uncompahgre River through the South Canal and increased flow through the tailrace is anticipated to be greatest for hydropower development at turbine design flows of 1,135 ft^3/s (alternatives B, C and F). Therefore, development at 1,135 ft^3/s represents the greatest potential for fishery impacts on the Uncompahgre River.

The fishery in the Uncompahgre River between the South Canal and Montrose and throughout the river is presently dominated by nongame fish species such as suckers; however, evidence exists that the trout population is improving. Although increased water diversion for hydropower would result in reduced flows between the South Canal and the proposed tailrace during the irrigation season, the fish barrier constructed at the AB Lateral diversion would direct adult fish into the canal. Therefore, the number of trout reaching the Uncompahgre through the South Canal should increase slightly due to slightly greater diversions through the Tunnel during irrigation season, assuming that flow conditions alone are important in fish movement.

Trout habitat between the South Canal and the proposed tailrace would be affected by hydropower development. Under the no-action alternative, summer flows on the 2-mile reach of the Uncompahgre River between the South Canal and the M&D Canal generally would range from 800 to 1,100 ft^3/s. Flows would be reduced to approximately 700 ft^3/s as a result of a 1,135-ft^3/s powerplant. Summer flows in the 5-mile reach between the M&D and the Loutzenhizer Canals presently range from 200 to 600 ft^3/s and would be reduced to approximately 150 ft^3/s with the project. Under worst case conditions, summer flows in the 5-mile reach between the Loutzenhizer Canal and the AB Lateral tailrace would decrease from 100 to 400 ft^3/s to 20 (under worst case conditions) to 65 ft^3/s.

Because of the lack of pool habitat between the South Canal and the proposed tailrace, greater historical flows especially between the South and the M&D Canals may have created river velocities greater than those considered desirable for trout habitat. Thus, reduced velocities could increase usable trout habitat between the South Canal terminus and the Loutzenhizer Canal Diversion Dam. However, the 20- to 65-ft^3/s flow regime (worst case) in the 5 miles of river below the Loutzenhizer Canal would prevent significant sport fishery development. The CDOW has made a preliminary estimate that a minimum flow of 60 to 80 ft^3/s would be needed to sustain a fishery. Habitat at 20- to 65-ft^3/s flows would be adequate for a put-and-take fishery in the spring and fall. However, summer water temperatures could exceed the range for trout growth and possibly survival.

Because of the variety of nongame fish species, reduced flows would not be expected to result in a decrease in nongame fish density. Should reduced flows result in severe conditions such as extreme summer water temperature, common carp may displace certain sucker species.

Below the proposed tailrace, development would increase river flows by an average of about 375 percent. Compared to present conditions, this may make the river less attractive for some species such as suckers and make the river more habitable for game species such as trout. However, habitat availability for trout may be limited by increased velocity. Substantially increasing the flow below the proposed tailrace where pools and slow deep runs represent less than 5 percent of the surface area could reduce available trout habitat by increasing the velocity beyond that which is optimum for trout.

Construction activities associated with the bank stabilization program would occur along the edge of the banks and, in some locations, along the edge of the streambed. Because the Uncompahgre River downstream from Montrose does not presently support a sport fishery, significant impacts to the fishery would not be expected to occur. Some temporary displacement of nongame fish such as carp and suckers could occur, resulting from instream activities. However, this loss would be expected to be insignificant. Long-term adverse impacts to fisheries would not occur if bank stabilization measures are installed.

The interaction of all of these altered environmental factors could be expected to have a positive overall effect on the Uncompahgre River sport fishery below the proposed tailrace, but the extent of the effect cannot be accurately assessed. For example, insufficient data exist to determine whether conditions in the Uncompahgre River would improve to the extent that natural reproduction of rainbow or brown trout would occur. However, it is reasonable to assume that the river would be suitable for establishing a plant-grow-take type of recreational fishery. Due to the project's proximity to Montrose, Olathe, and Delta, the demand would be high if available fishery developed.

Another factor limiting the assessment of the positive overall effect on the Uncompahgre River is that much of the riparian land between the proposed tailrace and Delta is in private ownership, which limits public access. In some instances, landowners will allow anglers and hunters to use the property, with prior permission; in others, the land is posted "NO TRESPASSING," and access is strictly limited.

SOILS AND VEGETATION

EXISTING CONDITIONS--SOILS

Project Feature Area

The proposed development would be located in the eastern portion of the UVRP. Physiographically, this area is a plain composed of outwash from the San Juan Mountains to the south of the study area. Its gently undulating or rolling topography has been formed by irregular erosion of the underlying Mancos Shale Formation; this topography is referred to locally as "adobe hills." Elevation in the study area ranges from 6,465 feet above mean sea level at the West Portal of the Tunnel to 5,720 feet at Montrose, for a drop of 745 feet or about 100 feet per mile.

The Mancos Formation is a calcareous marine shale and is fractured and jointed near the surface. About 34 percent of the irrigated acreage in the Uncompahgre Valley consists of soils formed on and from the Mancos Formation (USDI, Reclamation, 1982). Locally, these soils are termed "adobe soils" and have a medium-fine texture and a depth over the parent material varying from a few feet to more than 20 feet. Some contain excessive amounts of salts that dissolved during weathering and deposited in underlying joints and fractures. Return flows of irrigation water from adobe soils often contain high concentrations of dissolved solids, contributing to the salt-loading problem in the Upper Colorado River Basin.

The Sponsors analyzed surficial soil types within a corridor approximately 1/4 mile wide on either side of the penstock alignment from the penstock intake structure to the powerhouse site. The results of this analysis are summarized in table 3.35. The following descriptions of each of the types shown in the table have been extracted from the SCS (U.S. Department of Agriculture, SCS, 1967).

Billings

The soils of this series are deep, well drained, and moderately fine textured to fine textured. They are grassland soils formed on alluvial fans in sediments washed from shale and siltstone exposures and are calcareous throughout.

Depth to shale is generally more than 60 inches, but it is locally between 30 and 60 inches. Fourwing saltbush, sagebrush, and rabbitbrush are characteristic shrubs found on this soil type, often in association with or having been replaced by greasewood and cheatgrass. The soils are moderately productive for alfalfa, corn and small grains if irrigated and managed properly. In some cases, the land is used for orchards.

Table 3.35.--Summary of soil types within the penstock corridor

Soil type	Average slope (percent)	Area (acres)	Percent of total
Silty clay loams			
Billings (irrigated)	1	526.34	36
Billings	1	269.31	18
Persayo	1	35.84	2
Billings	4	18.43	1
Persayo	4	155.65	11
Silty clays			
Chipeta	1	3.07	0
Billings	4	2.05	0
Chipeta	4	4.10	0
Clay loams			
Vernal	1	23.55	2
Vernal	8	33.79	2
Loams			
Uncompahgre	1	10.24	1
Others			
Chipeta/Persayo complex	8	58.37	4
Rough broken land	50	260.10	18
Badland	50	69.63	5
Total		1,470.47	100

Source: UVWUA, 1984.

Chipeta-Persayo

The soils of the Chipeta-Persayo association are shallow, well drained, and moderately to fine textured. Like the Billings soil, these soils formed from weathering of calcareous parent material, primarily the Mancos Formation. Unlike the Billings series, these soils formed on upland slopes and ridges.

The depth to underlying shale layers is usually less than 18 inches, and Chipeta soils are more fine textured than Persayo soils. Typical natural vegetation on Chipeta soils is saltbush, galleta, and squirreltail. A poor cover of annual plants, cactus, and saltbush, with few native prairie grasses, develops under natural conditions on Persayo soils. Neither soils are normally suitable for tillage and are used primarily as range.

Vernal

The soils of this series are deep, well drained, and moderately fine textured. They are grassland soils that formed on stream terraces in fairly uniform, calcareous material underlain by sand and gravel. Because of the sand and gravel layers, tillage is often difficult, frequent irrigation is needed, and damage to farm machinery often occurs. Therefore, soils of this series are used most frequently as rangeland.

Badlands

Badlands consist of barren or nearly barren outcrops of gypsum and shale in various stages of weathering. These outcrops are capable of supporting little vegetation. The land is almost impermeable, runoff occurs rapidly following rain, and active erosion occurs.

Rough Broken Land

Like badlands, this land classification consists mainly of exposures of sedimentary shale and sandstone, gravelly alluvial material, colluvial debris and shallow coarse soils, and generally occurs on mesa slopes. Unlike badlands, rough broken land may support a fairly dense cover of native grasses, shrubs, and forbs; thus, soils of this type are useful as range but are seldom used for agriculture because of their steep slopes.

Uncompahgre River Corridor

Within a corridor 500 feet on each side of the Uncompahgre River, about 75 percent of the surface soils are classified as alluvial and wet alluvial soils. These soils, classified as hydric soils by the SCS, are poorly drained soils that are frequently flooded and generally unsuitable for tillage. The remaining 25 percent of soils within this corridor are of the Uncompahgre series, which the SCS classifies as nonhydric. They are deep, somewhat poorly drained, and moderately coarse to moderately fine textured. In their natural state, Uncompahgre soils are covered by riparian woodlands consisting mainly of cottonwoods and willows. Under cultivation, they are moderately productive and are used for truck farming, hay, and other crops.

Gunnison River Corridor

The major portion of the Gunnison River corridor consists of rock outcrop and extremely shallow soils. Figure 3.18 shows the general location of soil complexes and land types associated with the Black Canyon of the Gunnison National Monument and the Gunnison Gorge. Soil development is limited, with the most extensive soil development in the Ute Park area and between the

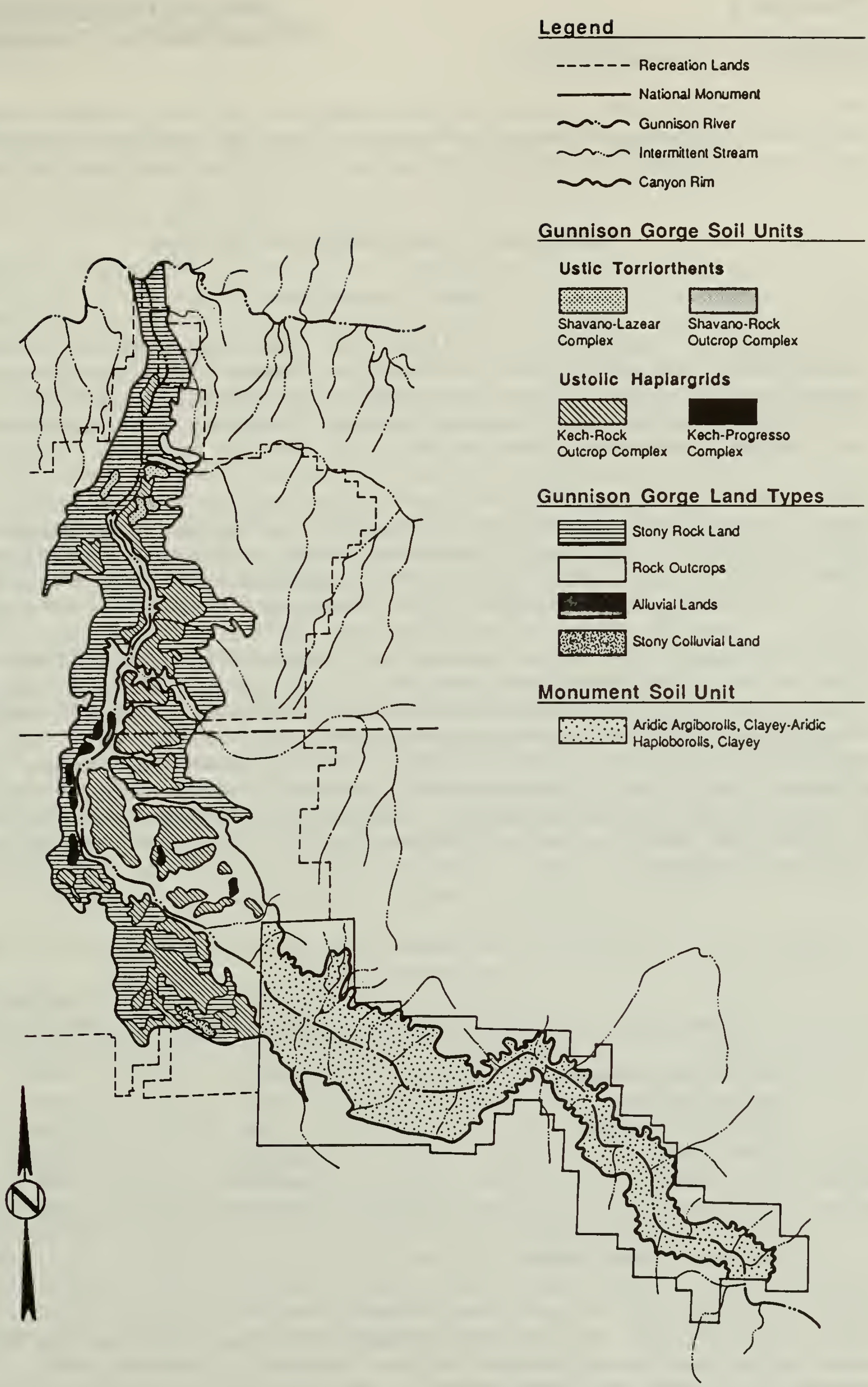

Figure 3.18. Gunnison River corridor soils (Source: U.S. Department of the Interior, National Park Service, 1979a).

Smith and the North Forks of the Gunnison River. Downstream from the North Fork confluence, the canyon and floodplain broaden, soil development is more extensive, and cottonwood groves occur.

EXISTING CONDITIONS--VEGETATION

Project Feature Area

Historically, vegetation in this area has been limited to desert shrub types consisting of saltbush at lower elevations and sagebrush at higher elevations (USDI, Reclamation, 1984). Pinyon-juniper stands occupied valley fringes, and riparian woodlands occurred along the major waterways.

Now a variety of species of vegetation occurs in the study area. Those more typically found on uplands and slopes are intermixed with introduced grasses, forbs and other naturally occurring phreatophytic and mesophytic species associated with riparian zones and wetland habitats. This mixture of species is probably due to a long history of disturbance including construction and maintenance of the canal system and associated facilities, crop production, and livestock grazing. The species present in the study area are distributed generally within four recognizable vegetation types or associations (see table 3.36)--sagebrush-saltbush shrub and half-shrub communities along the proposed penstock alignment, agricultural lands along the proposed tailrace and penstock alignments, wetlands along the existing AB Lateral, and riparian lands along the Uncompahgre and Gunnison Rivers.

Table 3.36.--Distribution of vegetation types in project feature area

Type	Total acres	Percent of total
Native shrubland	885	56
Agricultural	615	39
Urban/developed	68	4
Riparian	10	1
Total	1,578	100

Source: UVWUA, 1984.

Prior disturbance at the powerhouse site has resulted in that area being populated mainly with a variety of annual and perennial plants and greasewood. Greasewood is usually found at lower elevations and typically occurs on poorly drained or disturbed soils. Principal species at the powerhouse site are black greasewood, alkali sacaton, and broom snakeweed. Immediately west of the site are two alfalfa-brome grass hayfields separated by a stand of cottonwoods in which wood and other debris have been dumped.

Natural shrub and half-shrub communities may be dominated by saltbush, sagebrush, or greasewood. In the project area, these community types occur along the penstock route and are a mixture of all of these species. The saltbush community of western Colorado includes several species of saltbush usually interspersed between pinyon-juniper areas and irrigated croplands; dominant species include shadscale and fourwing saltbush. Prevalent grasses are galleta, bluegrass, and bottlebrush squirreltail. Rabbitbrush and broom snakeweed are also common.

The sagebrush community typically adjoins pinyon-juniper stands at higher elevations than the saltbush community. Big and low sagebrush and fringed sagewort are the dominant species in the study area, with rabbitbrush occurring less frequently.

An annual loss of 50 acres of deciduous and evergreen shrublands through agricultural use (50 percent) and housing (50 percent) now occurs in the Uncompahgre Valley (USDI, Reclamation, 1982). Agricultural land consists of cropland, range, pasture, and hayland. Crops in the study area include irrigated corn (which provides food sources for local wildlife populations), onions, and beans. Pasture and haylands are usually developed on irrigated acreage and produce crops of alfalfa and improved pasture grasses. Small patches of uncultivated shrub vegetation often border pastures.

Gunnison River

Mariah and Associates (1987a) characterized vegetation along the Gunnison River as riparian along the river and a complex mosaic of pinyon-juniper and various shrub/grassland types associated with abrupt changes in elevation along the canyon walls. Historically, riparian vegetation along the Gunnison River above the North Fork was probably limited due to extremely high spring flows and the narrow Black Canyon. Water storage and use began upstream in the nineteenth century and has included major storage impoundments such as the Taylor Park and the Aspinall Unit reservoirs. Reducing the high water flushing action has allowed several terraces to expand along the river edge. Stanford and Ward (1984) has described vegetation changes occurring here since the Aspinall Unit was completed.

Riparian vegetation along the Gunnison River now occurs in one of three zones: as a narrow band of grasses generally less than 8 feet wide adjacent to the river, as shrubs in seeps on gentler slopes of the valley walls, and as more well developed seral plant communities on the few low terraces and occasionally where side drainages join the Gunnison River. Primarily, the low terraces have formed recently in response to spring runoff peaks being reduced by upstream dams. Such regulation reduces annual flushing of alluvium from the canyon that might otherwise occur, thereby preserving the substrate needed for plant growth and riparian community development. Reducing periodic high flows also lessens cottonwoods regenerating in areas downstream from the North Fork.

Distribution of riparian vegetation within the canyon is discontinuous. An extremely narrow band of canary grass, the dominant invader species in this area, is present in portions of the canyon composed of granitic bedrock. Weber (1983) surveyed plants in the Black Canyon of the Gunnison National Monument and lists riparian species. The canyon widens in the Ute Trail crossing area and between the Smith Fork and North Fork where surface formations change from metamorphic to sedimentary rock. Extensive alluviation has occurred in these latter areas, allowing larger riparian zones to develop.

Terrace development in the canyon is most extensive near the Ute Trail crossing. The lowest primary terrace, which is the youngest and nearest to the river's edge, is composed of alluvium and has probably developed since the river was first regulated. The second terrace is also alluvium but is an older feature that probably developed before the river was regulated. A third and higher terrace of alluvial deposits also occurs near the Ute Trail crossing. Pinyon-juniper woodlands and shrub communities exist on the higher terrace. In addition to pinyon pines and junipers, a sparse band of boxelders occurs some distance from the river in granite canyon wall crevices that accumulate precipitation.

The vegetative communities and their seral phases in the Gunnison River Gorge are summarized in table 3.37. Species diversity in these communities is low, with each seral stage generally dominated generally by one or two species.

In addition to the species cited in table 3.37, phragmites (a reed) and salt cedar, which are less resistant to the flushing action of high flow, replace canary grass and coyote willow, respectively, in protected locations. Salt grass often replaces canary grass upriver from the Smith Fork, and greasewood is also more common there (Mariah and Associates, 1987a). Downstream from the North Fork confluence, riparian vegetation becomes more extensive with cottonwood groves scattered along the river.

Table 3.37.--Riparian vegetation of Gunnison River Gorge

Location/seral stage	Common name
First alluvial terrace	
Invaders	Canary grass
	Smooth horsetail
Secondary phase	Coyote willow
	Canary grass
Tertiary phase	Coyote willow
	Meadow grass
Second alluvial terrace	
Climax	Big sagebrush
	Rubber rabbitbrush
	Indian ricegrass
	Sand dropseed
	Fourwing saltbush
Colluvial terrace	
Climax	Serviceberry
	Big sagebrush
	Pinyon pine
	Juniper
	Bluebunch wheatgrass

Source: Mariah and Associates, 1987a.

Uncompahgre River Corridor

Cottonwood riparian zones occur along the Uncompahgre River at and downstream from the proposed tailrace. They typically exist as narrow, well-defined, linear stands along river banks or along abandoned water courses and along manmade waterways separating upland grass- and shrub-lands from aquatic habitats. In the study area, such stands are found along the banks of a small, unnamed irrigation ditch immediately west of the proposed powerhouse site and along the Uncompahgre River. They are the most common wetland type in the Uncompahgre Valley (Rector et al., 1979), constituting almost half of the total wetlands (USDI, Reclamation, 1982).

The riparian zone flanking the river is dominated by cottonwood and Russian olive trees and willow and salt cedar. Cattail stands and rush and saltgrass meadows also occur. Open water interspersed with cattails is found in scattered oxbows and sloughs. Greasewood stands occur along some banks. Plants such as thistle, bindweed, and American licorice are common understory species in these stands; they are typically classed as invaders and are found on disturbed sites. Alfalfa, timothy, and brome from nearby hayfields also occur here. See Rector et al. (1979) for additional descriptions.

Cottonwood woodlands are periodically lost due to lateral movement of the Uncompahgre River. Older stands are restricted to protected areas of the flood plain. Cottonwood reproduction is reduced by grazing during the winter along the river and by a reduction in periodic flooding along the river.

ENDANGERED PLANTS

The endangered clay-loving wild buckwheat (Eriogonum pelinophilum) is the only listed plant species inhabiting the project area. This buckwheat, a low, rounded shrub with white flowers, appears to be restricted to Montrose and Delta counties. When the plant was listed as endangered in 1984, only one population in a 100-acre parcel of land was known. However, since then more than 50 new locations have been discovered. Mariah and Associates (1986 and 1987b) described the habitat:

> Little was known about the habitat occupied by the species when the taxon was listed as endangered in 1984. Based on observations during the 1986 and 1987 field surveys conducted by Mariah, E. pelinophilum is restricted to the more weathered and less contoured Mancos Shale formations just west of the highly dissected adobe hills located east of both Delta and Montrose. The species usually prefers the more level terrain, but it can also be found within the large drainage systems. When the species is encountered in these areas it is usually found in patches in smaller side ravines in association with black sagebrush (Artemisia nova). Specifically, the habitat of E. pelinophilum can be characterized as follows: gently rolling to level, loose clay soils in various aspects in association with Atriplex cuneata, Artemisia nova, Hilaria jamesii, and Sitanion hystrix.

Habitat of the type that potentially contains the buckwheat appears to be scattered in patches throughout a 2- to 3-mile-wide band that extends at least 30 miles north to south between Delta and Montrose, on elevations ranging from 5,180 to 6,240 feet. The species appears to follow a band of the habitat, with the eastern edge bounded by the highly contoured adobe hills and the western edge bounded by the level plain that gently slopes towards the Uncompahgre River. The species does not occur in the area beyond these east-west boundaries.

The many small occurrences of the clay-loving wild buckwheat form six large populations. Because all of these sites are within the

Uncompahgre Valley, no major topographic barriers exist (except for the Gunnison River, which only separates one large population, the type locality)[4] between any of them. Approximately one-fourth of the sites are on BLM land and the rest are on private land. Total population and habitat estimates for the species are 45,000 to 50,000 plants and 400 to 450 acres. However, the Uncompahgre Valley has a hopscotch pattern of agriculture, residential development, and adobe areas. Consequently, the habitat of the clay-loving wild buckwheat has been fragmented and several of the occurrences on private land are less than 4 ha (10 acres) in size with 300 plants or less. These remnant sites may not be viable for recovery, especially if they are surrounded by residential developments. Although one-fourth of the sites are on BLM land, these larger rangeland sites contain nearly half of the total numbers--about half of the total numbers are contained on the two bigger large populations, the type locality on private land 10 miles east of Delta and the BLM South Canal locality 3 miles southeast of Montrose (USDI, FWS, 1987).

In a survey of the penstock route, Mariah and Associates (1987b) documented approximately 435 plants in small, scattered locations within and adjacent to the penstock route. The populations were healthy, with a good distribution of age classes and vigorous plants. No noticeable problems occurred with insects, fungus, or parasites. It was also observed that a variety of animal species pollinated the wild buckwheat. No indication was seen that the species were adversely affected by grazing.

According to the FWS (USDI, FWS, 1987), two plants that are candidates for official listing as threatened or endangered also occur in western Colorado--adobe penstemon (Penstemon retrorsus) and adobe desert parsley (Lomatium concinnum). These species also occur on the adobe with or near the wild buckwheat. The adobe desert parsley and the adobe penstemon inhabit barren, dry soils of the type found along the proposed penstock route.

Distribution of the penstemon appears to be similar to the wild buckwheat, although the penstemon has been recorded farther north near Paonia and farther east near Crawford.

Field surveys by Mariah and Associates (1986 and 1987b) failed to locate the desert parsley in the penstock route, but the penstemon was found in approximately the same locations as the clay-loving buckwheat. The plants, which occupied small swales in clay soils between elevations of approximately 5,900 to 6,150 feet, were reported to be healthy and vigorous. Approximately 155 of the mat-forming penstemons were recorded in nine areas along the route.

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[4] Where the plant was originally described.

UNCOMPAHGRE VALLEY WETLANDS

Project Feature Area

The COE and the EPA jointly define wetlands as those areas having saturated soil conditions (Environmental Laboratory, 1986). Wetlands have developed on approximately 10 acres of land along the existing AB Lateral, according to EMANCO (1986b; see figure 3.19). Approximately one acre of wetland also exists at the proposed powerhouse and tailrace site. No wetlands were identified along the proposed penstock route.

The wetlands along the AB Lateral generally exist as narrow, linear bands of phreatophytic or mesophytic species where water has seeped from the downslope or western side of the existing lateral and from smaller laterals and irrigation ditches. However, a relatively large patch of wetland has developed immediately north of U.S. Highway 50 due to lateral leakage. Wetlands may also receive moisture from Cedar Creek, although the amount of water provided by the various sources is not known.

These wetlands are primarily dominated by willow, with Baltic rush and cattail common on wetter sites. A variety of more typical upland species is also common in these wetlands. Rabbitbrush, thistle, milkweed, greasewood, tufted hairgrass, and foxtail barley are subdominants. Willows in several small areas on the upslope or eastern side of the existing AB Lateral between the South Canal and U.S. Highway 50 appear to be in poor condition, possibly from limited water, livestock damage, or other factors.

Wetlands along the Uncompahgre River are in the riverine and palustrine systems. Classes of wetlands include emergent wetlands, scrub-shrub wetlands, and forested wetlands.

Wetlands along the Uncompahgre River can also be divided into four general categories--constructed, terraced, gravel development, and seepage. Constructed wetlands along the river have been developed to provide short-term retention of irrigation return flows or to provide wildlife habitat. Plant species include cottonwood, willow, salt cedar, cattail, and bulrush.

Terraced wetlands are the typical natural wetlands along the river. A terraced effect is present along the river as the result of sediment deposition from periodic flooding. A typical terraced area consists of an abrupt 1 to 2-foot elevation increase above the elevation of the river followed by a gradually sloping first terrace. A series of terraces occur above the first terrace with the fourth terrace often irrigated. The first terrace supports annual plants and early stages of woody plants such as cottonwood, willow, and salt cedar. Frequent flooding and scouring of vegetation occurs in this area.

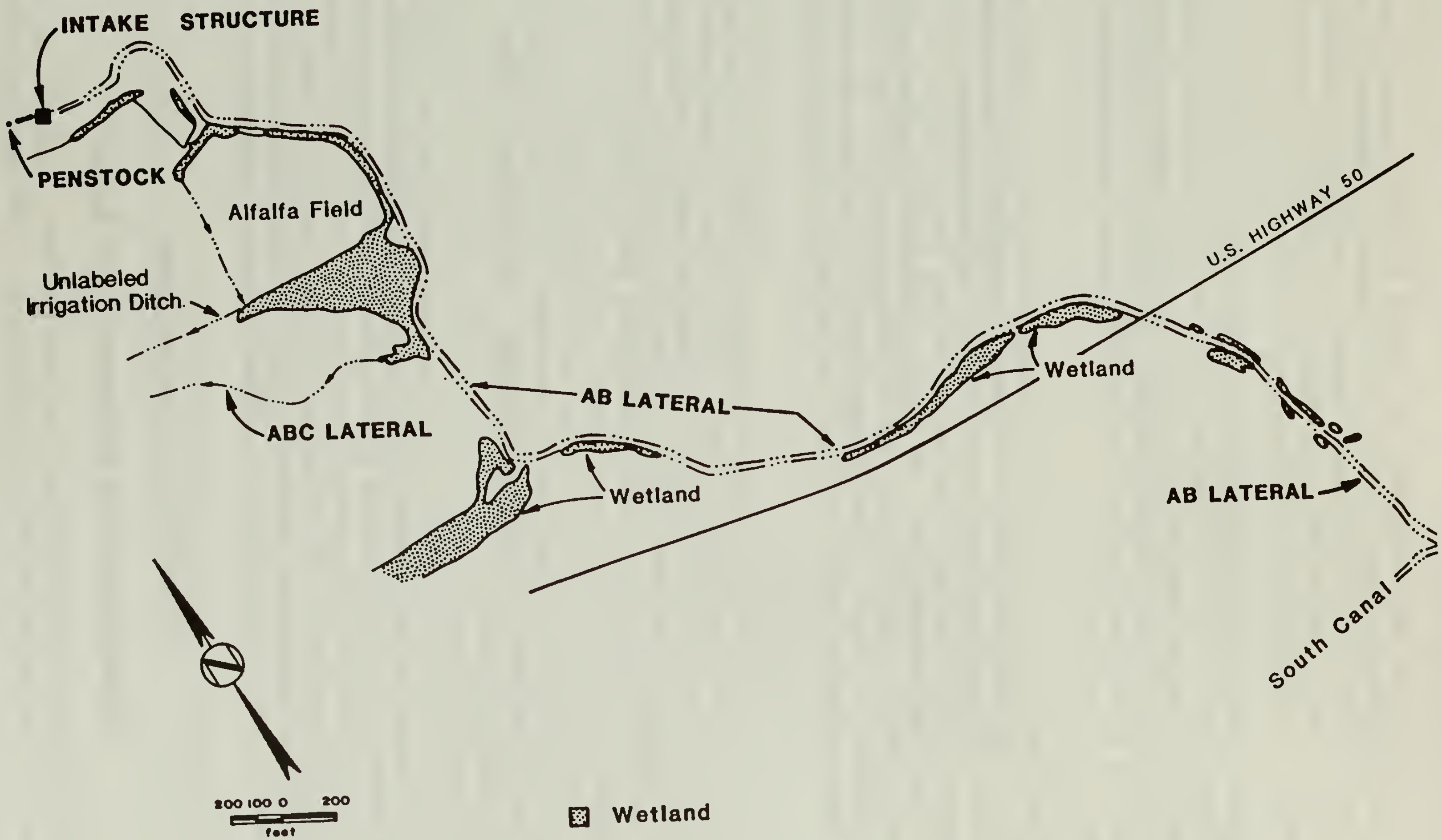


Figure 3.19. Wetlands along AB Lateral.

Mature cottonwoods and willows are found on the second terrace, as well as skunkbush, salt cedar, salt grass, horsetail, and baltic rush. The third terrace supports vegetation adapted to more xeric[5] conditions such as greasewood, rabbitbrush, and big sagebrush.

Abandoned or reclaimed gravel-mined areas occur along the river. These areas have little variation in elevation and are bordered by plants such as spikerush and various other rushes. In the long term, these areas would probably evolve into terraced-type wetlands and would be similar to artificially constructed wetlands.

Seepage wetlands occur along the river in areas of ground-water discharge. The ground-water discharge creating these wetlands is likely from irrigation deep percolation, although some "freshwater" seeps and springs exist along the river. An overstory of cottonwood, followed by a secondary layer of Russian olive, salt cedar, and willow, is characteristic of the flood plain adjacent to these types of wetlands. Ponding of these areas create marshes characterized by cattail, bulrush, and smart weed.

Based on a 1988 aerial photography analysis, field observations and a soils survey analysis, about 1,980 acres of wetlands occur within a corridor approximately 500 feet on each side of the river between Montrose and Delta. Commonly observed plant species in the Uncompahgre River wetlands are shown in table 3.38a.

Functions and values of wetland types were reviewed using the Army Corps of Engineers WET methodology, and table 3.38b summarizes the results.

Construction activities would occur at the confluence of the South Canal and the AB Lateral; along the AB Lateral and the proposed penstock route; along the tailrace and transmission line rights-of-way; and at the powerhouse site. At the powerhouse site and at the site of the proposed intake works on the South Canal, construction would disturb only a negligible amount of vegetation, consisting mainly of annual invader species.

IMPACTS OF ALTERNATIVES

Project Feature Area (Alternative A, No Action)

Under the no-action alternative, no significant changes in vegetation in the study area are predicted. The general area

[5] An arid system almost totally lacking water.

Table 3.38a
Commonly observed plant species in Uncompahgre River wetlands

Scientific name	Common name	Regional wetland indicator[1]
Anacardiaceae - Sumac family		
Rhus trilobata	Skunkbrush	FAC[2]
Asteraceae - Sunflower family		
Artemesia tridentata	Big sagebrush	
Chrysothamnus nauseosus	Rubber rabbit-brush	
Chrysothamnus viscidiflorus	Douglas rabbit-brush	
Chenopodiaceae - Goosefoot family		
Atriplex confertifolia	Shadscale salt-bush	
Atriplex corrugata	Saltbush	
Sarcobatus vermiculatus	Black grease-wood	FACU
Cruciferae - Cress family		
Nasturtium officinale	True watercress	OBL

[1] OBL: Obligate wetland. Occur almost always (estimated probability--greater than 99 percent) under natural conditions in wetlands.

FACW: Facultative* (capable of adaptive response to varying environments) wetland. Usually occur in wetlands (estimated probability--67 percent to 99 percent), but occasionally found in nonwetlands.

FAC: Facultative. Equally likely to occur in wetlands or nonwetlands (estimated probability--34 percent to 66 percent).

FACU: Facultative upland. Usually occur in nonwetlands (estimated probability--67 percent to 99 percent) but occasionally found in wetlands (estimated probability 15 percent to 33 percent).

[2] National wetland indicator used when Regional wetland indicator was not available.

Table 3.38a
Commonly observed plant species in Uncompahgre River wetlands(Con't)

Scientific name	Common name	Regional wetland indicator[1]
Cyperaceae - Sedge family		
Eleocharis palustris	Common spike-rush	OBL
Scirpus acutus	Hardstem bulrush	OBL
Scirpus americanus	Common three-square	OBL
Scirpus paludosus	Alkali bulrush	OBL[2]
Scirpus validus	Soft-stem bulrush	OBL
Elaeagraceae - Oleaster family		
Elaeagnus angustifolia	Russian olive	FAC
Shepherdia canadensis	Canada buffalo-berry	
Equisetaceae - Horsetail family		
Equisetum hyemale	Rough horsetail	FACW
Fabaceae - Pea family		
Melilotus officinalis	Yellow sweetclover	FACU
Trifolium hydridum	Alsike clover	FAC
Trifolium fragiferum	Strawberry clover	FACW
Gramineae - Grass family		
Bromus pumpellianus	Brome grass	
Deschampsia cespitosa	Tufted hairgrass	FACW
Distichlis spicata	Saltgrass	FAC
Echinochloa pungens	Wild millet	
Elymus innovatus	Wild rye	
Phalaris arundinacea	Reed canarygrass	OBL
Phleum pratense	Timothy	FACU

Table 3.38a
Commonly observed plant species in
Uncompahgre River wetlands(Con't)

Scientific name	Common name	Regional wetland indicator[1]
Phragmites australis	Giant reed grass	FACW
Sporobolus airoides	Alkali sacaton	FAC
Juncaceae - Rush family		
Juncus balticus	Baltic rush	FACW
Juncus confusus	Colorado rush	FAC
Juncus interior	Inland rush	FAC
Juncus nodosus	Jointed rush	OBL
Lemnaceae - Duckweed family		
Lemna minor	Least duckweed	OBL
Polygonaceae - Buckwheat family		
Polygonum pensylvanicum	Pennsylvania smartweed	OBL
Salicaceae - Willow family		
Populus angustifolia	Narrowleaf cottonwood	FAC
Salix exigua	Coyote willow	OBL
Salix nigra	Black willow	OBL
Sonanaceae - Nightshade family		
Solanum dulcamara	Climbing nightshade	FAC
Tamaricaceae - Tamarisk family		
Tamarix chinensis	Chinese tamarisk (salt cedar)	FACW
Typhaceae - Cattail family		
Typha latifolia	Broadleaved cattail	OBL

Table 3.38b.--Summary of wetland functions and values by type of wetland

Wetland function	Terraced wetland	Gravel-mined wetland	Artificially created wetland	Seepage wetland	Proposed mitigation area
Ground-water recharge	L	L	L	L	L
Ground-water discharge	H	M	M	M	M
Floodflow alteration	H	H	H	H	H
Sediment stabilization	H	H	M	H	M
Sediment/toxic retention	H	M	M	H	M
Nutrient removal/ transfer	H	L	M	H	I
Production export	L	M	U	L	M
Aquatic diversity/ abundance	L	L	M	H	L
General fish habitat	I	I	I	I	L
General wildlife habitat	H	H	H	H	M
Wildlife breeding	L	L	L	L	L
Wildlife migration	M	M	H	H	H
Wildlife wintering	L	L	L	L	L
Uniqueness/heritage	H	H	M	H	H
Active recreation	L	L	L	L	L

[1] H = high, M = medium, L = low, I = potentially high if improved

would remain one of desert shrubs and grasses. Most of the wetlands along the existing AB Lateral would remain as they have under historic operation of the canal system. Seepage areas along laterals are periodically repaired, drying up wetlands. Changes could also occur due to changing agricultural practices and market conditions. Landowners could expand crop fields or abandon planting, allowing active fields to revert to native grasses and shrubs.

Existing wetland areas on terraces near the Uncompahgre River would be affected by agricultural practices and lateral erosion of riverbanks. This erosion would cause the actual wetland acreage and location to fluctuate from year to year depending on hydrologic conditions. During moderate flow years, wetlands would flourish; during floods, these wetlands would be scoured, resulting in a loss of wetland acreage.

Project Feature Area (Development Alternatives)

Under any of these alternatives, direct impacts to vegetation would be generally restricted to the construction phase of the project. Table 3.39 summarizes impacts of the facility features.

Table 3.39.--Estimated vegetation disturbance due to facility construction and operation (acres)

Feature	Construction	Operation
Penstock (temporary)	172	Less than 1
AB Lateral enlargement	32	12[1,2]
Tailrace	11	6
Transmission line	15	Less than 1
Powerhouse	4	2
Total	234	Less than 18

[1] Includes 1.7 acres of BLM land.
[2] Includes up to 4 acres of seepage-caused wetlands that would be lost by lining the AB Lateral.
Source: USDI, Reclamation, 1988.

Construction activities would occur at the confluence of the South Canal and the AB Lateral, along the AB Lateral, along the proposed penstock route, at the powerhouse site, and along the tailrace and transmission line rights-of-way. At the powerhouse site and at the site of the proposed intake works on the South Canal, construction would disturb only a negligible amount of vegetation, consisting mainly of annual invader species.

Vegetation and soil disturbance associated with other project features would be more extensive and would occur along the AB Lateral, penstock, tailrace, and rights-of-way for the transmission line. In these areas, construction activities would consist of: removing trees and shrubs as needed to gain access to work sites; grading the penstock centerline; marking the centerline of the proposed rights-of-way by land survey techniques; stringing penstock pipe sections and other construction materials; excavating, using backhoes, scrapers and/or other mechanical equipment as needed for burial of the penstock; piling excavated materials temporarily on one side of the rights-of-way; backfilling the penstock ditch with at least 48 inches of cover; excavating for the powerhouse foundation; and fine-grading all disturbed areas and removing excess trash and debris, followed by revegetation as needed.

Of the approximately 234 acres affected, all but about 18 acres would be reclaimed after construction. Shrub-dominated wetlands along the existing AB Lateral would be directly affected by enlarging sections of the lateral and by filling in portions of the existing canal that would be abandoned. Alternative E requires 5 feet less expansion of the AB Lateral than the other alternatives, thus diminishing impacts to adjacent vegetation.

Additionally, lining the enlarged AB Lateral would reduce seepage, thereby conserving water and reducing salt loading. However, this action would also reduce or eliminate wetlands dependent on the seepage from the lateral. These wetlands are primarily willows. The areas would slowly convert to either shrubland or to cropland by landowners expanding adjacent fields. Wetlands along the northern end of the existing AB Lateral could receive water directly as seepage or leakage from the lateral, as seepage or leakage from sublaterals and other ditches, or from a combination of these sources. It is not possible to accurately portray the source of water serving individual wetlands, so it is difficult to project the ultimate effect of diminished seepage from the enlarged AB Lateral. However, a maximum of 4 acres of wetlands would be lost, and vegetation such as sagebrush, greasewood, or saltbush would replace the wetlands.

Portions of the study area are served by existing access roads. Upgrading these roads would remove a negligible amount of additional vegetation, primarily saltbush. Similarly, constructing a new access road along limited sections of the buried penstock and along the transmission line would occur with little loss of vegetation in addition to that removed while constructing these facilities.

Gunnison River Corridor (Alternative A, No Action)

If no development occurs, the soils and vegetation along the Gunnison River corridor would continue to be affected by Aspinall Unit operation and by human use. Changes would be expected to continue as a result of these activities. On one hand, river regulation will aid riparian species invading, while increased human use along the river will continue to trample vegetation. Downstream from the North Fork confluence, the continued reduction of spring flows may lessen cottonwood groves regenerating.

Gunnison River Corridor (Development Alternatives)

The proposed hydropower facility would affect vegetation along the Gunnison River where streamflows would be reduced. All of the proposed alternatives include minimum protected flows of 300 ft^3/s for the Gunnison River; thus, the impacts on the river would be similar. Alternative C, however, would have the greatest frequency of 300-ft^3/s flows as seen in tables 3.8 through 3.16. Mariah and Associates (1987a) conducted an inventory of vegetation in the Black Canyon of the Gunnison River and arrived at the following results in terms of project impacts:

Based on the existing vegetation response to the artificial river flows that exist, the reduced flows would probably allow the riparian vegetation to increase along the river's edge. In most cases, the primary invader would be canary grass. In areas subjected to higher flows with a mixture of alluvium and colluvium, such as at the mouth of side canyons, coyote willow would probably be the primary invader. The various species presently inhabiting the primary terrace would probably not be affected because of the highly capillary nature of the alluvium allowing subirrigation of the terrace. Occasional high water would flood out certain areas.

The vegetation on the second terrace and along the base of the canyon walls would probably not be affected by the reduced flows of the river. In this colluvium zone, the vegetation is adapted to more xeric conditions and has long taproots to reach to deeper water levels or does not require as much moisture. No effect is predicted for the boxelder trees, commonly occurring as narrow bands along the lower canyon wall, as these trees also have a long taproot and have the capability to adjust to a lower water table. Many of the individual trees are aided because they inhabit crevices that act as catch basins for water.

In some areas, coyote willow would be replaced by salt cedar, which appears to inhabit less disturbed sites. This replacement would be minimized with disturbance by high turbulent water.

The reduced flows would increase the exposure of the riverbed between the Tunnel and the North Fork confluence, which would encourage riparian vegetation to grow. However, this growth is not expected to be significant. Low flow cycles experienced since Blue Mesa Dam closed have apparently not resulted in significant riparian invasion. This would indicate that periodic low flows alone (of at least 2 years or less in duration) may not be sufficient to trigger colonization. Although such conditions would increase in frequency with the project, average postproject flows would still be well beyond these low levels, and scouring floods would be relatively unaffected. Perhaps more importantly, the principal project-related flow changes would occur in the winter when vegetation is dormant and seeds are generally nonviable. Riparian invasion is unlikely during these seasons. Vegetation that does invade the channel is expected to be scoured away during floods, which would be largely unaffected by development. After high flow periods, the river would appear the same as without development.

Uncompahgre River Corridor (Alternative A, No Action)

If no development occurs, the Uncompahgre River would become a slightly narrower, more stable river because of the influence of Ridgway Reservoir. Bank erosion and stabilization efforts would continue in the reach of the river within the study area.

Uncompahgre River Corridor (Development Alternatives)

All of the proposed alternatives are similar with respect to impacts on vegetation and soils along the Uncompahgre River. In the reach between the South Canal and the proposed powerhouse at Montrose, the Uncompahgre River discharges would be decreased significantly. This reduction in spring and summer flows would result in a decrease or total elimination of bank erosion. The remaining flows would tend to meander around the existing bars and islands. Riparian vegetation would develop on the newly exposed riverbed. The scouring potential would be slightly decreased so more vegetation would accumulate in the river bottom.

For any of the alternatives, the discharges from the proposed powerhouse would significantly increase the flows in the Uncompahgre River in the reach between the proposed powerhouse and the confluence with the Gunnison River at Delta, but alternative C would show the greatest increase. These new flows of Gunnison River water would erode the banks of the Uncompahgre River; this erosion would be reduced by the bank stabilization program but not eliminated. Sediment eroded from the banks would enlarge some old bars and create new ones. Riparian vegetation would erode in some areas, invade in sediment deposition areas and would encroach into abandoned sections of riverbed.

Under all of the development alternatives, channel and bank stabilization measures to minimize the erosive impacts of the increased flows would be constructed. The Sponsors have coordinated with the COE, the FWS, and the CDOW to reduce effects in wetland areas and to aid in creating replacement wetlands near the river channel.

Wetlands in the Uncompahgre River corridor would be affected by tailrace construction, bank stabilization measures, and changes in water flows in the Uncompahgre River. The change in water flow would decrease wetland diversity in some areas, increase it in others, and cause scouring loss of other wetlands.

The proposed stabilization measures that the Sponsors would install before facility operation would directly affect wetlands along the river. Approximately 7 acres of wetlands would be directly lost due to placement of the revetment, an impact that could not be avoided. These wetlands are primarily forested or scrub-shrub wetlands of the palustrine system. Once the revetment is operating, wetland areas behind the revetment would not be affected. The revetment, which protects the bank without deflecting flows away from the bank, would not include a liner membrane; hence, water supply to the wetlands would not be disrupted. As described in chapter 2, at least two of these riprap revetment sites would be covered with soil to aid growth of shrubs or trees among the rocks. If this program is successful, losses would be reduced.

The increased flows in the Uncompahgre River downstream from the facility tailrace would have both detrimental and beneficial impacts to riverine wetlands. Detrimental impacts include the loss of wetlands due to scour and erosion and the reduction of species diversity in some wetland areas due to more frequent inundation. Many wetlands with long periods of flooding duration have less vegetation diversity than do less frequently flooded areas. Simultaneously, other areas along the river that do not receive a frequent water supply would be flooded more regularly, an action that would increase the diversity of the species and would promote wetland areas. These impacts to wetlands due to flow changes are more difficult to predict than the direct impacts resulting from riprap placement. Because of these uncertainties on the quantification of wetland enhancement and losses, wetlands would be monitored along the Uncompahgre River. (A series of different assumptions were used to estimate the flow-related impacts on wetlands.)

Wetland loss due to scour were estimated by assuming that losses would occur when channel and flood plain velocities exceeded a scouring velocity of 4 feet per second. To quantify this impact, the highest mean monthly flows that occur during the winter with development were analyzed using hydraulic models to determine the areas affected by high scouring velocities. In reaches where the channel or flood plain velocities exceeded 4 feet per second, the water surface area (with development alternatives) was compared to the area that results from the highest mean monthly average flow without development. Results showed a scour loss ranging from 5 acres with alternative E to 15 acres with alternative C; these losses occurred in the channel. Flood plain (overbank) velocities throughout the entire river did not exceed 2 feet per second.

Scour loss of transient, wetland-type vegetation on gravel bars within the river would also occur. These areas have a much greater dependence on the cyclic hydrologic trends of the river. During dry periods, more bars are exposed and more vegetation emerges. During wet periods, these bars are moved downstream by natural degradation and aggradation processes. Because development would increase the frequency of high flows, it was assumed that many of these areas would also be lost. Aerial photography of the river taken in 1988 was used to determine impacts of development (wetland loss). Results showed a range from 6 acres lost for alternative E to 14 acres lost for alternative C.

Detrimental impacts to wetlands caused by more frequent flooding were assessed by comparing changes in water surface elevations and areas. These changes were measured using field cross sections and standard hydraulic techniques. The lowest mean monthly flows occurring during the growing season (hydroperiod) were compared to determine the acreage of wetlands that would have diminished diversity. Impacts would range from an estimated 77 acres of diminished wetlands with alternative E to 130 acres with alternative C. (See table 3.40 for a summary of wetland impacts for development alternatives.)

Table 3.40.--Summary of wetland impacts for development alternatives (acres)

Impacts	Alternative B&F	Alternative C	Alternative E
Stabilization	-7.1	-7.1	-7.1
Diminished diversity	-77.2	-129.6	-77.2
Increased diversity	129.9	190.6	129.9
Scour of channel banks	-14.6	-14.8	-4.8
Scour of gravel bars	-14.4	-14.4	-6.0
Losses along AB Lateral	-4.0	-4.0	-4.0
Direct loss[1]	-11.1	-11.1	-11.1
Indirect loss[2]	29.0	29.2	10.8
Net increased diversity[3]	52.7	71.0	52.7

[1] Direct losses calculated as the sum of stabilization and losses along AB Lateral.

[2] Indirect losses calculated as the sum of scour of channel banks and scour of gravel bars.

[3] Net increased diversity is the difference between increased diversity and diminished diversity.

Source: HDR, 1989b.

Increased flows under development alternatives would also enhance wetlands along the river, since the higher flows would reach areas which do not presently receive a frequent water supply during the wetland hydroperiod. Periodic flooding imports nutrients to the wetlands, exports organic and inorganic material from the flood plain, and is the ultimate determinant of the ecosystem structure and function.

At EPA's suggestion, peak daily flows in the Uncompahgre River, derived from analyzing existing USGS data at Colona together with the hydrologic models used for this project, were used to qualitatively determine the potential areas along the river that would experience increased wetlands diversity. The results indicate that the increased flows could lead to an increase in diversity ranging from 130 acres with alternatives B, E, and F, to 191 acres with alternative C.

Because of the lack of a long-term record on the Uncompahgre River that incorporates the flood reduction effects of Ridgway Dam, the increased diversity potential was also analyzed using mean monthly flows. The results showed that smaller acreage values would be affected, ranging from 77 acres for alternatives B, E, and F, to 115 acres for alternative C. Because these values represent more conservative results (i.e., a lesser value of increased diversity), the mitigation analysis has been conducted based upon the smaller acreages.

The net impacts on vegetation and soils would be lessened by the proposed mitigation measures. Current FWS policy for mitigating unavoidable wetland loss is generally to replace in-kind habitat values on an acre-for-acre basis. As mitigation for the anticipated total direct loss of 11 acres of wetland and riparian habitat, the Sponsors have agreed to create a 12-acre wetland near the proposed powerhouse on land purchased for the project. Additional acreage would be added to alternatives B, C, and F to maintain an acre-for-acre replacement ratio. The replacement area is already within the Uncompahgre River floodplain, and if developed and supplied with water, would be expected to provide habitat equivalent to that lost along the AB Lateral and Uncompahgre River.

In addition, approximately 20 acres of new vegetation would be planted along the Uncompahgre River as a bank stabilization measure, mitigating possible scour losses. The Sponsors would negotiate permanent maintenance easements for the newly vegetated sections of river bank to ensure their long-term success. If the revegetation is not successful, replanting or possibly supplementing the bank or toe with rock would be attempted. If the sites eventually have to be riprapped or otherwise treated (causing the vegetation to be lost), the Sponsors would arrange for equivalent substitution or mitigation on a one-for-one basis.

For example, if one acre of the newly vegetated slope was later riprapped or it eroded, the Sponsors would revegetate an equivalent river section; or they could add 1 acre to the wetland mitigation site near the powerhouse.

The proposed wetland development lies within the 100-year flood plain of the Uncompahgre River and is presently used as an irrigated hayfield. The site would be purchased by the Sponsors to serve as a gravel source for penstock bedding, concrete aggregate, and other construction purposes. Vegetation in this area now consists primarily of clover, brome grass, wheatgrass, and timothy. The surface soils are Uncompahgre loams and wet alluvial and alluvial soils, most of which are hydric and are capable of supporting wetlands. Topsoil at the site would be removed before gravel is extracted, stockpiled, and covered. Then the topsoil would be replaced over the excavated area, providing a source of organic material that would serve as an immediate food source for invertebrates and suitable substrate for vegetation.

The wetland would be herbaceous with a meandering edge. The proposed wetland area would have as its primary source of water flows diverted from the Gunnison River for irrigation and power production. Sufficient flow would be diverted from the tailrace through a small conduit into the wetland area. Because the area is located within the 100-year flood plain, Uncompahgre River flows would occasionally flood the area.

The sands and gravels would be extracted from the area to provide an uneven, rolling bottom contour, which would assist in the development of emergent vegetation and would create heterogeneity. Zones of different water depths would be developed in the area through controlled site grading to create low prairie, sedge marsh, shallow marsh, and marsh open areas. The proposed areas of marsh would include the construction of small islands that would provide nesting and roosting habitat for shorebirds and waterfowl. Slopes would be gradual (20:1) and varied (4:1-20:1) to provide a suitable substrate for colonization of vegetation. Wetland species common to terraced wetlands would be planted along the edge. Anticipated water depths and surface areas of these zones are described in table 3.41.

Table 3.41.--Water surface areas and depths in proposed wetlands

Plant zone description	Water surface area (acres)	Depth (ft)
Low prairie	3	0.0 - 0.5
Sedge marsh	1	0.5 - 1.5
Shallow marsh and shallow marsh emergent	2	1.0′- 2.0′
Marsh open and marsh emergent	5	2.0′- 4.0′

Source: HDR, personal communication, 1990.

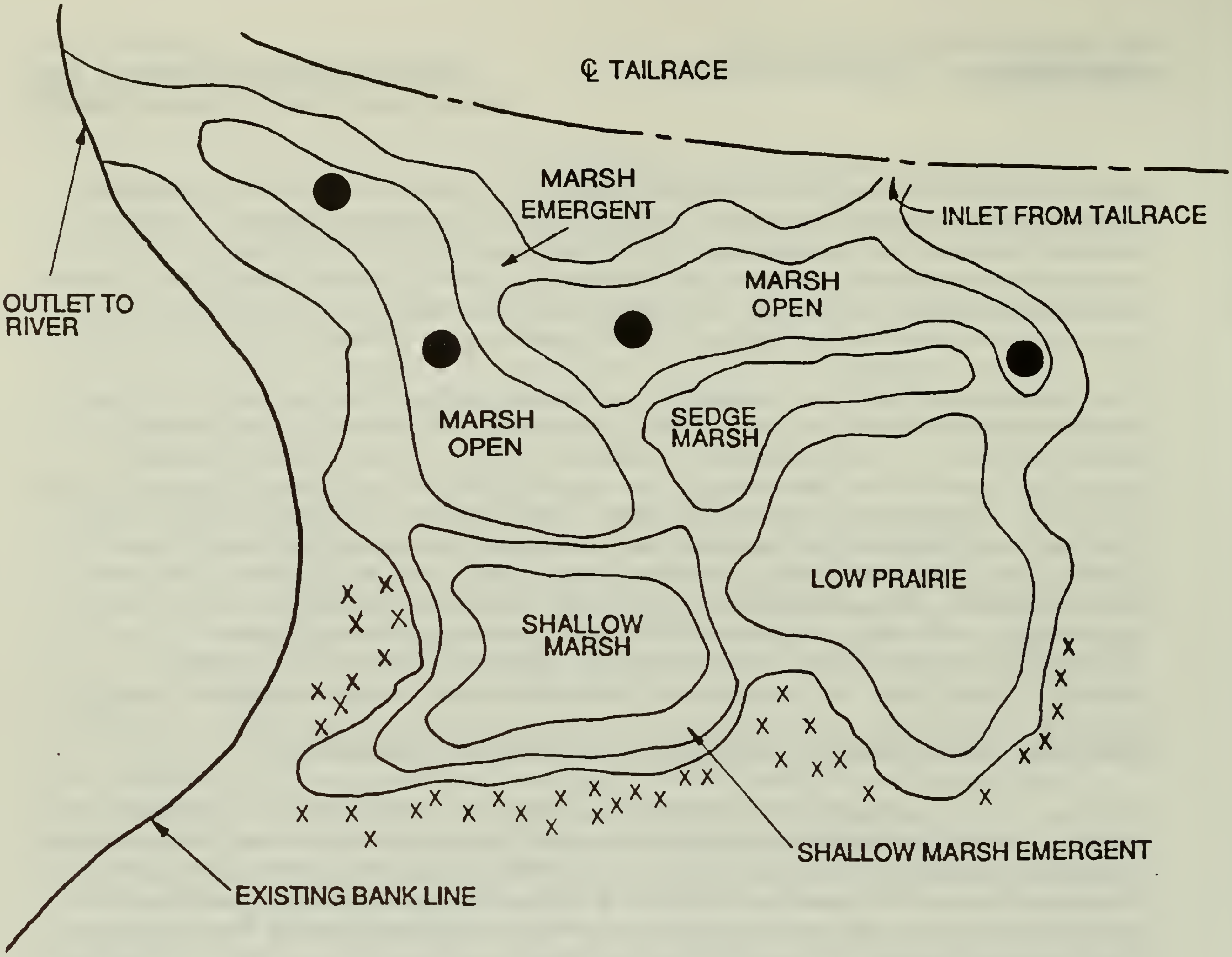
Water would be supplied by a mixture of ground water and water diverted from the tailrace through an 18-inch conduit. Under design operating conditions for the plant, this conduit would provide a constant supply of about 20 ft^3/s to the wetland. This flow would pass through the wetland, mixing with ground water, and would eventually enter the Uncompahgre River.

The wetland would be revegetated after construction activities were completed by using topsoil removed from the site before construction. Supplemental seeding, most likely with native species, would be necessary to establish an adequate ground cover within a reasonable time period. Management responsibility for the wetland would be determined through discussions with the CDOW, the COE, the FWS, Reclamation, and the Sponsors; however, the ultimate responsibility for the wetland would be with the Sponsors. The wetland site would be monitored at least semiannually to ensure successful vegetation establishment. Should plantings or growth be unsuccessful, the Sponsors would reseed, resprig, or consult with Reclamation, the CDOW, the COE, the FWS, and the EPA regarding additional measures.

Figure 3.20 provides a vegetation map of the proposed mitigation area. Final concept development and design of the wetlands would occur after consultation with the CDOW, the FWS, the COE, and Reclamation. As seen on table 3.38b, the mitigation wetlands would only partially replace the wetland values and functions that are provided by existing wetlands along the river. Complete replacement would not be possible for certain functions such as sediment stabilization and nutrient removal and transport.

The new wetland should not significantly affect salt loading to the river because it would be located in the gravel deposits of the Uncompahgre River flood plain. Also, seepage from the wetland would not encounter the Mancos Shale formation.

The bank stabilization program has been designed to minimize the likelihood of project-induced erosion damage to structures, farmlands, and wetlands in areas judged to be the most susceptible to erosion. In unprotected areas, however, the river is expected to erode, deposit, and shift as it has done in the past. While this condition is natural for this river, it would be accelerated by project operation under any of the development alternatives. Overall, this process is not predicted to result in significant net loss of wetlands. As one wetland is eroded, another would be expected to be formed. This has occurred in the past and is expected to occur under alternative A. By increasing water surface elevations, the project may enhance unquantified acreages of potential wetlands by recharging higher elevation grounds in winter and supplementing the numerous back channels and oxbows that line the river from Montrose to Delta. Sponsors



Explanation

● Islands

XXX-Terrace - Type Wetland

Types of wetland	Depth
Marsh open and marsh emergent	2′-4′
Shallow marsh and shallow marsh emergent	1′-2′
Sedge marsh	0.5′-1.5′
Low prairie	0.0′-0.5′

Figure 3.20. (Conceptualized) vegetation cover map for artificially constructed wetlands along the Uncompahgre River.

would be required to monitor wetlands in the Uncompahgre River corridor and to mitigate unanticipated net losses caused by project operation.

All disturbed areas would be reshaped by grading after construction. Landscaping and reseeding would be performed. Additionally, native shrubs and grasses would gradually encroach onto disturbed sites from adjacent, undisturbed areas within the shrubland type. Periodic mowing along portions of the transmission line would be performed, preventing large shrubs and trees from becoming reestablished there. Therefore, a conversion of shrubland to semi-shrub grassland would persist for the operational life of the project. This effect would be partially mitigated by filling in approximately 2 acres of the existing AB Lateral which can be expected to eventually develop a native shrub cover. Croplands and pasture would revert to agricultural productivity or grazing use as soon as they are replanted by the landowner.

ENDANGERED PLANTS

In a survey of the penstock corridor, approximately 435 wild buckwheat plants were documented in small, scattered locations within and adjacent to the penstock route. Because some of these plants grow on ridges and small ravines that run perpendicular to the penstock route, changing the penstock location would not avoid all the plants. Therefore, about 100 to 200 of the estimated 435 plants in the corridor would be destroyed in the 200-foot-wide construction right-of-way. At least four known locations of adobe penstemon are near the penstock route and would be lost during construction. As with the wild buckwheat, this represents a small portion of known populations. Constraints on construction for wild buckwheat habitat would reduce but not eliminate losses of adobe penstemon.

The following conservation recommendations were developed with the FWS (USDI, FWS, 1988a). To reduce losses of clay-loving wild buckwheat and adobe penstemon, special restrictions would be placed on penstock construction in portions of a 2-mile reach where the penstock crosses known populations. Special construction specifications would be developed for these areas and would include but not be limited to the following: Construction rights-of-way would be marked with temporary fencing and would be reduced to 75 feet in selected areas. Access roads would be selected to avoid plants and would be clearly marked to prevent off-road travel. Storage and soil waste areas would not be located in these sections unless the areas were confirmed not to contain wild buckwheat. Topsoil would be stockpiled separately and replaced after the pipeline was placed. The pipeline would be designed to reduce the need for maintenance access in these areas.

In addition, the Sponsors would acquire and transfer to the BLM approximately 60 acres of wild buckwheat and adobe penstemon habitat near Olathe identified by the FWS. If this land were unavailable, the Sponsors would be required to complete an alternative plan as designated by the FWS before operation.

TERRESTRIAL WILDLIFE

EXISTING CONDITIONS

Wildlife Associated with Riparian Habitat

Cottonwood riparian zones typically are used by various wildlife species disproportionately more than any other type of semidesert habitat (Thomas et al., 1979). Cottonwood trees along waterways, accompanied by an understory of shrubs, forbs, and grasses, provide excellent habitat in conjunction with adjacent agricultural lands. In addition to game species, the riparian area is the most important habitat for nongame wildlife, especially birds; this importance is confirmed by Rector et. al (1979) for the riparian areas along the Uncompahgre River.

The cottonwood-Russian olive stands along the Uncompahgre River offer potential habitat to medium and large mammals such as mule deer, coyote, bobcat, striped skunk, badger, mink, raccoon, and red fox. Small mammals and birds include desert cottontail, Colorado and least chipmunks, rock squirrel, white-footed deer mouse, and ring-necked pheasant. Furbearers include beaver, muskrat, and river otters.

River bottoms are also important to wintering waterfowl (the great majority of which are the mallard duck and the Canadian goose) and raptors. Of the raptor species found in the area, the two most common are the American kestrel and the red-tailed hawk, both of which breed here. The golden eagle, prairie falcon, goshawk, merlin, great-horned owl, and the ferruginous, Cooper's, marsh, and Swainson's hawk also occur.

Waterfowl, most commonly the mallard, Canada geese, and teal, use the Uncompahgre River Valley for migration, nesting, and wintering. Nesting and brood areas include the river, canal systems, and small ponds. The greatest concentrations of waterfowl occur during the winter.

During the winter, the river and small ponds provide resting areas for ducks and geese. Agricultural fields are heavily used for feeding. The waterfowl are not uniformly distributed--heavy concentrations occur along certain sections of the river and at several ponds where habitat conditions are better and human disturbance is controlled. For example, more than 90 percent of the ducks counted during January 1990 in aerial surveys of the Uncompahgre River occurred on one small pond and on the section of river downstream from the town of Olathe. Along the river, shallow riffles and gravel bars are important habitat as are springs that enter the river in several locations.

Studies have shown a variety of wildlife along the Gunnison Gorge downstream from the Tunnel. A resident population of mule deer occur in the canyon, and bighorn sheep have been reintroduced (USDI, BLM, 1987). Additional transplants of sheep were made in 1989. Elk also winter in the canyon. The canyon is nesting habitat for the peregrine falcon (D. Madsen, CDOW, 1988; personal communication). The National Park Service (NPS) reports more than one nesting pair (USDI, NPS, 1988). Bald eagles are winter residents along the river.

The river otter (Lutra canadensis) resides in both the Uncompahgre and Gunnison rivers. It was formerly known to occupy all of the major rivers of North America except Alaska and the desert Southwest (Toweill and Tabor, 1982). Its numbers were diminished in Colorado because of trapping, water quality deterioration, riparian habitat destruction, and water diversion (Goodman, 1981).

The river otter was reintroduced to the Gunnison River in 1976 when six animals from eastern Canada were released by the CDOW (Jones, 1977). The subspecies of otter introduced is not considered a candidate species under the Endangered Species Act. One of the release sites was immediately downstream of the Tunnel. Later, 15 more animals were released (Shepherd, 1986). The species has since been observed in the Uncompahgre River and other waterways in the area.

No quantitative data have been collected to date on the fate of otters released in the Gunnison drainage, although sightings have been reported that seem to indicate the otters now occupy the entire Gunnison River and have expanded their distribution to include the Uncompahgre River. According to Beck (1988), the CDOW is currently conducting a study to obtain basic information on numbers, relative distribution, habitat requirements, breeding success, and other pertinent information on the otter population occupying the Dolores River. They will monitor population on the Gunnison and Uncompahgre Rivers when better monitoring procedures are established. Currently, it is unknown as to otter population size and breeding success. There was one confirmed sighting of a female with young on the Gunnison in the spring of 1988. There have been six confirmed mortalities in the area since their release (1976), four from beaver traps, one from shooting, and one from unknown causes (Beck, 1988).

The minimum habitat requirements of the otter in the study area have not been addressed nor has a study of the quantitative change in a local otter population to incremental changes in habitat parameters been performed on any otter population reported in the pertinent literature. EMANCO (1986b and 1987) performed a literature search and found information on the river otter and its biology. Melquist and Hornocker (1983) provided a detailed study of river otter ecology in Idaho. They concluded that the determining factor on habitat use and survivability was the availability of food items, followed by adequate shelter. Shelter generally consists of beaver dens or lodges, dens of other species, dense riparian vegetation, log jams or talus rocks.

Fish compose the bulk of the river otter diet, with crustaceans, amphibians, reptiles, insects, birds, and mammals composing lesser portions (Melquist and Hornocker, 1983; Larsen, 1984; and Mack, 1985). Also, fish are apparently preyed upon in direct proportion to their occurrence and density and in inverse proportion to their swimming ability (Ryder, 1955; Erlinge, 1968; Toweill and Tabor, 1982; and Melquist and Hornocker, 1983), resulting in predation mainly on large, abundant, slow-moving fish, either those that swim slowly naturally or those that are weakened or injured. For example, Mack (1985) indicated that suckers were selected in Colorado in greater proportion than their availability. Fast-swimming species such as trout are taken in lesser numbers than their availability suggests (Toweill and Tabor, 1982), except where they are especially vulnerable such as on spawning beds or in winter concentration areas. Other relatively slow-moving species include carp, chubs, dace, shiners, and catfish, many of which occur in the Gunnison or Uncompahgre rivers.

The presence of open water during winter is also essential to allow the otters access to prey. Apparently, one of the criteria used in selecting this river for reintroduction of the otters was that portions of the Gunnison River currently remain ice free throughout the year. Otters have been documented leaving drainages that freeze completely, concentrating during winter around areas of open water (Greer, 1955). The relative amount of open water needed is not known, although Mack (cited as personal communication in Dronkert, 1982) gave an estimate of at least one opening in the ice per mile of stream (EMANCO, 1987).

Waterfowl use in the canyon is occasionally high in the winter when the isolation and open water of the river provide attractive habitat (see table 3.42). Feeding still occurs in agricultural lands west of the canyon. During past hunting seasons, the waterfowl concentrated in the lower end of the Gorge (D. Madsen, CDOW, 1988; personal communication). This concentration has been

Table 3.42.--Waterfowl counts along the Gunnison River

Date and location[1]	Number counted: Ducks	Number counted: Geese
January 6, 1981		
Above North Fork	257	0
Below North Fork	157	0
January 7, 1982		
Above North Fork	3,451	45
Below North Fork	700	55
January 6, 1983		
Above North Fork	5,231	0
Below North Fork	534	22
January 3, 1984		
Above North Fork	2,706	15
Below North Fork	0	0
January 9, 1985		
Above North Fork	20	0
Below North Fork	119	0
December 5, 1985		
Above North Fork	0	0
Below North Fork	82	0
January 21, 1987		
Above North Fork	0	0
Below North Fork	500	210
December 6, 1987		
Above North Fork	36	5
Below North Fork	541	110
January 8, 1988		
Above North Fork	50	8
Below North Fork	6,128	1,858
December 13, 1988		
Above North Fork	121	2
Below North Fork	56	0
January 3, 1989		
Above North Fork	59	0
Below North Fork	321	26
January 11, 1990		
Above North Fork	700	20
Below North Fork	1,180	400

[1] Above the North Fork includes the Gunnison River from the northern boundary of the Monument to the North Fork. Below the North Fork includes the river from the North Fork confluence to Delta.

Source: CDOW, 1989.

reduced over the last 5 years. The Gunnison River between the North Fork confluence and Delta is also important habitat. Species of waterfowl in the area include the Canada goose, mallard, gadwall, pintail, green- and blue-winged teal, American widgeon, shoveller, lesser scaup, common goldeneye, and common merganser.

Wildlife Associated with Shrubland Habitat

The desert shrub or halfshrub community typically occurs on relatively flat and unbroken terrain and offers little diversity for wildlife except along drainages, canyon edges, and at locations where the community adjoins another, more productive habitat type such as wetland or agricultural land. The mule deer is the most common large mammal found here but typically prefers to use riparian habitat and nearby agricultural land where available. The cottontail rabbit is the most common local game species. Chukars also occur near the AB Lateral. Mourning doves are seasonally abundant, and Gambel's quail and pheasant are also found. While probably not the most common species, the pheasant is probably the most popular game species in the valley. They are an introduced species and are most often found in association with nearby agricultural land or shrub wetlands.

The only raptor thought to breed in the desert shrub community in this part of Colorado is the Swainson's hawk. Other species, however, such as red-tailed hawk, great-horned owl, turkey vulture, and bald and golden eagles, hunt in shrublands.

Small mammals are represented by several species such as the pocket gopher, kangaroo rat, and harvest and deer mouse, but their total numbers are typically low due to the under-developed vegetative cover. Furbearers include the striped skunk, badger, and coyote. Additionally, the number of nongame bird species inhabiting this type of area is usually low, although large numbers of a single species may occur.

Few species of amphibians occupy the desert shrub-type habitat because of the scarcity of water. A small number of reptiles do occur, such as the Great Basin sagebrush lizard and snakes, including the Great Basin gopher snake (EMANCO, 1987). The CDOW (1981 and 1982) also provided additional information on wildlife resources of the Uncompahgre Valley.

Wildlife Associated with Wetland Habitat

Few of the wildlife species in the valley, except for those heavily dependent on water, are restricted to a specific habitat type. Thus, most are occasionally found throughout the year in most of the area's common habitat types. Included are the species previously discussed within the desert shrub community and others that may use wetland habitats, interspersed with other types who use the valley seasonally or daily.

Wetlands are especially important to nongame birds due to the diversity and density of cover found there, particularly during the breeding season. Rector et al. (1979) inventoried a representative sample of wetlands in the Uncompahgre Valley and found 73 species of breeding birds. Shorebirds usually associated with wetlands such as killdeer; common snipe; spotted, solitary, and least sandpipers; and greater yellowlegs occur in the valley. These species are only summer residents and migrate from the area during the nonbreeding season (EMANCO, 1987). Small mammal trapping in wetlands also produced a greater diversity and density of species, with the deer mouse most common, followed by voles and the western harvest mouse (USDI, Reclamation, 1982).

Wetlands are also important to furbearers and herptiles. For example, muskrats require considerably less water than beavers and river otters and therefore may occur in agricultural ditches such as those associated with wetlands in the study area. Similarly, fox, weasel, and skunks are more common in wetland habitats than in other lands, especially when wetlands are interspersed with agricultural land. Herptiles largely confined to wetlands in the study area include toads and frogs.

Wildlife Associated with Agricultural Land

Agricultural lands provide little cover for wildlife but are important habitat areas. Certain crops provide food sources and are important to maintaining local wildlife populations. Croplands provide very important feeding areas for waterfowl in the fall, winter, and spring. Agricultural lands are most important where they border other vegetation types. When a grainfield adjoins shrubland habitat, wildlife associated with the shrubland, such as cottontail rabbit, quail, and pheasant, use grain as a food source. These areas provide a convenient food source close to nesting and escape cover provided by shrubland. Pastureland provides some grazing for mule deer.

Endangered Wildlife

Four species of federally listed endangered species inhabit or may have inhabited the study area--the bald eagle, peregrine falcon, whooping crane, and black-footed ferret (USDI, FWS, 1988a). The bald eagle (Haliaeetus leucocephalus) is a large, long-lived bird of prey restricted in distribution to North America. Sexual maturity is reached at 4 to 6 years of age, but the birds may be considerably older before they breed for the first time. Many birds probably do not reach sexual maturity and few are likely to live until age 30 (USDI, FWS, 1983). The bald eagle winters along many of the drainages of the Colorado River, including the Gunnison River (see table 3.43). In addition, bald eagles are commonly seen downstream from the North Fork and along the Uncompahgre River. Food sources in the study area include waterfowl, fish, small mammals, and carrion. The river corridors are the primary focus of hunting activities, although the eagles do hunt away from these rivers. During severe cold spells, the relatively warm water in the Gunnison River released from upstream reservoirs reduces ice formation and may attract the eagles, and the lack of human activity in the winter in the Gunnison River Gorge may also attract eagles.

Table 3.43.--Summary of various bald eagle counts (1980-1989), Gunnison River between North Fork and northern boundary of Black Canyon of the Gunnison National Monument

Time period	Number of eagles
1980	42
1981	35
1982	83
1983	45
1984	48
1985	32
1986	28
1987	43
1988	24
1989	18
1990	25

Source: CDOW and BLM, unpublished data.

The BLM classifies the Gunnison River as one of high use and the Uncompahgre as one of low use for the bald eagle. Assuming that the presence of eagles indicates the presence of required habitat, wintering areas in Colorado that meet the following criteria should be considered essential bald eagle habitat (USDI, FWS, 1983): locations used annually by 15 or more eagles for two weeks or longer and locations used by bald eagles during periods of extremely harsh weather, when suitable feeding areas and night roost sites are limited in number (the minimum two-week period of use does not apply to this criterion). The Gunnison Gorge area appears to fit these criteria.

Because no way exists to measure the importance of particular wintering sites to bald eagle survival and reproduction, it is suggested that consideration be given to factors such as the length of time an area is occupied by eagles each year, the amount of use the area receives and its potential for supporting more use, the regularity of use over a period of years or during extreme weather when suitable habitat is most limited, and the number and extent of other nearby wintering areas. Preserving such areas is suggested to ensure the survival and recovery of the bald eagles (USDI, FWS, 1983).

The peregrine falcon (Falco peregrinus) nests along the Gunnison River downstream from the Tunnel and historically in the Cimarron Ridge country south of the study area. It is possible they use the Uncompahgre Valley for hunting and during migration.

In the past, whooping cranes (Grus canadensis) occurred in eastern Colorado as occasional migrants. Recently, however, a new population has been established by using greater sandhill cranes as foster parents for whooping crane chicks. Greater sandhill cranes migrate between Idaho and New Mexico, and their migration path includes Montrose and Delta Counties. The whooping crane has recently been observed at several locations in the Uncompahgre and Gunnison River drainages including the Black Canyon, but none of the study area has been identified as essential to the species. The whooping cranes in this new flock have failed to reproduce, so the success of this program is as yet undetermined.

The black-footed ferret (Mustela nigripes) is not known to exist in the Uncompahgre Valley nor are there records of historical sightings in the area. The ferret normally depends on prairie dog towns for food and shelter, but EMANCO (1987) indicated that no prairie dog towns existed in the penstock corridor of the project area.

Several species of vertebrates are candidates for listing as Federal endangered species but are not under any special legal protection. However, the FWS (USDI, FWS, 1988a) has suggested that it is "within the spirit of the Endangered Species Act to consider Project impacts to candidate species." Additionally, such species could be proposed for listing or listed before the facility becomes fully operational.

The ferruginous hawk (Buteo regalis) nests in streamside trees such as cottonwoods and junipers or on low cliffs and cutbanks (Snow, 1974). This hawk has been classified by the Colorado Field Ornithologists (1982) as a straggler in the Delta and Montrose areas, making nesting of the species in the study area unlikely. Less than four sightings of the species in southwestern Colorado have been recorded. The Swainson's hawk (Buteo swainsoni) breeds in grassland and shrubland habitat in western Colorado, and therefore nesting in the study area is possible. However, there have been no reports of nesting in the area. The long-billed curlew (Numenius americanus) is an accidental visitor in western Colorado during migration when it uses wet grasslands, other wet open ground, and areas close to lakes and reservoirs for resting and feeding. Irrigated hayfields and wetlands occur along the proposed penstock route, so the area may be used occasionally by this species.

The CDOW maintains listings of species within the State in need of protection and (or) special management, which include the whooping crane, white pelican (Pelecanus erythrorhynchos), and greater sandhill crane that migrate through the Uncompahgre Valley. NPS (USDI, NPS, 1979a) described use of the Gunnison Basin by cranes and white pelicans as "...brief...during their spring migration."

IMPACTS OF ALTERNATIVES

Project Feature Area (Alternative A, No Action)

Under the no-action alternative, no significant changes are predicted to occur to wildlife in the study area. The wetlands along the AB Lateral would remain as they have under historic operation of the canal system, although periodic lateral rehabilitation work could reduce water seepage to the wetlands.

Project Feature Area (Development Alternatives)

Project operation would have impacts on wildlife, with each alternative having similar impacts. Reduced wildlife habitat would result from seepage control from the existing AB Lateral, vegetation clearing, and other activities during construction. Project structures could result in hazards for certain wildlife species.

Facility construction would affect wildlife use on approximately 234 acres during the construction period. However, all but about 18 acres would be reclaimed after construction by revegetating disturbed areas. The most ecologically important loss would be the permanent loss of approximately 4 acres of wetland habitat along the existing AB Lateral; however, wetland mitigation should reduce resulting wildlife losses.

Hazards

The concrete-lined AB Lateral canal would pose a hazard to wildlife, particularly mule deer. Large and small animals could also fall into the canal while traveling through the area. Large animals would be prevented from entering the penstock, but the smooth, steep sides of the concrete-lined lateral might not allow the animals to escape. Two deer escape ramps would be included in the enlarged AB Lateral and should reduce the number of trapped animals.

The closeness of the project to U.S. Highway 50 probably would inhibit some animals from using the immediate area. Additionally, an occupied residence and UVWUA maintenance facilities could limit the movement of game animals south of the highway. However, the likelihood that wildlife would occasionally actually fall into the enlarged lateral is high.

The overhead transmission line would have the potential for entangling or electrocuting raptors, including the endangered bald eagle. Transmission lines and their rights-of-way also provide access opportunities for people who may be inclined to harass these species.

Noise and construction activities would temporarily disturb wildlife near work sites. However, the penstock would not be constructed in an area remote from other human activity. Existing development in the study area ranges from industrial along the western portion to scattered rural homes and farmsteads along the penstock alignment. Traffic is common along U.S. Highway 50 and secondary roads in the area. Thus, wildlife has become somewhat accustomed to humans, their vehicles and farm machinery.

Gunnison River Corridor

Developing any of the alternatives would result in reduced flows in the Gunnison River below the diversion point at the East Portal of the Tunnel. The largest reductions in winter months would occur with alternatives B and C. Reduced flows could affect waterfowl, bald eagles, and river otters if ice formation increased significantly. The potential for ice accumulation would be most extensive below the river's confluence with the North Fork.

Ice formation between Crystal Dam and the North Fork would occur more frequently than under present conditions. A series of freeze-thaw cycles rather than continual ice cover would be expected. Reduced water velocities associated with lower flows would probably be more attractive to waterfowl. However, floating ice would be less attractive. As long as open water remained, the river otter and bald eagle should have adequate hunting habitat. As indicated previously, scattered ice bridges totaling approximately 2.5 miles of the river occurred during January and February 1989. These areas would be lost for use by the otter and eagle. During the low-flow period of January and

February 1990, ice development was much less. Potential prey species such as suckers and trout should not be reduced by the facility.

Increased walk-in fishing encouraged by lower spring and fall flows would build up stress on wildlife such as bighorn sheep. This walk-in use would occur less in winter months when fishing use drops and would be less than under the no-action alternative in severe winters due to increased icing conditions. As discussed previously, salt cedar could somewhat replace willows along the Gunnison River. Generally, salt cedar provides lower quality habitat in the Southwest (R. Omhart, 1987; personal communication).

Uncompahgre River Corridor

Machinery noise and human activities would disrupt wildlife habitat near the construction of proposed bank stabilization measures. Although this disturbance would be short term, it would be significant, since the activities would displace waterfowl and other species. Wildlife using these areas would move to other areas along the river. To minimize the impacts to migratory waterfowl and other wildlife, construction in sensitive areas would be accomplished as quickly as possible.

Flow changes in the Uncompahgre River would affect wildlife. Winter habitat conditions would change significantly in the river channel. The discharges from the proposed tailrace should keep the river free from ice, providing potential habitat for waterfowl, bald eagles and river otters. Increased flow in side channels and backwaters would alter existing use by waterfowl, but overall, the net impact should be maintained waterfowl use of the Uncompahgre Valley. Patterns of use would change; however, shallow riffle areas now used by waterfowl in normal winters would become less desirable habitat and the waterfowl's distribution could significantly change.

The redistribution of waterfowl along the river would very likely occur. Riffles and gravel bars heavily used presently would have higher flows and increased water velocities that create undesirable resting habitat. Conversely, new shallow riffles and backwaters would be created. Water surface acreage with velocities of less than 2 feet per second are predicted to increase by approximately 17 percent under alternative E. The facility tailrace area also would be expected to attract wintering waterfowl because it would be ice free, and human disturbance would be limited. Increased flows in the spring and fall would reduce habitat for shorebirds that use exposed river channels during present low water periods.

Wetland habitat losses would be mitigated as discussed previously. Winter flows between the South Canal and tailrace would not change and should not affect wildlife. Reduced flows in the South Canal could lessen brood habitat for waterfowl since the water surface elevation would drop below the existing vegetation line, reducing escape cover for duck broods.

The increased flow below the tailrace could possibly inhibit big game animals and other species that cross the river. Although the higher flows are within channel capacity and should not entirely block the animal's movements, they would make winter crossings more difficult and energy consuming.

ENDANGERED WILDLIFE

Flow changes would not be expected to significantly affect fisheries that the bald eagle may use on the Gunnison River. Reduced velocities associated with reduced flows would be more attractive to waterfowl that eagles also may feed on; however, increased icing flows could nullify this. Ice development potential would be increased with lower flows. If significant freezing did occur, particularly during a severe winter, it would occur at a time of greatest stress to wintering eagles. The potential for ice buildup is greatest with alternatives B and C.

Improved winter flows would keep the Uncompahgre River ice free and could increase wintering waterfowl numbers on the river downstream from the tailrace. The relatively warm tailrace discharge could attract more waterfowl on the river downstream from Montrose and may indirectly attract bald eagles to this area.

The facility would not affect nesting habitat of the peregrine falcon but would reduce potential hunting areas by reducing wetlands along the AB Lateral. Whooping cranes should not be affected because their habitat loss in this area, agricultural lands and reservoirs and ponds for feeding and resting, would be temporary.

The Gunnison River is occasionally used by sandhill cranes, and these flocks are accompanied by whooping cranes. In this area, migration periods are generally between March 15 and April 25 and between September 10 and October 15. As can be seen by flow tables in chapter 3, flow changes in the Gunnison River can be significant with the AB Lateral in operation, particularly in March and April. The effect of flow changes, if any, on cranes is presently unknown. Lower flows would mean more shorebird-type habitat, a possible benefit to cranes. However, if riparian vegetation increased significantly, the usable area would be reduced until scouring flows cleared the area.

The project would not adversely affect the black-footed ferret since the species and its preferred habitat were not found in the study area. No areas exist that are affected by project construction that are essential to the white pelican, sandhill crane, or any other species of limited distribution that may occasionally visit the Uncompahgre Valley.

Candidate species should not be significantly affected. Potential habitat of the ferruginous hawk would be temporarily disturbed by penstock construction, but long-term impacts on potential habitat would not be significant. Suitable resting and feeding habitat of the long-billed curlew occurs throughout the Uncompahgre Valley, and the relatively small acreage lost due to the AB Lateral Facility would have no impact on the species. The features of the facility should not have any long-term impacts on the Swainson's hawk, although short-term effects include disruption of potential nesting habitat during the construction of the penstock.

Impacts to bald eagles and other raptors would be reduced by implementing proposed mitigation measures. The transmission lines would be constructed according to measures contained in the document Suggested Practices for Raptor Protection on Power-Lines--the State of the Art in 1981 (Olendorff and others, 1981). This would minimize potential impacts on these valuable species from electrocution or entanglement.

Little can be done to exclude persons who are determined to enter an area, especially on foot. However, the possibility that persons who might seek to harass raptors perching on power poles would be reduced because the transmission line route is located in a developed area near U.S. Highway 50. Traffic along that road may discourage eagles from using the area.

In its Biological Opinion regarding impacts to bald eagles, the FWS (USDI, FWS, 1988a) requested that the Sponsors initiate bald eagle surveys during the winter to fully evaluate the long-term impacts of development. The Sponsors would initiate such surveys as described in chapter 2.

LAND USE AND RECREATION

EXISTING CONDITIONS

General Land Use

Land use in the project area reflects the major role of government in local land ownership. According to Montrose County (P. Warner, personal communication, 1988), approximately 28 percent of the land in the county is owned by the private sector. In contrast, 68 percent of the land in the county is under Federal government ownership, 3.9 percent is controlled by the State of Colorado, with the remaining 0.1 percent owned by the county and municipalities.

The private land in the county is largely devoted to agriculture; of that approximately 642,000 acres, 400,000 are used for agriculture with about 86,000 acres irrigated. Crops include corn, alfalfa, other hays, small grains, pinto beans, potatoes, onions, sunflowers, and fruit. Land use in the AB Lateral and proposed penstock route area is approximately 50 percent dry grazing land, 40 percent irrigated agriculture, and 10 percent urban (USDI, Reclamation, 1988). The total amount of agricultural land use has changed little recently, and little change is projected for the near future (USDI, Reclamation, 1988).

The majority of Federal lands are BLM, USFS, or UVRP lands. Lands controlled by the Federal government along the Gunnison River include the Curecanti National Recreation Area and the Black Canyon of the Gunnison National Monument (both are managed by the NPS) and BLM's Gunnison Gorge Recreation Area.

The population of Montrose County is about 25,250, with approximately 10,000 persons residing within the city of Montrose. Other population centers are Olathe (population: 1,262), about 10 miles northwest of Montrose, and Delta (population: 3,931), approximately 11 miles northwest of Olathe in Delta County.

Montrose County's system of community facilities, such as highways, railroads, commercial bus and air service, schools, parks, and utilities, was developed to meet population demands in the early 1980's. Although the county population has increased, it has done so slowly, maintaining excess capacity in community infrastructure making it adequate to serve present and near-future populations without further growth.

Very little industrial development occurs in the region. Limited mining and timbering have occurred in the mountains surrounding the valley in past years. No mineral extraction activities are occurring in the immediate project area, except for sand and gravel operations (USDI, Reclamation, 1988). Development of geothermal or other natural resources of commercial importance is unlikely (USDI, Reclamation, 1988).

Gunnison River Recreation

Montrose and Delta Counties contain a wealth of recreational opportunities. Two of these opportunities are Gunnison River rafting and fishing, both of which make substantial contributions to the economies of both counties. Because of their economic importance, rafting and fishing use are described separately in chapter 3.

The Gunnison River and its canyon (see figure 3.2) are one of the most interesting tourist and sportsperson attractions in western Colorado. They owe their reputation to the spectacular vistas and hiking trails of the Black Canyon of the Gunnison National Monument, the Gold Medal fishing waters, and the relatively pristine aesthetic values of the Gunnison Gorge Recreation Area. The BLM's recreation management plan for the Gunnison Gorge emphasizes management to protect and preserve natural values.

About 250,000 to 300,000 visitor-days of use occur in the Black Canyon of the Gunnison National Monument annually. Most of these users visit the area because of its dramatic scenery. A major theme of the Monument is interpretation of the canyon itself and the Gunnison River that carved it. Most visitors view the canyon from trails and overlooks on the canyon rim where an interpretative visitor's center and camping and picnic facilities are located. Trails within the Monument lead into the gorge and are used by backpackers, day hikers, anglers, and rock climbers. From 1988 to 1989, inner canyon hikers have averaged 1,009 visitors annually, with the highest use in 1988 when 1,183 hikers registered. Records are not kept of inner canyon users who enter from upstream or downstream from the Monument's boundary, but NPS officials report this use is increasing. More use was especially evident in 1988 when low river flows permitted people to travel greater distances throughout the canyon (R. Thoreson, personal communication, 1989).

The NPS is currently conducting studies to evaluate the feasibility of enlarging the Monument. This study is scheduled for completion in mid-1990; alternatives include establishing a National Conservation Area under BLM jurisdiction. Some local interest has also developed in making the Monument a national park.

The segment of the Gunnison River within the Monument is generally not usable for boating except by highly experienced kayakers, although it provides an opportunity for high quality trout fishing and hiking. This segment of the river is floated by less than 50 persons annually (J. Welch, NPS, personal communication, 1989).

The aesthetic value of the Gunnison River itself varies according to the flows. The most visual elements such as rapids, pools, cobbles, and riparian vegetation are present between 300 to 700 ft^3/s. Conversely, high spring flows give the visitor an indication of the powerful forces that carved the canyon.

Special Land Uses

Portions of the Gunnison River and adjacent lands are eligible for designation under the Wild and Scenic Rivers Act and the Wilderness Act (see chapter 2). A 11,800-acre area of the Black Canyon of the Gunnison National Monument was designated a wilderness area in 1976. These areas are described in NPS (USDI, NPS, 1979a and 1979b) and BLM (USDI, BLM, 1987 and 1989a). The BLM plans to manage the Gunnison River corridor to maintain very low human group concentrations and little overall evidence of human use. The wilderness study area (WSA) along the Gunnison Gorge will be managed according to BLM's Wilderness Interim Management Policy and the Gunnison Gorge Resource Management Plan (USDI, BLM 1989a and 1990).

Other Recreation (Uncompahgre River)

The Uncompahgre River below the proposed powerhouse tailrace has only limited recreational or aesthetic value resulting from periodic dewatering; excessive sedimentation, turbidity, and channelization; and lack of access. Fishing on the Uncompahgre River below Montrose is poor.

The Uncompahgre River between the South Canal terminus and the M&D Canal does have recreational use because of the introduction of relatively high quality water and trout from the Gunnison River through the Tunnel and the South Canal. However, due to limited public access in the area, angler use is limited to residents with knowledge of the local area. However, fishing use should increase if water quality improves due to Ridgway Reservoir. Several small recreation lakes have been developed beside the river between the South Canal outfall and Montrose. These are filled by springs or from irrigation ditches. In addition, local interest has grown along this reach of the river to enhance the use of the riparian areas that line much of the Uncompahgre River.

Other Recreation (South Canal)

The fishery in the South Canal is a seasonal fishery, dependent on fish movement through the Tunnel. Flows within the South Canal are curtailed during the winter for maintenance and repair of the Tunnel and canal system. Public use of the canal is not authorized.

Other Recreation (Hunting)

Hunting in the Montrose area is an important recreation resource. The project area lies mainly within Large Game Management

Unit 64, managed by the CDOW (LGMU64), though the project itself would occupy a small geographic part of the unit. LGMU64 showed a recreational day use for deer hunting of 4,360 days with 909 hunters participating. In 1987, elk hunting accounted for usage of 2,093 recreational days, with 400 actual hunters (CDOW, 1987). Very little big game hunting occurs near the main features of the project.

Small game hunting may play a more important role in recreation usage in the immediate project area than big game hunting. During the 1984-85 small game hunting season, more than 60,000 recreational days were spent in the pursuit of game in CDOW's Small Game Management Unit 64 (SGMU64), which encompasses the proposed project area. The immediate project area includes a very small part of the unit, and the hunting usage is proportionally reduced for the project area. Upland game birds, such as the pheasant (who receive more than 25,000 days of recreational use) are hunted extensively in the region. Small mammals like the cottontail rabbit (more than 10,000 days of recreational use), which are commonly found in the project area, are also heavily hunted in SGMU64. No data are available on the amount of hunting usage in the project area; however, the immediate area of proposed development is used for pheasant, rabbit and chukar hunting. Waterfowl hunting also occurs along the Gunnison and Uncompahgre rivers.

According to EMANCO (1986b), the UVRP access roads and irrigation ditches are used as a local recreational resource, though no data are available on such usage. The canal and lateral system are not open for public use because of safety hazards and because much of the system is on private land. However, it is common to view autos, trucks, and off-road vehicles such as trail motorcycles on backroads in the project area, especially during upland bird hunting seasons. This includes roads maintained by UVWUA to provide access for maintenance of irrigation facilities. No data are available on visitor-days or use at any of these locations, since accounts of recreational visitors are anecdotal.

Other Developments

One major recreational development in the project area is Sweitzer Lake, a 137-acre recreational area owned and managed by the Colorado Division of Parks and Outdoor Recreation (CDPOR) and located about 2 miles southeast of Delta. Boating, swimming, and picnicking at the lake account for most of its 70,000 to 90,000 visitor days annually (CDPOR, 1981).

Another recent development in the area is the bike path between Montrose and south of Chipeta Lakes. This bike path, which begins at River Bottom Park in Montrose, has been developed by private interests with government support using an abandoned railroad right-of-way. Future plans include expanding the path from Chipeta Lakes, about 2 miles south of Montrose, south to Ouray. Also, a riverfront park is being developed at Delta near the confluence of the Uncompahgre and Gunnison rivers.

Private investors have also developed "Pleasure Park" on the Gunnison River a short distance downstream from the North Fork confluence. This facility offers a wide variety of recreational opportunities, including rafting, picnicking and camping. Jet boats are used to transport floaters upstream from the park to the Smith Fork confluence. The facility also includes a pavilion which will be used for "dances, reunions, conventions, parties and all manner of events..." (Delta County Independent, 1988).

Minor recreational developments are limited to public facilities at schools and city parks and include playgrounds, tennis courts, ball fields, swimming pools, and picnic areas. Other recreational opportunities are dispersed throughout the region and include horseback riding, bicycling, and hiking.

IMPACTS OF ALTERNATIVES

General Land Use

The development alternatives would temporarily affect 234 acres of land of which approximately 172 acres would be used for the penstock, 32 acres for the canal modifications, 15 acres for the powerhouse and tailrace, and 15 acres for the transmission line. After construction, about 18 acres would be required for operation.

Penstock construction would temporarily disturb unused ground, grazing lands, irrigated farmlands, and roadways within the city of Montrose and Montrose County. Although 172 acres would be required for construction, less than one acre would be required for operation. Land use above the buried penstock would revert to preconstruction use. However, development of new structures such as residences and buildings within the limits of the 100-foot right-of-way would be restricted to allow maintenance of the penstock.

Permanent land use changes would occur at the powerhouse and tailrace, in a 12-acre tract near the powerhouse, and in 6 acres along the AB Lateral. The land at the powerhouse is now unused; it would be converted to industrial use for the building, switchyard, stilling basin, and vehicle parking. The tailrace lands are presently used for livestock grazing; approximately 6 acres of this would be converted to industrial use for conveyance of water from the powerhouse to the Uncompahgre River. Additionally, 12 acres of grazing land between the powerhouse and the river would be converted to wetlands as part of the wetlands mitigation plan. At the AB Lateral, 6 acres of grazing land would be converted to a gravel maintenance road.

No construction or development activities would occur at the East Portal of the Tunnel or along the Gunnison River. Hence, development would not cause any land disturbances or land use changes along the Gunnison River. During construction of the Tunnel modifications under alternative C, temporary impacts would occur to State Highway 347 and the South Rim Drive due to construction traffic. Materials removed from the Tunnel walls would be hauled out through the West Portal. The Sponsors would repair damages to the roadways resulting from construction.

Irrigation water and hydropower water needs would be managed by UVWUA. No long-term negative impacts to current agricultural practices are anticipated due to the development. In the construction phase, the project could cause interruptions or reduced irrigation water flows for short time periods (less than one hour) along the existing AB Lateral and South Canal.

Gunnison River Recreation

No facilities would be constructed along the Gunnison River, and no alteration of existing facilities would occur there. Operation of the proposed alternatives would, however, alter the existing streamflow regime in the Gunnison River downstream from the Tunnel. The altered flows would affect recreational use, resulting in increased hike-in fishing and decreased rafting use as described later in this chapter. (Refer to tables 3.6 through 3.11 for estimated flow changes under all alternatives.)

The flow changes would affect recreation use in the inner canyon of the Monument. The NPS has expressed concern about a significant change in visitor use patterns and subsequent impact on the wilderness character of the Monument. According to the NPS (USDI, NPS, 1988),

> The low flow level (seen more frequently under development alternatives) will make it much easier to travel both up and downstream by foot. Access will no longer be from the canyon rim and down but laterally along the river from the easily reached East Portal and lower gorge areas. Easier access means more people, more human impact on the resource, and less of a wilderness experience.

The aesthetics of the Gunnison Gorge would be affected by reduced flows, with the greatest changes apparent under alternative C. These changes would be most apparent in the winter when the greatest flow reductions occurred. The frequency of flows in the range of 300 to 700 ft^3/s would increase from 50 percent (no-action alternative) to 70 to 80 percent with development alternatives. At this flow range, many visual elements are apparent--riffles, cobbles, and pools. From another viewpoint, the erosive power of the river would appear to be less under the development alternatives. This reduction would be most apparent in the early spring, late fall, and winter.

Average summer flows in the Monument would be reduced from 897 ft^3/s to 637 ft^3/s (alternative C) or 730 ft^3/s (alternatives B, E and F). Average winter flows would be reduced from 1,392 ft^3/s to a range of 471 to 581 ft^3/s, depending on the alternative. Minimum streamflows would not change with the facility in operation, although the frequency of river flows of 300 ft^3/s would increase. According to the NPS (USDI, NPS, 1988), during periods of reduced flows, "...the flows would no longer impress the wilderness users and give them a feeling for the tremendous water power the Gunnison had, which gave it the ability to carve the canyon to its present depth. The roar of the river will be gone."

Regarding river access, fishability, and rafting use, one way to view impacts is to look at changes in river elevations caused by project implementation. River cross sections downstream of the Monument were surveyed by the Sponsors in 1987. This information, in addition to existing data from the CDOW, transects at Duncan Trail and the USGS gauge at the upstream Monument boundary, were then used to develop stage and discharge curves for the sites. Table 3.44 shows estimated river depths for alternatives during the four principal recreation months of June through September, using average monthly proposed diversions. Actual curves for each of the stations are included in attachment F. Figure 3.21 graphically displays Gunnison River depths of flow for all alternatives.

As can be seen from table 3.44, impacts to river depths vary by location. Impacts are greatest in September - the average change in river depth across six sections would be about 15 percent for alternatives B, E, and F, and 18 percent for alternative C. Impacts would be smallest in July, with alternatives B, E, and F causing a depth change of 6 percent, and alternative C a depth change of 8 percent. These elevation changes are generally within the normal annual fluctuation of the Gunnison. Average postproject depths in June and July (see table 3.44) are greater than preproject depths in August or September. Postproject August depths would be similar to preproject September depths. As stated above, September would be the major recreation month affected the most by river depths, and, thus, would have the greatest impact to rafting and fishing accessibility. Changes in flow would be greater during the months immediately preceding the major recreational season. On the Gunnison River, this flow

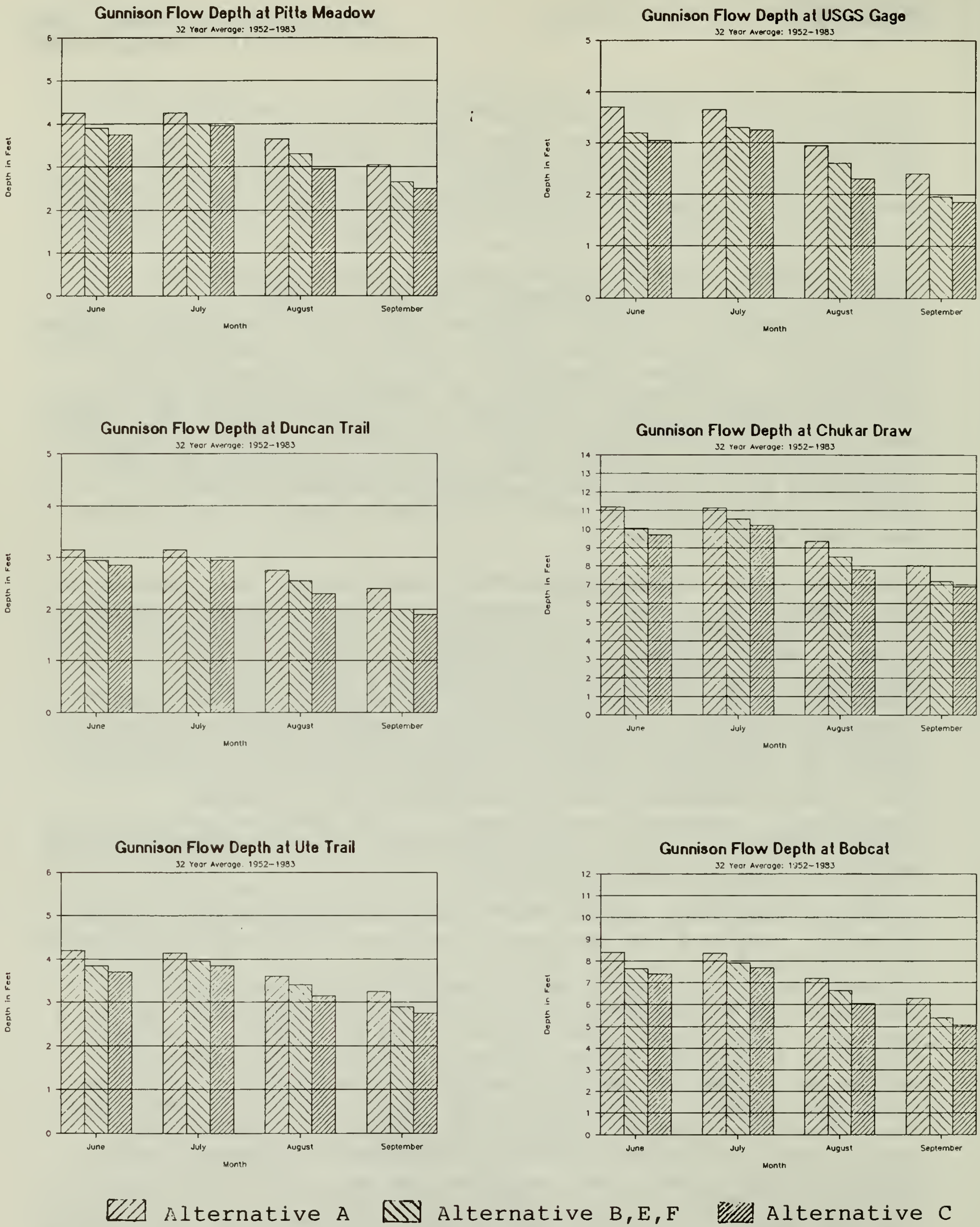


Figure 3.21. Flow depths of Gunnison River for all alternatives.

Table 3.44.--Gunnison River depths for alternatives during June through September (average monthly flow conditions in feet)

Site	Alternative	June	July	August	September
USGS Gauge	A	3.7	3.7	3.0	2.4
	B, E, F	3.2	3.3	2.6	2.0
	C	3.0	3.2	2.3	1.9
Chukar Draw	A	11.2	11.2	9.4	8.1
	B, E, F	10.0	10.6	8.5	7.2
	C	9.7	10.2	7.8	6.9
Bobcat Trail	A	8.4	8.4	7.2	6.3
	B, E, F	7.7	7.9	6.7	5.4
	C	7.4	7.7	6.1	5.1
Pitts Meadow	A	4.3	4.3	3.7	3.1
	B, E, F	3.9	4.0	3.3	2.7
	C	3.8	4.0	3.0	2.5
Duncan Trail	A	3.2	3.2	2.8	2.4
	B, E, F	3.0	3.0	2.6	2.0
	C	2.9	3.0	2.3	1.9
Ute Trail	A	4.2	4.2	3.6	3.6
	B, E, F	3.9	4.0	3.4	2.9
	C	3.7	3.9	3.2	2.8

Source: HDR, personal communication, 1987.

would cause additional use by anglers in March and April and October and November when the most noticeable change in visitor use would probably occur.

The BLM indicated in its comments on the DEIS that additional staff and funding would be needed to effectively provide visitor services and resource protection for an extended recreational season (9 months instead of 5). They estimated that it would cost an additional $50,000 annually to administer the Gunnison Gorge Recreation Area with the projected increase in hike-in anglers caused by project development.

Stevens (1988) concluded that the changes in flow regimes would not affect the river mechanics of the Gunnison River through the canyon; thus, the natural short- and long-term geologic conditions of the canyon would not change. The sport fishery resources in the Monument should not be adversely affected and may even be improved. Even under extreme case conditions, winter and summer water temperatures should not be adversely affected due to the Monument's proximity to Crystal Reservoir. However, recreation use in the Monument could be affected.

Although stream fishing makes up a small portion of the use in the Monument (less than 1 percent [USDI, NPS, 1979a]), this use would be affected by the facility. The lower spring and fall flows would increase the accessibility of the river within the Monument. Under low flow conditions, the NPS may need to increase their management of the river corridor, which could increase management costs. This management could include permit systems for entering the Monument from upstream and downstream points in addition to existing permit systems for other trails. The existing road closure to the East Portal area in the winter would continue under all alternatives and would continue to reduce use during the winter.

As previously mentioned, the existing Gunnison Gorge wilderness within the Monument would be affected by reduced flows. Winter flows would be significantly decreased, with lesser changes during the irrigation season. Winter flows would be lowered to near historic natural levels.

Special Land Uses

Under the no-action alternative, the Gunnison River is eligible for designation as a wild river and sections of the Gunnison Gorge Recreation Area are eligible as wilderness.

The AB Lateral alternatives would not make the eligible segment of the Gunnison River ineligible for potential designation in the National Wild and Scenic Rivers System, according to the NPS (USDI, NPS, 1988). As indicated in Chapter 2, both recreation use and volume of water in the reach of river would be affected. The Wild and Scenic River Study (USDI, NPS, 1979a and 1979b) mentioned that flows were expected to stabilize near 200 ft^3/s with the completion of Crystal Dam. The NPS continued to state that, "Reclamation expects to maintain a flow of at least 400 ft^3/s below the Tunnel whenever Blue Mesa Reservoir is full. This is expected to occur during the March-through-September period in 85 percent of the years." As discussed later in this chapter, hike-in fishing would be expected to increase and rafting decrease under development alternatives.

Reclamation requested that BLM evaluate the suitability of the Gunnison Gorge WSA for wilderness if the AB Lateral Facility were constructed and operated. The BLM (USDI, BLM, 1988a) stated that,

> Although operation of the facility may affect wilderness quality, the BLM would not change its recommendations to the Secretary of Interior that the Gunnison Gorge is preliminarily suitable for wilderness designation. However, only Congress can designate an area as wilderness. We cannot say how Congress would react towards a designation of the Gunnison Gorge as a wilderness, if the AB Lateral Facility is completed.

In comments on the DEIS, BLM further stated:

> While the implementation of the development alternatives might not change the BLM's recommendation for wilderness or wild and scenic designation, resulting impacts would impair biological, aesthetic and primitive recreational values for which the Gunnison Gorge is managed...Outstanding opportunities for solitude would be decreased and the carrying capacity and limits of acceptable change established in the Recreation Area Management Plan (RAMP) for the Gorge would be exceeded.
>
> Not only does this conflict with the BLM's non-impairment standard for wilderness study area management, but it changes the scope and objectives of the Gorge's management plan in terms of use levels and types of uses. Necessary RAMP revisions would reduce primitive and unconfined recreational opportunities currently available in the Gunnison Gorge and result in an inflated cost to the Government.

The BLM also indicated that the operation of the AB Lateral Facility would conflict with management plans due to impairing biological, aesthetic, and primitive recreational values for which the Gunnison Gorge WSA is being managed. The BLM has also expressed concern that changes in river morphology and the associated aquatic and terrestrial ecosystem would conflict with management objectives. In the WSA, increased hike-in fishing use and streamside travel would result in increased soil compaction, vegetation damage and removal, disturbance to wildlife, and an increase in the number of campsites. Due to more publicity about the Gunnison River, this increase would occur under the no-action alternative, but the increase would be greater under development alternatives. At lower flows, walk-in anglers can disperse more easily along the river; however, increased use can lead to a loss of solitude.

The increased number of anglers would be offset to some extent because anglers can disperse along the river much more readily because of improved wading conditions. In addition, jet boat activity between the Smith Fork and North Fork segments of the Gunnison River is reduced at lower flows, thus decreasing this source of noise.

The ultimate carrying capacity of the river is not known. Even in a year like 1988 with a record number of anglers, fishing pressure was less than 20 percent of that observed on prime trout fisheries along the South Platte and Fryingpan Rivers in Colorado. This information may indicate a capacity for the fishery to sustain more use, but it is no indication of the capacity of other values in the canyon. The BLM (USDI, BLM, 1988a and 1989b) estimated the carrying capacities for recreational use in the Gunnison Gorge WSA and presented plans to monitor use. The BLM (1990) reported the recreational-carrying capacity of the Gunnison River corridor within the WSA at 75 persons per day. In the future, hike-in use may have to be regulated more to protect resources.

Other Recreation (Uncompahgre River)

Under all development alternatives, increased flows below the tailrace could improve the recreational value of the Uncompahgre River as the result of relatively stable, year-round releases of high quality, clear Gunnison River water. These releases, coupled with the effect of Ridgway Dam upstream, could improve the water quality of the channel and stabilize or expand the wetlands of this area (R. Clark, CDOW, personal communication, 1988). A cold water trout fishery could develop in the river in response to the improved habitat conditions. However, habitat may still limit development of a significant fishery. The realization of the full recreational potential of this development would require increased public access (USDI, Reclamation, 1988).

The stabilized wetland area would enhance its wildlife potential that would, in turn, help increase its recreational and aesthetic value. Wintering waterfowl and their associated pursuit by hunters and birdwatchers could also increase in some areas and decrease in others downstream on the Uncompahgre River. This would occur in response to the winter release of relatively warm water (32 to 35°F) that should maintain an open, ice-free channel downstream to Delta (USDI, Reclamation, 1988).

The potential recreational and aesthetic value of sections of the Uncompahgre River between the Loutzenhizer Diversion Dam and the AB Lateral tailrace would be reduced with development due to the reduced flows in this reach. Although the number of trout entering the Uncompahgre River from the South Canal essentially would be unchanged, special management could be required to preserve the trout population and fisherman use in this reach of the river. Impacts would be reduced but not eliminated under alternatives E and F, which provides extra water to the reach.

As mentioned previously, Chipeta Lakes and River Bottom Park along this reach of the river are managed for public recreation. Their ponds are filled by springs or ditches that divert from the Uncompahgre River under senior water rights; thus, their water supply would not be affected by development of any of the alternatives.

Other Recreation (South Canal)

During the irrigation season, the project would direct approximately 40 percent of the Gunnison Tunnel flow of 1,135 ft^3/s into the AB Lateral, reducing the flow in the South Canal. The Sponsors would install a fish barrier on the AB Lateral at the South Canal diversion that would limit adult trout from entering the lateral, guiding them instead through the South Canal. Thus, during the irrigation season, the number of trout entering the South Canal should remain unchanged.

Other Recreation (Hunting)

The project would have an insignificant impact on hunting by changing 18 acres of land that are used by animals as habitat. However, on the rest of the project site, the impacts would be temporary in nature, due to revegetation plans.

The Montrose CDOW office has stated that the project could positively affect hunting on the reach of the Uncompahgre River below the tailrace (R. Clark, CDOW, personal communication, 1988). The increased flows below the tailrace as a result of developing the project could enhance the area's wetlands and improve eagle and wildlife habitat. The increased flows would make the river more floatable (within certain reaches) and could increase accessibility for duck hunters. Overall, the proposed development would have no significant impact on hunting in the Gunnison River Basin.

Other Developments

None of the development alternatives is predicted to significantly affect current or future use of Sweitzer Lake, although the quality of the water supply to the lake would improve. However, development would affect the Montrose-Chipeta Lake bike path and River Bottom Park. The impacts would be largely aesthetic due to the reduced flows in the Uncompahgre River between the South Canal and Montrose. The river is visible from the bike path at the bridge where it crosses the river; otherwise, the visibility of the river is obscured by riparian vegetation. No impacts to existing structures, i.e., bridges or bike-path paving, would occur. The western boundary of River Bottom Park is formed by the Uncompahgre River; reduced summer flows in the channel would affect the aesthetics of the river in this reach.

At the Pleasure Park on the Gunnison River, reduced flows during low and moderate flow periods would reduce rafting, and jet boat activity between the Pleasure Park and Smith Fork would also be reduced. These situations would occur as a result of the project more frequently in the early spring and late fall, since these are the recreational periods experiencing the largest changes in flow. For example, in 1988, with flows between 300 and 400 ft^3/s, jet boat activity was curtailed. Concurrently, the reduced flows would also stimulate interest in walk-in fishing activities, which may offset the reduced rafting usage. Other values, such as camping and picnicking, would not be affected.

SOCIAL AND ECONOMIC CONDITIONS

EXISTING CONDITIONS

The area immediately affected by the proposed development would include Montrose and Delta Counties in southwestern Colorado. Montrose County had a 1980 population of 24,352 and an estimated population in 1986 of 25,248 (from 1980 Census population data, U.S. Department of Commerce, 1988; and local sources). The largest community in the county and the nearest community to the project is Montrose with a 1980 population of 8,722 and an estimated population in 1986 of 10,010. Employment data in table 3.45 indicate that total employment has declined in Montrose County since 1982, with the unemployment rate at times as great as 13.2 percent. The leading economic sectors in the county are (in order of importance): trade, services, agriculture, and government.

Delta County had a 1980 population of 21,225, and Delta, the largest community in the county, had a 1980 population of 3,931. Employment data in table 3.46 indicate that total employment has declined in Delta County since 1982, with the unemployment rate

Table 3.45.--Employment in Montrose County

Year	Labor force	Employment	Unemployment	Unemployment rate (percent)
1980	11,532	10,641	891	7.7
1981	11,372	10,467	905	8.0
1982	11,572	10,104	1,423	12.3
1983	11,552	10,233	1,319	11.4
1984	11,488	10,151	1,337	11.6
1985	10,972	9,627	1,345	12.3
1986	10,895	9,458	1,437	13.2
1987[1]	10,859	9,503	1,356	12.5

[1] Average monthly labor force for January through August 1987.

Source: Colorado Division of Local Government, 1984.

Table 3.46.--Employment in Delta County

Year	Labor force	Employment	Unemployment	Unemployment rate (percent)
1980	8,204	7,597	607	7.4
1981	8,497	7,902	595	7.0
1982	9,025	7,924	1,101	12.2
1983	10,010	8,939	1,071	10.7
1984	9,578	8,572	1,006	10.5
1985	8,767	7,881	886	10.1
1986	8,411	7,166	1,245	14.8
1987	8,209	7,207	1,002	12.2

Source: Colorado Division of Local Government, 1984.

at times as great as 14.8 percent. The leading economic sectors in the county are, in order of importance: trade, services, agriculture, and government.

The counties' system of community facilities, such as highways, railroads, commercial bus and air service, schools, parks, and utilities, were developed to meet population demands in the early

1980's. Excess capacity in community infrastructure remains, making it adequate to serve present and near-future populations.

No mineral extraction activities occur in the immediate project area except for two sand and gravel operations, both of which are owned by the same company. One operation is located upstream (south) from Montrose, and the other is located downstream from the proposed tailrace near the existing Montrose Sewage Treatment Plant. Geothermal or other natural resources of commercial importance that could be developed in the future are unlikely.

Montrose and Delta Counties are both close to the Gunnison Gorge; as mentioned previously in this chapter, the Gorge offers a variety of recreational opportunities, including trout fishing and rafting; these opportunities are nationally known; consequently, they are responsible for economic contributions to the area. The economic contributions and the anticipated impacts of the development alternatives are discussed below.

Gunnison River Fishing

The steep terrain of the Gunnison Gorge generally restricts hike-in angler use of the Gunnison River between Crystal Reservoir and the North Fork confluence. The river is accessible by car at the Tunnel and at the North Fork confluence. Access to the entire reach between these points is by steep and, in some cases, unmaintained foot trails. On the river bottom, lateral movement along the river is also restricted, especially during higher flow periods.

Table 3.47 presents estimates of hours of fishing activity and trout catch in four selected years since Crystal Reservoir was completed. Angler-use statistics compiled by the CDOW indicate an inverse relationship between flow levels and fishing activity. Flows above 1,000 ft^3/s result in significant decreases in fishing activity. This relationship is reflected in the 1983 data (see table 3.47) when fishermen use on the Gunnison was significantly reduced by flows in excess of 1,000 ft^3/s from May through September. Fishing activity was reported to be heavy in the late summer of 1987 when flows fell to around 600 ft^3/s and was heavy in 1988 when flows remained in the range of 300 to 400 ft^3/s (Nehring, 1988c).

According to the CDOW:

> The Gunnison River in the Black Canyon is most fishable in the 200-600 ft^3/s range. It is still fishable at 600-1,000 ft^3/s but cannot be crossed safely even in chest waders at these levels. In flows over 1,000 ft^3/s, the fishability of the river is very limited except from a raft, boat or canoe.

Table 3.47.--Comparison of angler hours and catch (number of fish) for the Gunnison Gorge from Crystal Reservoir to confluence with North Fork

Angler hours and catch	1977[1]	1982[2]	1983[3]	1984[4]
Angler hours	22,079	51,128	39,160	52,219
Total catch	11,345	57,363	33,723	84,286
Total harvest		17,713	13,151	13,395
Rainbow catch	11,634	31,849	24,140	56,663
Rainbow harvest		10,125	11,067	9,848
Brown catch	2,529	24,934	9,562	27,623
Brown harvest		7,275	2,085	3,547
Total catch per angler-hour	0.65	1.12	0.86	1.61
Rainbow catch per angler-hour	0.53	0.62	0.62	1.08
Brown catch per angler-hour	0.12	0.49	0.24	0.53

[1] April 16 to October 11.
[2] May 1 to September 30.
[3] May 1 to September 30.
[4] May 1 to September 30.
Source: Nehring, 1983 and 1988b.

Because of the Gunnison River's rapidly growing regional and national popularity, the CDOW believes that, in an unusually dry year (200 to 300 ft^3/s from April to September), 100,000 angler hours can be expected between the Tunnel and the North Fork confluence (Nehring, 1983). This use level has not been reached to date, but as public interest increases, the level could be reached.

Gunnison River Rafting

The BLM indicates that both commercial and private rafting in the Gorge have increased dramatically since the early 1980's, due to increased publicity, improved fishing, and above-normal river flows. In 1982, the BLM issued 2 commercial rafting permits; in 1987 they issued 15 permits. The increased use occurred during a period of unusually high summer flows (J. Sering, personal communication, BLM, 1986). (Background information is from Tucker-Leak, 1987, 1988b, and 1990; and USDI, BLM, 1987.)

In 1982, the BLM estimated rafting use at 208 user days. By 1986 and 1987, use reached 2,700 and 3,500 user days, respectively.

At first, most of the rafting use was by commercial outfitters. However, as a result of changes in BLM policies regarding permit allocations, private use is now nearly equal to commercial use, with about 55 percent commercial and 45 percent private use.

Low water conditions in late 1987 restricted commercial outfitters with larger rafts. Because it was necessary to perform maintenance repairs on an upstream powerplant, flows in the Gorge were reduced from approximately 1,600 ft^3/s in early July to about 800 ft^3/s by late July. Beginning approximately August 18, 1987, flows were further reduced to about 600 ft^3/s, with this flow level continuing into mid- to late September.

According to BLM staff, the lower water conditions and the accompanying publicity led to an increase in private boat trips by people who thought the fishing would be greatly improved in the Gorge. An increase in boating accidents during this period occurred, either due to the low flows or to the boaters' inexperience, with 90 percent of the accidents occurring with private floaters. Several commercial outfitters began in 1987 using smaller boats and increased their use of the river, leaving the total commercial use at or near its previous level.

A comparison of both day and overnight trips for commercial and private boaters is provided for 1986 through 1989 in table 3.48. In 1987, a major change occurred from whitewater rafting at higher flow periods early in the year to fishing-oriented rafting at lower flows later in the summer recreational season. In 1988, average flows in the Gunnison Gorge were 353, 355, and 395 ft^3/s in June, July and August, respectively. As table 3.48 shows, these low flows resulted in reduced day and overnight trips for both private and commercial floaters. The number of private boaters during the 1988 season decreased by 58 percent from 1987 levels and commercial boaters decreased by 27 percent from their 1987 levels. These decreases indicate that, when flows drop below 600 ft^3/s, floating the Gunnison Gorge becomes more technically demanding, and both private and commercial rafters reduce the number of rafting trips. During 1988 and 1989, flows in the Gunnison Gorge were substantially lower than in the past due in part to drought conditions in the Upper Colorado River Basin. These low flows resulted in substantially reduced boating activity in both the private and commercial sectors during 1988 (see table 3.48). The commercial boating activity in 1989 increased to near 1987 levels despite the low flows, but private boating use remained low.

The boating data summarized in table 3.48 are conservative because they are based on voluntary registrations. Because commercial outfitters are licensed and must register when they take a party on the river, the records of commercial raft trips are fairly accurate. Although private rafters are requested to register before entering the river, many do not; the BLM

Table 3.48.--Summary of private and commercial boating use on the Gunnison River (1986 - 1989)

	June				July				August				September				Totals			
	'86	'87	'88	'89	'86	'87	'88	'89	'86	'87	'88	'89	'86	'87	'88	'89	'86	'87	'88	'89
Day trips																				
Private	NA	20	5	6	18	37	12	16	33	21	5	8	8	4	6	1	59	82	32	32
Commercial	7	30	10	6	16	19	14	23	18	25	15	16	4	3	3	4	45	77	49	56
Overnight trips																				
Private	NA	5	10	7	5	22	15	16	19	33	5	10	5	14	8	14	29	74	43	47
Commercial	6	18	11	28	15	41	23	27	37	33	26	34	14	19	16	23	72	111	79	112
Day boaters																				
Private	NA	95	18	15	108	182	48	36	165	77	23	32	38	22	34	2	311	376	140	85
Commercial	58	208	83	46	109	147	105	176	188	186	111	143	40	16	23	25	395	557	355	390
Overnight boaters																				
Private	NA	21	32	21	60	113	50	70	86	156	19	32	19	52	50	65	165	342	165	188
Commercial	65	100	83	216	122	325	183	232	279	239	208	288	93	116	124	175	559	780	620	911
Total boaters																				
Private	NA	116	50	36	168	295	98	106	251	233	42	64	57	74	84	67	476	718	305	273
Commercial	123	308	166	257	231	472	288	408	467	425	319	431	133	132	147	200	954	1,337	975	1,301
Total boaters	NA	424	216	293	399	767	386	514	718	658	361	495	190	206	231	267	1,430	2,055	1,280	1,574

Source: Tucker-Leak, 1987 and 1988b.

estimates that the number of private boaters is about 25 percent greater than the actual numbers in their records. The numbers in table 3.48 are from BLM data and have not been adjusted to reflect this underestimate.

Economic Contributions of Rafting and Fishing

Regional economic effects of both Gunnison River rafting and fishing were estimated from the recent number of boater and angler days and daily expenditures for each group. The economic study area (ESA) was assumed to be Delta, Montrose, Mesa, Ouray, and Gunnison counties because these counties are where the majority of expenditures occur. Estimates of boater and angler days are presented in table 3.49. Boater days are presented for private and commercial trips since the expenditures associated with each type are different. The 1987 rafting season was used as the basis for estimating the existing economic contributions of the Gunnison Gorge because the low flow levels of 1988 make 1988 an unrepresentative year. The estimate of angler days was derived from CDOW reports (Nehring, 1988c) and personal communication (Nehring, CDOW, 1988d).

Daily expenditure estimates for rafting were taken from a recent survey of rafters (Public Information Corporation, 1986), and estimates of angler expenditures were derived from a FWS survey done in 1980. These figures were adjusted to 1988 values using Gross National Product-Implicit Price Deflator methods (U.S. Department of Commerce, 1988) and are summarized in table 3.50. Table 3.51 presents total economic and employment contributions to the area resulting from fishing and rafting activities in the Gunnison Gorge during 1987. Multiplying activity days times daily expenditures for rafting and fishing resulted in an estimate of total expenditures in 1987 of $538,900.

To estimate the full economic effect in the region, sales, earnings and employment multipliers were applied to total expenditures for each category to arrive at estimates of total regional effects to the economy resulting from rafting and fishing activities. The multipliers used were derived from the RIMS-II Multiplier Model (U.S. Department of Commerce, 1988). As table 3.51 shows, rafting and fishing activities in 1987 resulted in total sales of $877,000, created 41 jobs and added $279,200 to personal earnings in the region.

IMPACTS OF ALTERNATIVES

General (Alternative A, No Action)

If no hydropower development occurs, the general economy of the region would not be changed. Fishing and rafting would continue

Table 3.49.--Estimate of boater days and angler days for Gunnison Gorge (1987)

User category	Total days
Boater days[1]	
Private boater days[2]	1,435
Average group size (people)	4.6
Average length of stay (days)	1.6
Commercial boater days	1,886
Average group size (people)[3]	5.9
Average length of stay (days)	1.7
Angler days[4]	11,286

[1] Boater days were calculated from information supplied by BLM (Tucker-Leak, 1987, 1988a, and 1988b).
[2] Private boater days were increased by 25 percent to correct for non-registrations.
[3] Group size does not include outfitter or guide personnel.
[4] Angler days were calculated based on information from CDOW (Nehring, 1988c). One angler day is assumed to equal 4 angler hours (Nehring, 1988d).

Table 3.50.--Local expenditure estimates for rafting and fishing, per person/per day[1]

Category of use	Expenditures
Private rafting[2]	
Hotel/motels	$ 19
Transportation and camping fees	2
Restaurants	12
Other: Food, drink, misc.	4
Total	37
Commercial rafting	
Rafting company average fee[3]	$ 69
All other (same as private)	37
Total	$106
Fishing - per person/per day[4]	$ 25

[1] Values escalated to 1988 dollars using GNP-Implicit Price Deflator method.
[2] From a survey by the Public Information Corporation (1986).
[3] Average rafting commercial fee derived from data supplied by BLM District Office in Montrose, CO.
[4] Source: FWS, 1980.

Table 3.51.--Economic contribution to the economic study area made in 1987 from recreation and fishing activities in the Gunnison Gorge (in 1988 dollars)[1]

Category	Total seasonal expenditures (dollars)	Total regional sales (dollars)[2]	Total employment generated (jobs)[2]	Total labor income generated (dollars)[2]
Boaters				
Private	$ 53,600	$ 87,000	4	$ 27,800
Commercial	200,300	326,000	15	103,800
Subtotal	$253,900	$413,000	19	$131,600
Anglers	$285,000	$464,000	22	$147,600
Totals	$538,900	$877,000	41	$279,200

[1] Economic Study Area is Delta, Montrose, Mesa, Ouray and Gunnison Counties.
[2] Source: U.S. Department of Commerce, 1988.

and probably increase as important economic factors, and use would vary yearly depending on river flow conditions. No major changes in the local economy are presently foreseen.

General (Development Alternatives)

If any of the development alternatives were implemented, the general economy of the region would be affected by both short-term and long-term development-related effects. These effects include the short-term construction of the facility and its long-term operation, and would be related to the capital expenditures made by the Sponsors.

The estimated construction cost of the facility would range between $48 and $53 million, depending upon the selected alternative. Of these costs, approximately $20 to $25 million would be spent in the local economy for labor and materials. The balance of the cost would be spent outside of the local economy for purchasing specialized equipment and materials. The Sponsors have estimated that construction would result in a one-time expenditure of $300,000 to the city of Montrose for sales and use tax and a one-time expenditure of $500,000 to the State of Colorado for sales tax.

The construction of the facility would occur for a 2-year period. Three construction crews would be employed for canal and lateral modifications, penstock installation, and powerhouse construction. According to the Sponsors, the average field crews would be 48 to 50 people annually, with peak manpower requirements between 70 and 100 people. The local labor force would contribute about 60 percent of these requirements. The maximum crew size is anticipated to be 25 to 30 persons for canal modifications, 25 to 35 for penstock installation, 25 to 30 for powerhouse construction, and 3 to 5 for transmission line installation. Canal work would take from 2 to 4 months and would be completed during the nonirrigation season. Penstock construction may require a full year for completion, with the actual amount of time depending on weather conditions. A 16-month construction period is anticipated for the powerhouse.

The Colorado State Employment Service reports that no problem would occur in acquiring this number of skilled construction employees from the present number of unemployed (USDI, Reclamation, 1988). Additionally, the Employment Service indicated that construction workers in the Montrose, Ouray, Delta, and Mesa County areas all tend to compete for local jobs, creating a large pool of construction labor. If additional construction workers are needed from outside the area, adequate lodging and subsistence accommodations are available. The presence of these employees would also provide a limited and unquantifiable local benefit due to purchases of food and lodging in the area during construction.

Purchases of local goods and services during the plant's operation would also be relatively modest but would somewhat benefit the local economy. No new businesses would be required to provide the necessary goods and services; thus, little commercial or industrial growth would be stimulated by the project. However, the additional power supply generated by the project may be attractive to new industrial or commercial enterprises.

Operation of the proposed facility would create a steady source of revenue to the UVWUA and to Montrose County. Annual property taxes paid to the County have been estimated by the Sponsors to range between $400,000 and $800,000. The final tax assessment would depend upon the selected alternative and its ultimate valuation. The net economic impacts to Montrose County residents resulting from this windfall cannot be assessed now because it is not known if the county would increase spending levels or reduce property taxes to residents. The Montrose County property tax receipts are presently about $10 million annually.

The Sponsors have estimated the revenue to the UVWUA to range between $150,000 and $300,000 for the first year of operation and increasing thereafter to more than $1 million annually by 2008.

The actual values would depend on the selected alternative, power wheeling arrangements, property taxes, final bids on construction and financing terms. These revenues would be used for three purposes, including retirement of UVWUA indebtedness, rehabilitation and betterment (R&B) of the irrigation system, and reduction of water user assessments.

For this FEIS, it has been assumed that no reduction in water user assessments would occur during the first 15 years of operation and the revenue to the UVWUA ($150,000) would be equally divided between debt retirement and R&B work. Water user assessments would probably not increase; however, they would increase under the no-action alternative. The monies used for the latter category would create additional economic impacts to the region through increased regional sales and increased labor requirements and income. These impacts, along with the short-term economic impacts stemming from construction dollars entering the economy, are summarized in table 3.52.

Table 3.52.--Economic contributions to the economic study area resulting from construction and operation of proposed hydropower facility (in 1992 dollars)

Category	Total seasonal expenditures (dollars)	Total regional sales (dollars)	Total labor income generated (dollars)
Short term			
Construction (per year)	$12,500,000	$22,025,000	$7,287,500
State sales taxes	500,000	Not estimated	
Local sales tax	300,000	Not estimated	
Long term (estimated for 1st year of operation only)			
UVWUA revenues			
R&B	75,000	127,600	50,600
Debt retirement	75,000	Not estimated	
Annual property tax	400,000	Not estimated	

Source: HDR, personal communication, 1989.

Long-term local employment would not increase significantly due to power facility operation since that operation would be automatic. Routine maintenance and repair would be performed by present employees of the UVWUA supplemented by specialized contract labor as required.

The facility would have slight impacts to both sand and gravel operations. The operation located south (upstream) from the proposed tailrace would benefit from the reduced flows in the river during the summer. The reduction would result in exposing more materials, allowing more economically feasible extraction.

However, the gravel operation downstream from the tailrace would be affected by the increased flows, particularly during the winter. The degree of impact is impossible to presently assess because gravel mining operations here have been indefinitely suspended due to a recent change in ownership (1988). Previous owners constructed a temporary roadway along the riverbank to provide access between the gravel pits and rock-crushing facilities. With the increased flows resulting from hydropower development, construction of this temporary access road would be more difficult. Should mining operations resume, the Sponsors would assist the new owner in finding a suitable location for the access road after beginning hydropower operations.

Impacts to the Rafting and Fishing Economy (Alternative A, No Action)

If no action was taken, the rafting and fishing economy in the Gunnison Gorge would continue to be influenced by natural flow variation, operation of the Aspinall Unit, irrigation diversions through the Tunnel, and use regulations of the BLM and the CDOW. Rafting use would be affected by management plans implemented by the BLM. Under this plan, the BLM would restrict the Gunnison Gorge to 2 commercial launches per day, along with a goal of four private launches daily (USDI, BLM, 1988b). River-boating use would be limited to 6 to 10 group encounters per day. Allocations between private and commercial river-boating use would be made if necessary to protect wilderness values or to emphasize opportunities for specific recreational experiences, such as self-reliance, as opposed to guided and outfitted experiences (USDI, BLM, 1989a).

June through September constitutes the primary rafting season in the Gunnison Gorge. From experience gained in 1987 and 1988, it appears that although small rafts and kayaks can negotiate the river at flows below 600 ft^3/s, 600 ft^3/s appears to be the minimum flow needed for larger commercial boats (K. S. Tucker-Leak, USDI, BLM 1988a; personal communication). For recreation and fishing- oriented rafting, optimum flows are probably between 600 and 1,000 ft^3/s. Optimum flows for whitewater boating are estimated between 1,200 and 2,500 ft^3/s (USDI, BLM, 1989b). The evidence from these two years and from information gained from interviews with commercial rafters suggests that, under extended low-flow conditions, whitewater rafters would be replaced over time by fishing-oriented boaters in smaller boats.

Using the flow data presented in table 3.6 for June through September and the 32-year study period (1951 to 1983), the economic returns to the ESA resulting from rafting and fishing were estimated based upon the expenditure estimates presented in table 3.47. During months when the average flow was greater than 600 ft^3/s, it was assumed that the full benefit of rafting would be achieved; i.e., the maximum number of launches under current BLM restrictions would occur.

To assess the impacts of facility development to rafting use of the river, it was assumed that lower flows would make the river less desirable for the rafting experience; consequently, use would decrease as flows decreased. The scale used to incorporate this adjustment is shown in table 3.53.

The percentage reductions in rafting use assumed for this FEIS are estimates. However, in light of recent BLM data (Tucker-Leak, 1988a) and review of staged-discharge information (table 3.44), the reductions may be conservative. Gunnison River flows were generally below 400 ft^3/s throughout most of the summer of 1988 when commercial rafting use decreased by 27 percent from 1987 use and private use decreased by 57 percent. In 1989, when flows were below 400 ft^3/s, commercial use was down 3 percent from 1987; private boater numbers were down 62 percent from 1987.

According to comments received during the scoping process for the DEIS, rafters do not agree among themselves as to what the actual minimum flow should be to achieve maximum economic returns. According to BLM, a marked downward trend in quality of float boating occurs under flows of 1,000 ft^3s and especially under flows of 600 ft^3/s. They also report a significant decrease in float fishing quality at flows below 600 ft^3/s. Consequently, the no-action flows entering the Black Canyon were analyzed for several minimums between 600 and 1,200 ft^3/s to determine a range of possible economic contributions and impacts; for this analysis, it was assumed that no difference would occur in the direct expenditures between float boating and float fishing. (see table 3.54 for results).

From tables 3.53 and 3.54, it is seen that the number of boater days and the value of direct expenditures decline as the assumed minimum flow value increases. This tendency should be expected, as the number of months when the average flows are equal to or greater than 600 ft^3/s is greater than the number of months when higher values occur. As a result of this analysis, the 600 ft^3/s was assumed to represent the worst case for analyzing the economic impacts of hydropower development on the rafting industry. Direct expenditures at this flow level are higher than at any other flow level, implying that the economic impacts of development at the 600-ft^3/s flow level would be greater.

Table 3.53
Percent of use as a function of flow assumed for rafting and angling impact assessment

Mean monthly flow	Percent of maximum launches taken by Commercial	Private	Percent of maximum angler use
If flow is greater than 1,000 ft^3/s	100	100	25
If flow is between 800 and 1,000 ft^3/s	100	100	50
If flow is between 600 and 800 ft^3/s	100	100	75
If flow is between 450 and 600 ft^3/s	75	67	100
If flow is between 300 and 450 ft^3/s	50	33	100

Source: HDR, personal communication, 1989.

Table 3.54.--Economic contributions attributable to rafting and fishing for no-action alternative (in 1988 dollars)

Minimum flow value for maximum use	Private boater days	Commercial boater days	Direct expen-ditures ($)
600 ft^3/s	2,688	1,985	311,000
800 ft^3/s	2,414	1,846	286,000
900 ft^3/s	2,320	1,798	278,000
1,000 ft^3/s	2,311	1,793	276,000
1,200 ft^3/s	2,265	1,769	273,000

Source: HDR, personal communication, 1989.

According to Nehring (1983), the Gunnison River below the Tunnel is most fishable when river flows range between 200 and 600 ft^3/s. Although it is still fishable at flows as much as 1,000 ft^3/s, the river cannot be safely crossed even in chest waders. At flows of more than 1,000 ft^3/s, "the fishability of the river is very limited except from a raft, boat or canoe." The CDOW feels that in an unusually dry year (200 to 300 ft^3/s from April to September), 100,000 angler-hours could be expected between the Tunnel and the North Fork confluence, resulting from the Gunnison River's rapidly growing regional and national popularity (Nehring, 1983).

For flows averaging between 300 and 600 ft^3/s from April through September, the above information suggests that a maximum usage of 25,000 angler-days could be expected. For this FEIS, this usage was separated into a pattern of 2,000 angler-days in April, 3,000 in May, 6,000 in June, 5,000 in both July and August, and 4,000 in September. Further, the monthly usage was adjusted to account for the difficulty of bank and wade-in fishing at higher flows. The scale used for this adjustment is shown in table 3.53.

Increased regulation of recreation may be necessary in the future to protect the resources along the Gunnison River, and this regulation would affect angler numbers.

Using this usage pattern combined with the flows entering the Black Canyon for the no-action alternative (see table 3.6), an average of 17,680 angler days would be annually available for the 6-month period. Applying the expenditure estimates of $25 per angler day results in an average annual direct expenditure of $442,000 resulting from angler use of the Gunnison River.

Impacts to the Rafting and Fishing Economy (Development Alternatives)

Under any of the alternatives being considered, the rafting industry could expect an increase in the number of months when flows would fall below 600 ft^3/s. With each of the four alternatives proposed for the AB Lateral Facility, changes would occur in both rafting and hike-in angler use of the Gunnison River.

Generally, decreases in river flows would result in decreased rafting opportunities but increased hike-in angler use. The effects of decreased flows on the rafting industry can be observed in the reductions in rafting associated with reduced flows during August and September of 1987 and during 1988. During late August and September of 1987, flows in the Gunnison Gorge were kept relatively constant at around 600 ft^3/s. During 1988, flows were reduced to below 400 ft^3/s in May through August. The rafting industry representatives indicated that the lower flows during 1988 restricted use by rafts larger than 14 feet, and rafts 12 to 14 feet in length could negotiate the river at these flows but were subject to increased wear and tear.

According to the recent BLM correspondence (Ken Hermann, BLM, 1990, personal communication), flow values of less than 800 ft^3/s

could result in a shift in use from wilderness-dependent activities, for which the Gorge is currently managed, to primarily fishing-oriented activities. Historically, there has been a natural balance between rafting and angling use in the Gorge. May through mid-July have been generally viewed as the primary "river season" when higher flow conditions favor whitewater rafting, and the majority of angling has occurred during the lower flow periods from late July through early November.

Development of the proposed facility would not significantly affect this pattern. From May through July (1952-1988), mean monthly flows entering the Canyon were greater than 800 ft^3/s in 54 out of a possible 111 months. The average discharge during those 54 months would be about 2,330 under alternative A conditions. Under alternative E conditions for the same time period, flows were greater than 800 ft^3/s in 48 out of 111 months and resulted in an average discharge of approximately 2,120 ft^3/s. Thus, the net impact of development would be to decrease the river season by 6 out of 11 months or about 5.4 percent.

Using the more conservative rafting use versus flow fluctuations shown in table 3.53 and the flow data for each of the alternatives presented in tables 3.8 through 3.11, the direct expenditures, total regional sales, employment and labor income resulting from rafting on the Gunnison River were computed using RIMS Multipliers (U.S. Department of Commerce, 1988). Results of this analysis are shown in table 3.55.

Although rafting activity can be expected to decline with reduced flows in the Gorge, hike-in fishing activity should increase. This is because, as discussed earlier, flows in the 300- to 600-ft^3/s range produce excellent fishability on the Gunnison River; flows of 600 to 800 ft^3/s, good fishability; flows of 800 to 1,000 ft^3/s, fair fishability; and flows of more than 1,000 ft^3/s, poor fishability. As was illustrated previously, all alternatives for the project, except alternative A, would decrease flows during the primary angler-use period of April through September. Thus, for all of the alternatives proposed for the AB Lateral except for alternative A (the no-action alternative), an increase in hike-in fishing activity in the Gunnison Gorge would occur.

The impact of the development alternatives on hike-in fishing activity was calculated following the assumptions outlined for alternative A. Values are presented in table 3.56 and include the effects on regional sales, and employment and labor income generated.

The overall economic impacts of the AB Lateral with respect to both rafting and fishing are shown in tables 3.55 and 3.56. Development of any of the proposed alternatives would reduce the

Table 3.55
Comparison of annual economic contributions to the economic study area from rafting activities in the Gunnison Gorge for all alternatives (in 1988 dollars)[1]

Alternative	User category	User days	Direct expenditures ($)	Total regional sales ($)	Total employment generated (no. of jobs)	Total labor income generated ($)
A	Private	2,688	$100,000	$163,000	8	$51,800
	Commercial	1,985	211,000	344,000	16	$109,300
	Total	4,673	311,000	507,000	24	$161,100
B, E & F	Private	2,286	85,000	138,000	6	$44,000
	Commercial	1,780	189,000	308,000	14	$97,900
	Total	4,066	274,000	446,000	21	$141,900
C	Private	1,872	70,000	114,000	5	$36,300
	Commercial	1,568	167,000	272,000	13	$86,500
	Total	3,440	237,000	386,000	18	$122,800
Differences between alternative A and development alternatives						
B, E & F	Private	-402	-$15,000	- 25,000	-1	-$7,800
	Commercial	-205	-$22,000	- 36,000	-2	-$11,400
	Total	-607	-$37,000	- 61,000	-3	-$19,200
C	Private	-816	-$30,000	- 49,000	-2	-$15,500
	Commercial	-417	-$44,000	- 72,000	-3	-$22,800
	Total	-1,233	-$74,000	- 121,000	-6	-$38,300

[1] The economic study area includes Delta, Montrose, Mesa, Ouray and Gunnison Counties.

Table 3.56
Comparison of annual economic contributions to the economic study area from fishing activities in the Gunnison Gorge for all alternatives (in 1988 dollars)[1]

Alternative	User category	User days	Direct expenditures ($)	Total regional sales ($)	Total employment generated (no. of jobs)	Total labor income generated ($)
A	Fishing	17,680	$446,000	$726,000	34	$231,000
B	Fishing	20,078	507,000	826,000	39	262,600
C	Fishing	21,414	541,000	881,000	41	280,200
E	Fishing	20,063	507,000	826,000	39	262,600
F	Fishing	20,078	507,000	826,000	39	262,600
Differences between alternative A and development alternatives						
B		2,398	61,000	100,000	5	$31,600
C		3,734	95,000	155,000	7	49,200
E		2,383	61,000	100,000	5	31,600
F		2,398	61,000	100,000	5	31,600

[1] The economic study area includes Delta, Montrose, Mesa, Ouray and Gunnison counties.

total expenditures attributable to private and commercial rafting on the Gunnison River. Because alternatives B, E and F propose to divert the same amount of flow during the rafting season (June through September), their impacts are identical and would reduce direct expenditures by about 12 percent. However, alternative C would result in larger diversions due to the increase in Tunnel capacity; consequently, greater impacts to rafting would occur, reducing direct expenditures by about 24 percent.

Conversely, implementing alternatives B, E or F would increase fishing expenditures by about 14 percent. Alternative C would increase expenditures by about 21 percent.

The fishing economic analysis was based upon flow changes during the principal historical fishing season of April to September. During the low flow years of 1988 and 1989, the BLM observed increased use of the Gunnison Gorge by anglers in the off season. By reducing flows to a more fishable range in the off season, the project could result in increased fishing use during this period. Angler use from December through February would probably not change significantly from its present low levels due to the potential for river icing, accessibility to the Gorge and canyon, and weather concerns. However, increased use would occur in October, November, and March. As no substantial baseline information for angler preferences in these months is available for the Gunnison, the economic effects were not quantified. Increased use would result in additional positive economic impacts to the region but would also result in increased management costs.

SUMMARY OF ECONOMIC IMPACTS

The alternatives represent both social and economic tradeoffs. Development alternatives provide substantial tax revenues to Montrose County; substantial revenues to the UVWUA, which has members in both Montrose and Delta Counties; and construction employment. The greatest revenues would occur under alternative C; however, the greatest decreases in the rafting economy would also occur under this alternative. Actual angler and hike-in usage of the Black Canyon and the Gunnison Gorge is predicted to increase under development alternatives, which may be accompanied by increased resource and management problems. Initially, the actual increase may be more or less than indicated in this FEIS, depending upon the public's perception of the fishery resource and conditions.

CULTURAL RESOURCES

EXISTING CONDITIONS

Cultural resources surveys conducted in the Uncompahgre Valley have documented prehistoric sites ranging in age from the Archaic through the precontact period. Historic properties, some of which have been listed on the National Register of Historic Places (National Register), also occur in the Uncompahgre Valley (Chandler, 1984 and 1986).

As one of the oldest irrigation projects in the nation, the Uncompahgre Project is of historical significance. The Gunnison Tunnel, for example, is listed on the National Register, and also is a National Engineering Landmark (USDI, NPS, 1976). Similarly, the M&D Canal and the South Canal have been officially determined as eligible for listing on the National Register.

Agricultural practices and construction and maintenance associated with the Uncompahgre Project have obliterated many traces of prehistoric cultural activity in the area (Chandler, 1984 and 1986). Five Class III cultural resources surveys have been conducted in the AB Lateral Facility area by Collins et al. (1981), Chandler (1984 and 1986), Tucker (1984), and McDonald (1987).

In 1980, the Laboratory of Public Archaeology at Colorado State University, Fort Collins, conducted a survey along the South Canal (Site Number 5MN1851) and the AB Lateral in connection with the Lower Gunnison Basin Unit (Collins et al., 1981). Two historic sites (5MN1618 and 5MN1617) were located near the AB Lateral Facility; one is a ditch rider's house and one a railroad bridge. Neither site is considered to be eligible to the National Register, and both are outside of the facility area. Chandler (1984) surveyed the area around the AB Lateral headgate on the South Canal in connection with another hydroelectric project. One historic site (5MN2347), an adobe structure, was recorded near 5MN1618; it is not considered to be eligible to the National Register and is outside the area of the AB Lateral Facility.

Tucker's survey of the AB Lateral penstock route (1984) located one site and one isolated find. The isolated find (5MN2716) consisted of a single lithic flake of prehistoric origin and is not eligible for the National Register. Site 5MN2715 consists of four wooden structures, a stock pond, and a trash concentration enclosed within a wooden post and barbed-wire fence. Tucker concluded that this property is part of the original homestead of Cyrus Stilson dating from 1891. Because the site is considered to be architecturally and historically significant, it may be eligible for listing on the National Register.

The existing AB Lateral is part of the South Canal system (5MN1851) that has been officially determined to be eligible for nomination to the National Register. Therefore, Chandler (1986) also photographed five irrigation structures in the area that would be affected by the facility: (1) the AB Lateral headgate on the South Canal; (2) the ABA Lateral headgate and bridge across the AB Lateral; (3) the ABC Lateral headgate on the AB Lateral; (4) the AB 0.99 Lateral headgate on the AB Lateral; and (5) a log bridge abutment on the west bank of the AB Lateral. Chandler also reported that engineering plans for these structures are on file at the UVWUA office in Montrose. McDonald (1987) surveyed the preliminary transmission line for the AB Lateral Facility and found one previously recorded site in the survey area, the Selig Canal (5MN1854), which is not eligible to the National Register. The final transmission line will be resurveyed before construction.

IMPACTS OF ALTERNATIVES

Facility development would involve new construction and modifications of the AB Lateral and installation of a new diversion structure on the South Canal. These modifications would substitute for R&B activities that would occur under the no-action alternative. In any case, these changes have been fully recorded. Therefore, modification to a replacement of these structures would not be considered to be a significant, adverse effect (Colorado State Historic Preservation Officer [CSHPO, 1986b]). Other cultural resources would be avoided under the no-action alternative, although they would continue to be subject to natural degradation, decay, and vandalism.

Three of the four alternatives would not modify the Tunnel as part of project development--alternatives B, E and F. However, modifications to the Tunnel are proposed as part of alternative C. The proposed work would be accomplished within the Tunnel; no construction activities would be evident to the general public. The work would be limited to those activities necessary to increase the hydraulic carrying capacity of the Tunnel (as described in chapter 2). Construction activities would be coordinated with the CSHPO if alternative C were recommended, and specific consultation requirements under the National Historic Preservation Act would have to be met.

Except for the Stilson Homestead, no previously unrecorded cultural features of significance were discovered in the area. The Sponsors would install temporary fencing or otherwise assure that the homestead would not be affected during construction. Therefore, it is unlikely that any known site would be affected by construction. Should previously unknown cultural materials be revealed by construction activity, construction at the site would cease and Reclamation and the CSHPO would be notified to evaluate the nature and possible significance of the material before reinitiating work. The CSHPO has determined that no adverse impact would occur on any significant cultural resources, provided that the present scope of the development remains essentially unchanged (CSHPO, 1986a and 1986b).

AIR QUALITY AND NOISE

EXISTING CONDITIONS

Air Quality

The proposed development site, located in Montrose County, has little industry and a low population density resulting in little degradation of ambient air quality. The primary source of air pollution in the area is from the combustion of fossil fuels for transportation, agriculture and heating. A secondary contributor to air pollution in the valley is fugitive emission of dust from agricultural tillage of the semiarid soils.

Ambient air quality standards, which have been established by the EPA, establish the maximum ground-level concentrations of designated pollutants in the ambient air that the agency determines to be adequate to protect the public health and welfare. At present, National Ambient Air Quality Standards (NAAQS) have been adopted by the EPA for six pollutants, otherwise known as "criteria pollutants": particulates, sulfur dioxide (SO_2), ozone, oxides of nitrogen (NO_x), carbon monoxide (CO), and lead (see 40 CFR, Part 50, 1987). An area that is determined to be in compliance with NAAQS standards for a given pollutant is designated as an attainment area for that pollutant. The EPA determines attainment status for criteria pollutants by comparing modeled or monitored data of the area to the applicable ambient air quality standards. The area of the proposed development is classified as attainment for all the "criteria pollutants," based on a review of Code of Federal Regulations 40 (40 CFR; parts 81 to 99; revised July 1, 1987). That is, the air quality in the Montrose County area meets or exceeds the NAAQS.

Noise

Noise in the proposed project area is generally low and not disturbing. Normal sources of noise include vehicles, periodic agricultural equipment such as tractors and harvesters, wind, animal life, and occasional airplane overflights (USDI, Reclamation, 1988).

Except those areas that are close to heavily traveled roadways such as U.S. Highway 50 and within Montrose, day-night weighted sound levels within the project area probably range from 20 to

25 decibels (dB) on the A-scale dB(A) at midnight to 45 to 50 dB(A) during typical afternoons with moderate wind. A value of 55 dB(A) is comparable to the noise heard approximately 50 feet from a road carrying light auto traffic.

Impacts of Alternatives

Air Quality

The proposed right-of-way for the facility alternatives would be about 234 acres; however, construction would occur only on a maximum of about 5 acres on a given day. Activities during the construction phase of the AB development would result in fugitive dust emissions and emissions from internal combustion engines. Dust would be generated due to excavation, earthmoving traffic on unpaved surfaces, and wind erosion. An average particulate emission factor for heavy construction that accounts for all of these activities is 1.2 tons per acre per month of construction activity (EPA, 1985b); this emission factor assumes no mitigative measures. The unmitigated fugitive dust emission rate from the construction activities can be calculated based on the following assumptions: (1) Construction occurs on a maximum of 5 acres per day, (2) construction takes place 6 days a week (26 days a month), (3) a fugitive dust emission rate of 1.2 tons (2,400 lbs) per acre per month occurs, and (4) a twelve-hour work day also occurs.

To determine the daily emission of fugitive dust per acre per day, the emission rate of 2,400 lbs per acre per month is divided by 26 working days (2,400 lbs/acre/month - 26 days = 92.3 lbs/acre/day). Multiplying 5 acres by the daily emission rate per acre (92.3 lbs/acre) yields the maximum daily fugitive dust emission rate from the project construction activities. This could result in a low-level release of approximately 461 lbs per day of fugitive dust. Over the course of a 12-hour work day, this is an unmitigated emission rate of approximately 38.5 lbs/hr. However, the concentrations are short lived, settling rapidly when construction ceases for the day. In addition, the high concentrations of dust would primarily occur within the boundaries of the project site. Mitigation measures applied to control and reduce the amount of fugitive dust should greatly reduce particulate emission and help eliminate potential occurrences of high particulate concentrations during construction.

Motor vehicles such as pickup trucks typically emit hydrocarbons, such as carbon monoxide and nitrogen oxide. Diesel-powered construction equipment, however, emits source pollution consisting of particulate matter, sulfur and nitrogen oxides, hydrocarbons, and carbon monoxide (EPA, 1985b). For example, at normal emission rates for these types of equipment, a pickup truck on the project construction site in use for 12 hours a day could produce 1 lb of hydrocarbons, 9.5 lbs of carbon monoxide and 1 lb of nitrogen oxide. Operation of a road grader at the powerhouse site for a 12-hour working day could generate 0.7 lb of particulate matter, 1 lb of sulfur oxides, 9 lbs of nitrogen oxides, 0.5 lb of hydrocarbons, and 1.8 lbs of carbon monoxide (EPA, 1985b).

Hydroelectric facility operation would have little, if any, direct impact on the air quality of the region. Implementing this project could have a net positive effect on the region's air quality due to its potential pollution emission offsets. Operation of the project would mean that an equivalent amount of generation would not be produced elsewhere. The estimated emission offsets for the project are shown for the various development alternatives in table 3.57.

Table 3.57.--Emissions offsets achieved with development (tons of pollutant)

Alternative	Pollutant	Annual offset	Offset for 40-year Project life
B and F	SO_2	800	32,000
	NO_x	1,300	52,000
	CO_2	234,000	9,360,000
C	SO_2	825	33,000
	NO_x	1,375	55,000
	CO_2	247,000	9,880,000
E	SO_2	740	30,000
	NO_x	1,235	49,000
	CO_2	223,000	8,920,000

Source: Sponsors, personal communication, 1989.

The SO_2 and NO_x values presented in table 3.57 are based on emission factors developed by the EPA in their "Compilation of Air Pollutant Emission Factors" (EPA, 1985b). Assumptions used in this report include using a low sulfur Wyoming coal (0.3 percent) and a low- to mid-range NO_x release (18 lbs/ton). Carbon dioxide emissions are based upon ratios used by the Congressional Research Service (CRS, 1989).

The economic value of emissions offsets can be estimated by using the cost of directly controlling emissions from existing coal-fired generation plants as an example. The CRS (1988) has estimated the annual cost of reducing SO_2 at utility plants to range from $452 to $508 per ton (1985 dollars) under a nationwide reduction program of approximately 12 million tons, or about one-half of this amount for a reduction of 10 million tons. In 1988 dollars, this is approximately $500 to $560 per ton for 12 million tons, or $250 to $280 per ton for 10 million tons. Pending Federal legislation, as well as the Clean Air Act reauthorization proposal for SO_2, generally fall between the 10- and 12-million ton levels. For this FEIS, the cost associated with a lower or less expensive level of emissions reductions was used ($250 per ton).

The economic cost of NO_x reductions was similarly calculated. Pending legislation calls for NO_x reductions of 2 to 4 million tons. The cost for a utility reduction of 2.5 to 2.7 million tons has been estimated to range from $577 million to $1 billion per year (1985 dollars; CRS, 1988). Escalating to 1988 dollars gives a range of $215 to $440 per ton per year. The conservative number of $215 per ton was used to value nitrogen oxide offsets for this FEIS.

The cost of CO_2 emissions offset is not only expensive but varies widely among existing technologies. For generating plants run by electric utilities, these technologies can generally be divided into two categories: fuel switching at existing plants (e.g., natural gas emits about one-half of the CO_2 per British thermal units (of coal) and installing CO_2 removal equipment at existing facilities. The CRS (1989) has estimated fuel switching costs to range from $29 to $2,814 per ton of CO_2 saved. Using the lower of these figures, AB Lateral would offset costs of approximately $6.5 million per year through using fuel switching.

Costs for installing and operating a typical CO_2 removal system at an existing generating plant would be less expensive and include a capital component ($26 million for a 100-megawatt plant) and energy loss (21 percent reduction in plant efficiency; CRS, 1989). The Sponsors have estimated that these costs would translate to approximately $3 million annually for a coal plant with generation characteristics similar to the AB Lateral. Thus, the costs would, for a CO_2 removal system, be offset by construction of the project (see table 3.58).

Table 3.58.--Annual economic value of emissions offsets (in 1988 dollars)

Pollutant	Alternatives A	B and F	C	E
SO_2	0	$ 200,000	$ 206,000	$ 185,000
NO_x	0	280,000	295,000	265,000
CO_2	0	3,124,000	3,198,000	2,778,000

Source: Sponsors, personal communication, 1990.

As no final congressional action has been taken yet regarding emissions reductions related to electric utilities, the above numbers need to be considered subjective, particularly true regarding CO_2 costs, for which a firm knowledge base is only just beginning to be established. The figures are nonetheless useful in understanding the economic values of emissions offsets.

Air quality would be affected near the revetment and fencing because of construction equipment and dust resulting from equipment travel and installation. Noise levels near each location due to the increase of vehicular traffic would also be affected. After project installation is completed, these impacts would no longer occur.

Noise

The primary noise effects during construction of the proposed project would result from additional traffic caused by commuting construction workers, material delivery trucks and operation of construction equipment at the project site during a normal workday.

The type and numbers of construction equipment used on the project would vary during each construction phase. Each phase from penstock construction to plant site preparation, foundation construction, building erection, equipment installation, and finishing requires a different number of workers and different types of equipment. Construction would be characterized by the near-continuous operation of large equipment, compactors, water trucks, cranes, truck-mounted augers, bulldozers, pile drivers and graders throughout the workday. The location of equipment and the amount of usage (ranging from idling to operation at full power) are highly variable. However, these activities are all temporary.

The State of Colorado presently exempts construction noise from any enforceable standards during the daytime hours (7 a.m. through 7 p.m.). During nighttime hours, the exemption is lifted and the standard reverts to the standard enforced for the type of neighborhood where the construction activity is occurring (see table 3.59).

Noise created during penstock construction could affect residences at various locations along the route and commercial and light industrial areas near the downstream end of the penstock. Noise created by construction at the powerhouse could affect residential, commercial and light industrial areas that are located nearby.

The noise level at the powerhouse during operation would be created by four primary sources: the turbines, generators,

Table 3.59.--Maximum permissible noise levels allowed by Colorado State law (dB)

Type of neighborhood	Daytime (7 a.m. - 7 p.m.)	Nighttime (7 p.m. - 7 a.m.)
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

Source: USDI, Reclamation, 1988.

transformers and minor vehicular traffic moving in and out of the site. Turbine and generator noise would originate inside the plant structure and would be muffled by the walls and roof of the building. Within the operational areas of the plant, the noise levels and vibrations would conform to the safe levels as established by Occupational Safety and Health Administration regulations.

Vehicular traffic to and from the plant would be infrequent because plant operation would be automated. Plant traffic would consist of UVWUA employees involved in routine maintenance and emergency repairs.

Outside of the plant structure, only the transformers would be a constant noise source, producing an estimated 60 dB(A). Within a distance of 500 feet of the transformer, this level would be reduced to approximately 40 dB, which would comply with Colorado's nighttime residential noise level of 50 dB or less. Because the nearest residences are several blocks away from the plant site, plant operation would not cause a significant noise impact to local residents.

The penstock would not be a source of noise or vibration, as it is buried. The small amount of noise and vibration generated by the flowing water would be dampened by the earth covering the pipe.

Impacts of noise and air pollution would be reduced by special measures during the construction and operation of the facility. Operation of construction equipment, especially earthmoving equipment, produces both air emissions and fugitive dust. Although these impacts are short term and localized, several measures would be employed to mitigate their effects.

Measures to minimize mobile source emissions and impacts would be required in the construction contract as follows: (1) construction vehicles would be well maintained under an inspection and maintenance program to minimize air pollutant emissions; (2) engine idling would be discouraged when vehicles are not directly in use during construction; and (3) entrance and egress routes would be limited, and delivery times for materials will be scheduled to reduce queue lengths for vehicles serving the site.

Fugitive dust generated by construction activity could be significant in the short-term, uncontrolled worst-case condition. Sources of on-site fugitive dust include conveyance, transfer, earthmoving, and dumping operations; vehicular traffic; and open storage areas. Several commonly used mitigative measures are proposed to reduce construction-generated fugitive dust emissions. Conveyance operations would be enclosed wherever possible. All transfer points and material handling operations would be periodically cleaned. Dumping and transfer of loose, fine-aggregate materials would be restricted. Vehicles transporting these materials would be covered and loading and unloading would be controlled.

Vehicular traffic on unpaved areas would be avoided where possible and vehicle speeds would be controlled. Surface dust loadings on paved access routes would be minimized by periodic sweeping. Open storage areas containing fine, unbound materials would be either covered or sprayed with surfactants and/or water to reduce wind effects. Watering unpaved surfaces would be done during construction to control dust. Dust emissions can be virtually cut in half, with complete water coverage applied twice a day (EPA, 1985b). Employing wind breaks and covering dusty material storage areas also would help to reduce fugitive dust by sheltering exposed materials from the wind. Disturbed surfaces would be promptly revegetated when construction ends to minimize dust emissions due to wind erosion.

ENERGY AND DEPLETABLE RESOURCES

The facility would use an estimated 200,000 kilowatthours (kWh) of energy annually to run the plant, with little chance to reduce the amount. This energy would be used largely for heating, cooling, pumping, controls, and generator excitation. The project would be a net producer of electric energy, generating from 247,264,000 kWh (alternative E) to 274,911,000 kWh (alternative C) annually, after deductions for energy use at the plant. Operation of the project would not affect the electrical conservation potential of Public Service or other regional utilities.

Project operation would cause a net savings of fossil fuels. Since a balanced utility system requires instantaneous generation to equal instantaneous load, integration of project power into the grid would avoid the need to burn additional fossil fuels for an equivalent amount of generation. The total fossil fuel savings would range from approximately 412,000 to 458,000 barrels of oil per year, or 124,000 to 137,000 tons of coal per year, depending on the alternative. Table 3.60 below details these projected savings.

Table 3.60.--Annual generation and fuel savings (AB Lateral Hydropower Project)

Alternative	Generation (MWh)	Equivalent amount fossil fuel saved Oil (barrels)	Coal (tons)
A	0	0	0
B	261,006	435,000	130,000
C	274,911	458,000	137,000
E	247,264	412,000	124,000
F	258,619	431,000	129,000

Source: Sponsors, personal communication, 1989.

CUMULATIVE IMPACTS

Cumulative impacts are those that result from the incremental impacts of an action added to other past, present and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a given time period.

Cumulative impacts on flow regimes, water quality, and recreation are particularly important in relation to the AB Lateral Facility. Upstream water projects have significantly altered the flow regime in the Gunnison River (see attachment B) and Ridgway Reservoir is now beginning to significantly affect flow regimes and water quality in the Uncompahgre River.

To more accurately describe impacts of the AB Lateral alternatives, future river and reservoir operations have been projected under the no-action alternative. The changes due to the proposed alternatives have been compared to this base so that the total impacts on the river system can be seen.

Cumulatively, the impacts of reduced flows in the Gunnison River and the resultant increase of hike-in human use would affect wilderness and river values and would also reduce solitude and primitive recreational opportunities. Extensive publicity (both recent and ongoing) about the river and efforts to acquire additional access to the river will also contribute to an increase in hike-in human use. To preserve wilderness values, it will likely be necessary for the NPS and the BLM to institute more restrictive management practices on lands they administer along the Gunnison River.

The cumulative impacts of past water development on the riparian vegetation and associated wildlife of the Gunnison and Uncompahgre Rivers are also significant. Overall, the high spring flows that characterize rivers in Colorado have been diminished. Late season flows are supplemented for irrigation or hydropower operations. In general, riparian vegetation has increased in response to lower spring flows; however, certain species that benefit from periodic flooding such as cottonwoods are adversely affected. This trend would continue and probably increase with further water development.

A number of other projects upstream from the Aspinall Unit are currently being considered, which include transmountain diversions to the eastern slope of Colorado. The feasibility of these proposals is directly affected by Colorado law. If any of the development alternatives proposed in this FEIS were to be implemented, the available water supply for those projects could be reduced if their water rights are junior to those of the AB Lateral Facility.

CHAPTER 4

CONSULTATION AND COORDINATION

This chapter summarizes public involvement on the AB Lateral Project and serves as the public involvement summary report.

INITIAL ACTIVITIES

Since 1979, developing hydropower in the Uncompahgre Valley has been proposed by many groups, including the Uncompahgre Valley Water Users Association (UVWUA) and Montrose Partners (referred to as the "Sponsors"). These proposals have been considered by numerous groups and agencies. Early studies were conducted under Federal Energy Regulatory Commission (FERC) procedures and involved assorted alternatives for producing power from water diverted from the Gunnison River through the Gunnison Tunnel (Tunnel). Reviews under FERC procedures generated significant correspondence in efforts to complete consultation and coordination efforts.

Various parties either prepared preliminary comments on the hydropower proposals or requested information and data relating to the affected project area environment. Agencies and organizations who participated at that stage included:

FEDERAL AGENCIES

Environmental Protection Agency (EPA)
U.S. Army - Corps of Engineers (COE)
U.S. Department of Agriculture - Forest Service (USFS)
U.S. Department of Interior (USDI)
Bureau of Land Management (BLM)
Bureau of Reclamation (Reclamation)
Fish and Wildlife Service (FWS)
National Park Service (NPS)
Office of Environmental Affairs (OEA)

STATE AGENCIES

Department of Health
Division of Parks and Outdoor Recreation
Division of Wildlife
Public Utilities Commission
State Engineer
State Historic Preservation Officer (SHPO)
Water Conservation Board
Water Quality Control Division

LOCAL AGENCIES

City of Montrose
Montrose County
Tri-County Water Conservancy District

The primary environmental concerns raised in this early consultation included:

- loss of small mammal habitat and increased erosion due to construction,

- location of powerlines to minimize habitat disturbance,

- possible hazards to raptors through electrocution on contacting powerlines or through increased hunting pressure in the powerline right-of-way,

- the potential for game animals to be trapped in the canals or laterals,

- hazards to waterfowl that might strike the powerline,

- effects of increased river icing or lowering of ambient temperatures on overwintering waterfowl and other migratory and resident fauna below the Tunnel,

- adverse effects of peak flow fluctuations on riparian zones and banks along the Gunnison and Uncompahgre Rivers,

- increased flows in the Uncompahgre River impeding game movement,

- a minimum flow in the Gunnison River below the tunnel at 300 cubic feet per second (ft^3/s) or greater to protect the Gold Medal trout fishery as well as endangered or threatened species found in the Colorado River,

- effects of fish populations if instream work on the powerplant system occurred during fish spawning seasons,

- coordination of project maintenance with operation of Wayne N. Aspinall Unit to avoid fluctuations harmful to trout,

- design of project features to prevent hazards to fish during powerplant shutdowns, and

- effects on endangered species requiring Section 7 consultation under the Endangered Species Act.

In response to these initial concerns, the Sponsors and other applicants under FERC procedures conducted several specific environmental studies and reviewed existing data. As indicated in chapter 1, Reclamation published a Notice of Intent to contract for hydropower development on the Uncompahgre Project in the Federal Register (50 CFR 50238) on November 9, 1985. The USDI through Reclamation became the lead Federal agency; therefore, the hydropower proposal was no longer under FERC's authority.

Early in 1986, the BLM, the FWS, the NPS, and Colorado Division of Wildlife (CDOW) were contacted to discuss any additional environmental concerns and necessary environmental studies. In June 1986, news releases on the AB Lateral facility were issued to local newspapers and other news media; in response, comments were received from The Nature Conservancy and the Western Colorado Congress. Concerns raised and studies suggested by these agencies and organizations included:

- need for a survey of endangered plants along the penstock route,

- need for quantification of fish losses through the Tunnel,

- determination of the effect of ice on Gunnison River waterfowl and eagles,

- consideration of the effect of flows on Uncompahgre Valley gravel operations,

- consideration of the effect of flows on livestock operations on the Uncompahgre River,

- consideration of the northern pike in the analysis of Gunnison River impacts,

- use of existing rafting data to assess impacts on rafting,

- study of the potential of a tailrace fishery on the Uncompahgre River downstream from the powerplant, and

- determination of the effect of a project on water quality in the Uncompahgre River.

These issues were addressed in several ways. Field surveys of the endangered plant species were initiated and an analysis of icing potential in the Gunnison River was conducted. Contacts were made with landowners along the Uncompahgre River to determine the potential problems with livestock and gravel operations. The CDOW was contacted on fish loss through the Tunnel, waterfowl, northern pike management, and the tailrace fishery. The FWS was contacted concerning data needs regarding bald eagles on the Gunnison River, and consultation under section 7 of the Endangered Species Act was initiated between Reclamation and FWS (see more detail in chapter 3).

In 1987, Reclamation began preparing an environmental assessment for the AB Lateral Facility. Two environmental scoping meetings were held regarding the facility in October 1987, one in Denver and one in Montrose. A Notice of Environmental Scoping Meetings was published in the Federal Register before the meetings, and news releases were published in local newspapers. In addition, letters were sent to various interested agencies and organizations advising them of the meetings, including local, state, and Federal agencies and organizations such as Trout Unlimited and Western River Guides. Concerns and issues raised in the scoping meetings are listed below.

CONCERNS AND ISSUES

Minimum flows for the Gunnison River

Date of hydropower water rights and whether later instream flow rights would be honored

Relationship of the project to the Lower Gunnison Basin Unit winter water replacement program

Potential of fish losses through the Tunnel

Effect of the project on Blue Mesa Reservoir

Effect of the project on the Upper Gunnison-Uncompahgre Basin Study

Effects on utilities in city of Montrose

Potential for improved water quality and flow to cause classification of the Uncompahgre River to be upgraded, in turn causing stricter discharge limitations to be placed on Montrose sewer plant

Type of permit Reclamation would issue on the project

Impact of higher winter flows in the Uncompahgre River on wetlands and land use including positive and negative effects on waterfowl, livestock, vegetation, and other parameters

Designation of Reclamation as the lead agency and question as to why Reclamation would not prepare environmental statement

Potential of topsoil along penstock to be returned to irrigated lands

Assessment of new transmission line

Placing pipeline within easements of existing drainage ditches to avoid productive fields

Authority needed to perform surveying on private land

Alternative routes for penstock

Use of water that goes into the Uncompahgre River in spring (earlier than at present) and availability to farmers

Use of earlier spring water for recreation, i.e., fishery purposes

Earlier spring water creating more of a floodplain situation with positive and negative effects

Effects of higher flows in Uncompahgre River on salt leaching from banks

Potential for increased flooding on Uncompahgre River

Consideration of Ridgway Dam for reducing flooding caused by powerplant

Need for Section 404 Permit

Need for bank protection program on the Uncompahgre

Capacity of AB Lateral

Consideration of community benefits and local control

At the meetings, Reclamation explained that either a finding of no significant impact or a draft and final environmental impact statement would be prepared to comply with the National Environmental Policy Act (NEPA). The issues raised at the scoping meetings were used to finalize the Sponsors' proposal and to finalize the environmental assessment (EA). Additional contacts were made with the CDOW, BLM, COE, FWS, Region 10 League for Economic Assistance and Planning (Region 10), The Nature Conservancy, the Colorado Department of Health (CDOH), and others to clarify and answer issues.

The FWS (USDI, FWS, 1988b) prepared a draft Planning Aid Memorandum on the project in accordance with the Fish and Wildlife Coordination Act and a Biological Opinion in accordance with the Endangered Species Act. The draft recommendations of the FWS include in-kind replacement of wetland losses, inclusion of winter flows such as in alternative F to reduce icing, inclusion of deer escapes in the enlarged AB Lateral, development of a South Canal management plan, and establishment of a summer minimum flow of 60 to 80 ft^3/s in the Uncompahgre River through Montrose. (See attachment E for the recommendations.)

ENVIRONMENTAL ASSESSMENT

The EA was mailed to approximately 200 individuals, organizations, and agencies in March and April 1988. In addition, copies were available in local libraries and at the UVWUA and BLM offices in Montrose. A press release was issued on the availability of the EA and received substantial coverage by local and state news media.

A review period of 30 days was set for the assessment; however, the review was extended to 60 days after several individuals and organizations requested additional time. The extension was the subject of additional news releases, and individual notification was made to those who requested an extension.

During the review period, meetings with local Government agencies were held to answer questions on the project. In addition, meetings were held with the Colorado Division of Parks and Outdoor Recreation (CDPOR), Trout Unlimited, the Sierra Club, Region 10, FWS, and CDOW. The Sponsors also met with several local agencies and individuals to answer questions concerning the project.

Approximately 300 comment letters were received on the EA. Comments included three general categories: additional studies or an environmental impact statement (EIS) needed on the project, opposed to the project based on various reasons, and supporting the project based on various reasons.

Specific comments are available at Reclamation's Grand Junction Projects Office. The primary environmental issues addressed are summarized below and were considered the most significant issues for additional consideration in the EIS.

Effect of the proposal on various land uses and land use designations along the Gunnison River (i.e., Wild and Scenic River and wilderness study area status)

Effect of reduced flows in Gunnison River on water temperature

Effect of proposals on Gunnison River fishery, particularly downstream from the North Fork

Effect on rafting on the Gunnison River

Effect on reserved water rights associated with the Black Canyon of the Gunnison National Monument (Monument) and the existing wilderness area

Effect on channel morphology, erosion, sedimentation, and other river mechanics factors on the Gunnison and Uncompahgre Rivers.

Effect on existing and potential recreation use of the Uncompahgre River

Effect on recreation and tourism from a visitor use and economic standpoint

More discussion on the purpose and need for the project is needed

Additional alternatives should be addressed

In response to the comments received and based on the EA itself, Reclamation determined that an EIS should be prepared. This decision was published in local and state newspapers as well as being the subject of a notice in the Federal Register. Additional studies and coordination were initiated to answer comments on the assessment and are summarized on the following pages.

Concern	Response
The effect of the project on various land uses and land use designations along the Gunnison River (such as Wild and Scenic River status and wilderness).	Additional consultation work was done with the NPS and the BLM on these issues. Written comments were obtained from both agencies.
The effect of project on water temperatures in Gunnison River in summer and winter.	Low flows in the summer of 1988-1989 provided an excellent opportunity to monitor water temperatures.
	Temperature stations were installed between Crystal Reservoir and Delta and were used to monitor summer and winter temperatures. In addition, further studies were completed by a consultant with expertise in icing. Alternative F includes plans to bypass additional flows down the Gunnison River to reduce icing if it becomes a problem.
Effect of project on Gunnison River fishery downstream from the North Fork confluence.	Once again, the 1988-1989 water temperature data helped assess these conditions. Also, Reclamation obtained input from the CDOW on angler use, fish harvest, distribution, and fish population collected at the end of 1988 from the Gunnison River upstream and downstream from the North Fork confluence.
Effect of the project on river rafting.	Information from BLM on the effects of low flows on rafting in the 1988 season provided additional data to evaluate this impact. Comments made on the EA were used to better define the types of rafting, minimum and optimum flow needs, and other flow-related factors.

Concern	Response
Effect of the project on river morphology and related subjects.	An independent consultant prepared an analysis of this subject, and the results were included in the DEIS.
Effect of the project on recreation use and potential use along the Uncompahgre River.	Additional flow analyses were completed to better determine flow changes in this area to more accurately define pre- and post-project conditions. An alternative plan includes provisions to supplement flows in this reach.
Effect of the project on recreation and tourism from an economic standpoint.	An independent consultant prepared information on recreation and tourism impacts in Montrose and Delta Counties.
Need for project should be explained more thoroughly.	This section of the DEIS was expanded with additional information not included in the EA.
Additional alternatives should be addressed.	The DEIS included more detail on alternatives considered and why they are considered viable or nonviable.

In September 1988, a status letter on the preparation of the EIS was mailed to news media and to interested organizations and agencies. The Notice of Intent to prepare the EIS was published in the Federal Register on December 27, 1988.

The comments received at the public hearings, written comments, and responses to these comments are presented in volume II of this FEIS. The text has also been revised in response to the concerns and comments listed. Additional information was also collected to assist in answering the comments. For example, additional design data for the Uncompahgre River bank stabilization program were collected in the field and discussions were held with the FWS, CDOW, COE, EPA, and landowners to further develop the stabilization program. Additional data on resources and use were provided by the NPS, BLM, and CDOW on Gunnison River resources. Data collected on the Uncompahgre and Gunnison River fisheries in 1989 are included in the FEIS.

During the public hearings period, negotiations were held between the Sponsors (represented by the UVWUA and Mitex, Inc.) and environmental groups represented by the Sierra Club, Western Colorado Congress, Trout Unlimited, and Western River Guides. Reclamation and a private citizen, Mr. Bill Alexander, facilitated the negotiations, and the BLM, NPS, and CDOW attended as technical advisors.

The Sponsors discussed the possibility of changing their preferred plan to alternative E, which would reduce diversions by 66,000 acre-feet annually. The Sponsors believed that this would greatly reduce concerns with the project's impacts in the summer months. Table 4.1 shows the frequency of time flows would drop below 550 ft^3/s under alternative E.

Table 4.1.--Number of times in 32 years average monthly Gunnison River flows dropped below 550 ft^3/s[1]

Month	No-action (alternative A)	Alternative E
June	13	18
July	16	18
August	4	5
September	19	24

[1] 1952 through 1983.
Source: HDR, 1989a.

Western Colorado Congress, Trout Unlimited, and Western River Guides expressed an interest in an alternative that would provide a minimum flow for hydropower of 600 ft^3/s rather than 300 ft^3/s. The Sierra Club could not present a flow recommendation, indicating that no additional diversions should occur until the Black Canyon of the Monument's reserved water right was quantified. The 600 ft^3/s was not financially feasible according to the Sponsors and therefore could not be financed and constructed. The environmental groups indicated that they could not consider minimums below 600 ft^3/s without additional information showing that resources would not be significantly affected. A consensus was not reached on an alternative that would be agreeable to all parties in the negotiations, although a better understanding of different positions and concerns developed.

The FEIS was prepared by Reclamation addressing comments received on the draft. Following publication of the FEIS, a record of decision will be prepared stating Reclamation's decision on the project.

ENVIRONMENTAL IMPACT STATEMENT

The availability of the draft environmental impact statement (DEIS) was published in the Federal Register and in local and State newspapers. Public hearings were held in Denver, Montrose, and Delta, Colorado. The distribution list for the FEIS follows, and the FEIS has been provided to those listed. Individuals or organizations providing written comments on the DEIS or providing testimony at the public hearings are marked with an asterisk (*).

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NEWS MEDIA

Crested Butte Chronicle, Crested Butte, Colorado
The Daily Sentinel, Grand Junction, Colorado
Delta County Independent, Delta, Colorado
Denver Post, Denver, Colorado
Gunnison Country Times, Gunnison, Colorado*
Montrose Daily Press, Montrose, Colorado
North Fork Times, Paonia, Colorado
Ouray County Plaindealer, Ouray, Colorado
Rocky Mountain News, Denver, Colorado

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Uncompahgre Recreational Corridor Coalition, Montrose, Colorado
Uncompahgre Valley Association, Montrose, Colorado
Uncompahgre Valley Water Users Association, Montrose, Colorado
University of Colorado Wilderness Study Group, Boulder, Colorado*
Water Market Update, Santa Fe, New Mexico
West Slope Energy Research Center, Hotchkiss, Colorado*
Western Colorado Congress, Montrose, Colorado*
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Jody L. Werner, Buena Vista, Colorado
Fred Wetlaufer, Montrose, Colorado*
Kent Wheeler, Salt Lake City, Utah*
Bill White, Telluride, Colorado
Charles White, Denver, Colorado
Gary and Syril Whitlock, Montrose, Colorado*

Louis Wick, Delta, Colorado
Joe and Ruby Williams, Montrose, Colorado
Mr. and Mrs. Bill Wilson, Montrose, Colorado*
Mike Wilson, Gunnison, Colorado
Fred Witaschek, Englewood, Colorado
Mr. and Mrs. Andrew Wolcott, Paonia, Colorado*
Steve Wolcott, Paonia, Colorado
Steven Wondzell, Las Cruces, New Mexico
John Wood, Englewood, Colorado*
Mary Wood, Montrose, Colorado
Roberta Wood, Central City, Colorado*
Ralph Woods, Montrose, Colorado
Chuck Worley, Cedaredge, Colorado*
Fred Yost, Washington, DC
Frank Young, Olathe, Colorado
Millicent Young, Paonia, Colorado*

LIST OF PREPARERS

This final environmental impact statement (FEIS) has been prepared by Reclamation using an interdisciplinary team effort. Reclamation's Grand Junction Projects Office, Upper Colorado Regional Office, and Denver Office were involved in its preparation. Certain studies were prepared by private consultants as were preliminary sections of the report. In addition, private citizens as well as representatives from local, state, and Federal agencies have provided data or prepared reports that were used in the statement's preparation. These individuals and organizations are cited in the text and in the references cited portion of this report. The following list includes those primarily responsible for the document.

RECLAMATION PERSONNEL

Name: Arlo Allen
Position: Supervisory Electrical Engineer
Education: B.S., Electrical Engineering
Experience: 22 years
Input to report: Contracts, purpose and need

Name: Peggy Barnett
Position: Archeologist
Education: M.A., Archeology
Experience: 9 years
Input to report: Cultural resources coordination

Name: Jane Blair
Position: General Engineer
Education: M.S., Civil Engineering
Experience: 11 years
Input to report: Hydropower, lease of power privilege

Name: Linda Branch
Position: Writer-editor
Education: B.A., Journalism
Experience: 15 years
Input to report: Editing, coordinating, and publishing

Name: Fred Crabtree
Position: Supervisory Civil Engineer
Education: B.S., Civil Engineering
Experience: 27 years
Input to report: Design, bank stabilization, and operation and maintenance concerns

Name: Patrick Koelsch
Position: Fishery Biologist
Education: M.S. Environmental Science
Experience: 12 years
Input to report: Fisheries

Name: Gordon Lind
Position: Environmental Protection Specialist
Education: M.S., Wildlife Biology
Experience: 17 years
Input to report: NEPA compliance and impact analysis

Name: Steve McCall
Position: Environmental Specialist
Education: M.S., Wildlife Biology
Experience: 17 years
Input to report: Environmental coordination

Name: Coll Stanton
Position: Hydraulic Engineer
Education: B.S., Agricultural Engineering
Experience: 14 years
Input to report: Hydrology and water rights

Name: Lynnette Wirth
Position: Public Involvement Specialist
Education: B.S., Education
Experience: 11 years
Input to report: Public involvement matters

PRIVATE CONSULTANTS

Name: Kelly A. Bettendorf
Position: Environmental Assistant, HDR Engineering, Inc.
Education: B.S., Biology
Experience: 20 years
Input to report: Terrestrial wildlife and soils and vegetation

Name: Barry Butterfield
Position: Civil Engineer, HDR Engineering, Inc.
Education: M.S., Water Resources
Experience: 13 years
Input to report: Hydrology and technical analysis

Name: Mark R. Deutschman
Position: Environmental Specialist, HDR Engineering, Inc.
Education: B.A., Zoology
Experience: 5 years
Input to report: Water temperature and quality and fisheries

Name: William Fowler
Position: Project Manager, Montrose Partners
Education: B.S., Electrical Engineering
Experience: 10 years
Input to report: Sponsor's input

Name: Richard Kentro
Position: Environmental Planner, HDR Engineering, Inc.
Education: M.S., Environmental Planning
Experience: 15 years
Input to report: Quality assurance

Name: George Minerich
Position: Environmental Specialist, HDR Engineering, Inc.
Education: B.S., Environmental Studies
Experience: 2 years
Input to report: Air quality and noise and land use

Name: Michael A. Stevens
Position: River morphologist, private consultant
Education: PhD., Civil Engineer
Experience: 22 years
Input to report: River mechanics and channel morphology

Name: James Thompson
Position: Economist, Western Research Corporation
Education: PhD., Sociology
Experience: 25 years
Input to report: Fishing and rafting economics

Name: Jeffrey Turner
Position: Environmental Specialist, HDR Engineering, Inc.
Education: M.S., Geography
Experience: 11 years
Input to report: Environmental analysis

The following Upper Colorado Regional Office and Denver Office Personnel provided technical review of the report:

Thayne Coulter-social aspects and public involvement
Art Cudworth-hydrology
Reed Harris-fisheries and endangered species
Marvin Hein-hydropower and lease of power privilege
Richard Long-bank stabilization and lease of power privileges
Larry Schluntz-economics
Bob Strand-sedimentation and bank stabilization
Doug Yoder--fish and wildlife

CHAPTER 6

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GLOSSARY OF TERMS

acre-feet	A measure of water volume, 1 foot of water covering an acre in area.
age class	A grouping of organisms in which all of the individuals originated in the same regeneration period.
alluvium	A deposit of sand and gravel formed by flowing water.
autotrophic	Refers to organisms that are capable of producing organic substances from inorganic materials by means of energy received from outside the organism.
back-calculated length	Mathematical relationship between fish age determined by scale measurements and fish length.
benthos	Organisms living in or on the bottom of a lake or stream.
biomass	The amount of living matter in the form of one or more kinds of organisms present in a particular habitat.
Celsius (centigrade)	°C = (°F-32)5/9.
colluvium	A deposit of soil and gravel deposited at the foot of slopes by gravity.
cubic foot	A measure of a moving volume of water (ft^3/s) per second.
cultural resource	Any building, site, district, structure, or object significant in history, architecture, archeology, culture, or science.
degradation	The geologic process wherein streambeds and flood plains are lowered in elevation by the removal of material. The opposite of aggradation.
discontinuity distance	The distance from a dam to a point in a river gradient where biophysical conditions resemble those that existed in an upstream area before regulation.

ecosystem	A complex system composed of a community of fauna and flora taking into account the chemical and physical environment with which the system is interrelated.
endangered species	A species that is in danger of extinction throughout all or a significant portion of its range.
Fahrenheit	°F-(9/5°C)+32.
forbs	An herb other than grass.
fry	Fish between the egg and fingerling stage.
gneiss	A metamorphic rock of granite or feldspar.
head	The difference in elevation between two bodies of water.
hectare	An area of land or water equal to 2.471 acres.
invader plants	Species, often annuals, which are not part of the climax vegetation, that invade land when there is little or no competition from other plant species.
Julian day calendar	The system used especially by astronomers of numbering days consecutively from an arbitrarily selected point instead of by cycles of days.
lease of power privilege	A contract between the U.S. Department of the Interior and the Project Sponsors allowing use of Federal facilities for power production.
limnology	The scientific study of physical and chemical conditions in fresh waters.
macro-invertebrates	Animals lacking a backbone and internal skeleton, such as insects, worms, and crayfish.
mesophyte	A plant growing under medium condition of moisture.
metabolism	The sum total of the chemical transformations occurring in the body of a living organism.

micron	A unit of measure equal to one thousandth of a millimeter (0.000039 inch).
National Register	The National Register of Historic Places is the federally maintained register of significant districts, sites, buildings, structures, architecture, archeology, and culture.
Oligochaeta	Oligochaete--any of various worms of the class.
periphyton	Organisms that live attached to underwater surfaces.
phreatophyte	A deep-rooted plant that grows in riparian zones and obtains water from the water table or the soil just above it.
phytoplankton	Passively floating plant life, primarily algae.
reach	A portion of a stream or river.
recruitment	The increase in population caused by natural reproduction or immigration.
redd	The spawning ground or nest of various fishes.
revetment (bank)	A facing for supporting an embankment.
riparian (vegetation)	Living on the banks of a river or stream.
riprap	Stones placed on the face of a dam or on streambanks or other land surfaces to protect them from erosion.
salmonid	Of or related to the Salmonidae, the family of fishes including trout.
schist	A metamorphic rock having no granites or feldspar.
sediment	Any usually finely divided organic and/or mineral matter deposited by water in nonturbulent areas.
sere	A series of ecological (vegetative) communities.

sinuosity	The ratio of the total length of the river reach to the straight line distance between the beginning and end of the reach.
South Canal terminus	The point where the South Canal enters the Uncompahgre River.
specific conductance	A measure of the electrical conductivity of water that reflects the concentration of dissolved solids in the water. Generally, the total dissolved solids can be estimated by multiplying the specific conductance by 0.66.
surfactant	A water soluble compound which is applied to ground surfaces to reduce dust emissions.
taxon (pl. taxa)	A group of genetically similar organisms.
thermal stratification	A temperature gradient within a body of water caused by warmer water occupying the upper level of the water and colder, denser water occupying the lower level.
threatened species	A species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
trophic	Related to nutrition, particularly the types of food an organism requires.
trophic level	Place of an organism in the food chain.
trophy fish	In terms of trout, a fish that exceeds 14 inches.
weighted usable area	An expression of the quantity of fish habitat, in feet squared per 1,000 feet of river channel.
wetland	An area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.
year class	Animals born in a given year.

CHAPTER 8

LIST OF ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS

Btu	British thermal unit
C.I.	confidence interval
cm	centimeter
CO_2	carbon dioxide
dB	decibel
DOC	dissolved organic carbon
ft^3/s	cubic feet per second
ha	hectare
HP	horsepower
kg	kilogram
kg/ha	kilograms per hectare
km	kilometer
kV	kilovolt
kW	kilowatt
kWh	kilowatthour
m	meter
mg	milligram
mg/L	milligrams per liter
MW	megawatt
MWh	megawatt-hours
N	sample size
NO_x	oxides of nitrogen
N/ha	number per hectare
O&M	operation and maintenance
°C	degrees Celsium (centigrade)
°F	degrees Fahrenheit
R&B	rehabilitation and betterment
SO_2	sulphur dioxide
SO_x	oxides of sulfur
spp.	species (two or more)
sp.	species (one)
TDS	total dissolved solids

ACRONYMS

BLM	Bureau of Land Management
CDOH	Colorado Department of Health
CDOW	Colorado Division of Wildlife
CDPOR	Colorado Division of Parks and Outdoor Recreation
COE	U.S. Corps of Engineers
Colorado-Ute	Colorado-Ute Electric Association
CPUC	Colorado Public Utilities Commission
CRS	Congressional Research Service
CRSP	Colorado River Storage Project
DEIS	draft environmental impact statement
DMEA	Delta-Montrose Electric Association
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	economic study area
FEIS	final environmental impact statement
FERC	Federal Energy Regulatory Commission
FWPCA	Federal Water Pollution Control Act
FWS	U.S. Fish and Wildlife Service
M&D	Montrose and Delta Canal
Monument	Black Canyon of the Gunnison National Monument
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969
NPS	National Park Service
OSHA	Occupational Safety and Health Administration
PHABSIM	Physical Habitat Simulation Model
POC	particulate organic carbon
Public Service	Public Service Company of Colorado
PURPA	Public Utilities Regulatory Policies Act of 1978
Reclamation	U.S. Bureau of Reclamation
RTU	remote terminal unit
SCADA	Supervisory Control and Data Acquisition
SCS	Soil Conservation Service

SHPO	State Historic Preservation Officer
Sponsors	Uncompahgre Valley Water Users Association and Montrose Partners
Tunnel	Gunnison Tunnel
USDI	U.S. Department of the Interior
USGS	U.S. Geological Survey
UVRP	Uncompahgre Valley Reclamation Project
UVWUA	Uncompahgre Valley Water Users Association
WAPA	Western Area Power Administration
WUA	weighted usable area
WMP	Water Management Program
WSCC	Western Systems Coordinating Council

INDEX

ATTACHMENT A

ENVIRONMENTAL COMMITMENTS

ATTACHMENT A

ENVIRONMENTAL COMMITMENTS

The following is a general summary of environmental commitments for the AB Lateral Hydropower Facility. Additional commitments are found in the text of the FEIS. Unless specified, each commitment applies to all development alternatives (alternatives B, C, E, and F). These commitments will be included in any lease of power privilege negotiated between the Sponsors and Reclamation. Reclamation would monitor commitments and provide quarterly progress reports to interested agencies. The Sponsors would provide monthly progress reports to Reclamation during the construction period and quarterly reports during operation. Reclamation, the NPS, BLM, FWS, and CDOW would meet annually to discuss aspects of the Gunnison River affected by the project.

STREAMFLOWS AND WATER RIGHTS

- Hydropower diversions would not be made that would reduce streamflows downstream from the Gunnison Tunnel below 300 ft^3/s, even if the hydropower water right was senior to any future instream flow right or even if future instream flow rights were less than 300 ft^3/s or not designated at all. Hydropower diversions would honor the adjudicated Federal reserved water right for the Black Canyon of the Gunnison National Monument.

- Hydropower diversions would be reduced as described in chapters 2 and 3 if flooding along the Uncompahgre River was aggravated.

- Hydropower operations would not interfere with or reduce the amount of water diverted for irrigation under the UVRP nor would hydropower diversions interfere with the domestic water supplies furnished through the Gunnison Tunnel or with the existing exchange agreement under the Dallas Creek and Uncompahgre Projects that provides for municipal water to be furnished through the Tunnel.

- The West Canal would continue to receive its irrigation supplies directly from the South Canal.

- Under alternative F, the Sponsors would bypass a minimum flow in the Gunnison River of 600 ft^3/s (if available from Crystal Reservoir releases) when and if adverse icing conditions occur. Also under alternatives E and F, the Sponsors would provide 1,000 acre-feet of water diverted from the Gunnison River to be conveyed through the South Canal for fisheries in the Uncompahgre River during the summer.

- No increase in Gunnison Tunnel capacity for hydropower production would be made, except in alternative C where the capacity would be increased to 1,300 ft^3/s.

- Powerplant capacity would be limited to 950 ft^3/s under alternative E and 1,135 ft^3/s under other alternatives.

- The UVRP would not place a call on the Uncompahgre River using its senior water rights for the West, Montrose and Delta, and Loutzenhizer Diversions if the Gunnison Tunnel were diverting water in excess of UVRP irrigation demands, including UVRP diversions downstream from the proposed tailrace.

BANK STABILIZATION

- The Sponsors would complete initial bank stabilization efforts (as described in chapters 2 and 3) before operation of the hydropower facility.

- Channel conditions and vegetation on the Uncompahgre River would be monitored and further corrective actions taken during the operation of the facility as described in chapter 2.

- Bank stabilization work would be done under the conditions of a Section 404 Permit to be obtained by the Sponsors.

- The Sponsors would provide additional mitigation through vegetation plantings on the Uncompahgre River as described in chapters 2 and 3.

VEGETATION AND LAND USE

- All areas disturbed during construction would be restored and reseeded. Irrigated lands would be restored to their original condition to the satisfaction of the landowner. Topsoil would be stockpiled and replaced on the surface of disturbed areas.

- A wetland replacement area of approximately 12 acres, or as modified in the Section 404 Permit, would be developed near the tailrace to replace wetlands lost directly on an acre-for-acre basis. The replacement plan design would require approval by Reclamation and the FWS before construction of any project facility and would be implemented before the second year of operation of the hydropower facility.

- Construction specifications would designate areas for disposal of materials. Material would not be disposed of in wetlands, riparian areas, or areas of greasewood.

- A revegetation plan would be approved by Reclamation before construction would occur.

- The Sponsors would monitor the wetlands replacement area and Uncompahgre riparian vegetation to ensure the success of plantings and to identify unanticipated project impacts. The Sponsors would mitigate net losses of wetlands caused by project operation as discussed in chapters 2 and 3.

FISH AND WILDLIFE

- Transmission lines and poles would be of a raptor-proof design.

- Two deer escapes would be included in the enlarged AB Lateral as described in chapter 2.

- A fish barrier would be constructed at the AB Lateral-South Canal diversion.

- Flushing releases from the Aspinall Unit would be bypassed under alternative E to reduce sediment downstream.

ENDANGERED SPECIES

- A plan for protection of the endangered clay-loving wild buckwheat would require approval from Reclamation and FWS before construction. This plan would describe in detail how impacts to these plants would be minimized as described in chapter 2.

- Approximately 60 acres of habitat of the clay-loving wild buckwheat would be acquired before operation of the facility and transferred to the BLM. If the land were not available, the Sponsors would be required to implement an alternative plan (as designed by the FWS) before operation.

- The Sponsors would monitor bald eagle use and prey use as described in chapter 2 and in the Biological Opinion.

CONSTRUCTION PERIOD

- The Sponsors would pay for any damages to crops or other property associated with obtaining the required construction and operation easements.

- Construction specifications would include provisions to limit noise and air pollution and to minimize traffic disruptions.

- Irrigation water would continue to be supplied during the construction period.

- The Sponsors would obtain all necessary construction and operation permits before construction.

- Cultural resources clearance surveys would be conducted on any new areas of construction not previously surveyed and cleared.

- Construction specifications would provide measures to protect cultural resources discovered during construction.

- The Stilson Homestead, a cultural resources site, would not be disturbed during construction or operation.

- The Sponsors would repair damages to State Highway 347 and South Rim Drive resulting from construction traffic during modifications to the Gunnison Tunnel under alternative C.

ATTACHMENT B

HISTORICAL FLOWS IN THE GUNNISON RIVER

Table B.1
Monthly mean discharges, in ft³/s, for the Gunnison River below the East Portal of the Gunnison Tunnel, USGS station No. 09128000, for the period 1903 - 1988

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual volume (acre-feet)
BEFORE GUNNISON TUNNEL													
1903										641	519	413	
1904	390	416	535	1,503	3,851	3,292	1,103	1,232	896	1,020	500	340	912,355
1905	330	340	700	1,217	5,246	8,383	2,039	1,130	560	519	491	475	1,294,530
1906	465	460	750	2,270	6,620	8,830	3,510	1,470	1,060	905	620	475	1,658,826
1907	470	460	990	2,500	4,400	10,500	6,620	2,400	1,310	986	640	450	1,918,366
1908	450	450	700	1,940	2,690	4,880	2,170	1,630	698	634	510	475	1,040,646
1909	460	450	750	1,950	7,160	10,800	5,470	1,880	2,600	1,270	610	470	2,048,251
BEFORE TAYLOR PARK RESERVOIR													
1910	460	460	1,730	3,703	6,292	5,336	1,337	882	464	467	550	480	1,339,950
1911	470	460	700	2,309	6,251	8,696	4,456	1,436	836	2,114	886	610	1,768,933
1912	540	500	800	2,793	7,156	8,883	4,423	1,292	674	981	562	480	1,759,720
1913	450	420	590	2,269	4,685	4,250	1,225	538	756	785	709	525	1,039,375
1914	475	450	900	2,187	7,521	8,268	3,762	1,450	759	1,014	909	520	1,708,149
1915	490	480	890	1,672	2,529	5,084	1,735	322	241	409	510	440	892,393
1916	400	390	730	2,173	5,726	8,232	2,692	2,039	706	1,038	700	550	1,534,562
1917	420	490	550	1,548	3,563	10,770	4,410	1,015	279	419	580	450	1,477,025
1918	420	540	650	1,259	5,088	8,961	2,169	1,105	1,100	746	666	470	1,397,927
1919	340	400	680	1,614	4,882	3,286	1,285	490	189	340	640	500	886,804
1920	450	500	850	943	8,436	10,343	3,146	763	207	680	760	540	1,670,886
1921	530	500	660	815	5,063	11,235	3,309	1,263	592	253	650	500	1,530,601
1922	500	520	660	1,205	6,087	6,411	1,146	339	25	28	487	430	1,077,600
1923	390	430	570	958	5,477	7,714	3,132	1,442	764	758	732	500	1,383,310
1924	500	520	610	2,067	5,487	6,381	825	34	32	342	553	470	1,074,760
1925	450	490	780	2,354	3,870	3,340	1,204	513	744	472	670	450	926,021
1926	360	460	600	1,563	4,156	5,813	1,291	314	81	387	526	490	967,751
1927	440	500	640	1,524	6,450	6,146	2,276	982	1,525	1,113	910	700	1,403,863
1928	620	580	950	1,344	8,613	7,132	2,138	513	60	201	599	420	1,403,098
1929	380	420	860	1,539	6,528	8,294	2,566	2,097	2,447	1,353	979	580	1,695,499
1930	400	450	550	3,282	2,979	5,010	934	1,182	80	333	432	500	971,778
1931	430	440	480	324	657	1,220	138	46	34	203	527	480	299,353
1932	400	390	520	1,427	5,113	5,594	2,101	501	48	42	415	400	1,025,111
1933	380	370	650	386	3,047	6,012	707	166	51	16	269	469	754,483
1934	410	450	435	469	1,573	208	63	47	31	17	116	420	256,334
1935	380	370	520	329	1,885	7,204	1,606	298	204	385	501	350	844,253
1936	390	400	550	3,089	6,942	3,622	632	745	202	189	440	360	1,062,819
1937	360	410	470	1,674	5,766	2,583	524	70	8	136	500	440	783,820
AFTER TAYLOR PARK RESERVOIR BUT BEFORE ASPINALL UNIT													
1938	390	340	600	2,654	4,914	8,161	1,796	279	705	424	598	441	1,283,200
1939	420	300	926	1,550	3,335	2,358	215	243	230	111	471	360	635,700
1940	310	250	470	556	2,257	1,608	61	69	24	339	497	330	411,000
1941	320	360	480	617	5,230	5,139	1,659	143	205	1,017	849	605	1,026,000
1942	480	440	570	2,930	4,881	7,191	1,545	328	120	66	483	412	1,171,400
1943	370	424	420	2,514	3,449	4,666	1,066	1,093	487	225	510	434	943,900
1944	368	429	331	654	5,521	6,985	2,162	310	99	93	376	353	1,069,400

Table B.1 (cont'd)
Monthly mean discharges, in ft^3/s, for the Gunnison River below the East Portal of the Gunnison Tunnel, USGS station No. 09128000, for the period 1903 - 1988

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual volume (acre-feet)
AFTER TAYLOR PARK RESERVOIR BUT BEFORE ASPINALL UNIT													
1945	399	389	352	451	3,746	3,759	1,504	888	70	295	468	411	770,700
1946	388	435	505	1,137	1,580	3,666	401	171	67	199	268	365	551,600
1947	340	352	307	575	4,239	5,647	2,525	631	420	589	568	603	1,016,300
1948	536	544	590	2,523	7,418	6,184	1,367	354	151	113	356	466	1,246,500
1949	359	386	463	1,808	3,747	7,341	2,880	402	213	280	644	419	1,142,500
1950	377	414	402	1,402	2,013	3,360	524	199	53	36	216	411	566,000
1951	394	394	527	388	2,129	3,673	864	333	68	83	298	408	576,700
1952	450	439	450	2,268	6,505	8,788	2,024	764	431	315	292	516	1,427,900
1953	484	432	481	516	1,709	4,928	890	413	130	143	458	460	664,700
1954	373	404	356	177	696	123	224	110	83	213	260	377	205,200
1955	325	279	299	672	1,350	2,118	342	342	80	61	334	461	401,600
1956	376	329	431	1,034	2,994	2,982	271	203	33	58	413	322	570,500
1957	317	377	445	989	4,073	11,670	8,468	2,237	610	459	884	878	1,900,700
1958	543	535	595	1,627	8,060	6,170	485	309	76	39	390	474	1,167,300
1959	411	422	328	303	1,194	2,708	177	268	79	584	550	381	445,500
1960	395	443	880	2,414	1,883	3,958	555	200	136	90	426	397	708,800
1961	331	341	496	428	2,025	1,996	232	218	217	840	765	506	507,500
1962	465	522	460	3,032	5,171	5,294	2,228	403	278	240	404	393	1,140,500
1963	323	435	860	613	1,595	845	220	251	60	89	451	321	366,200
1964	294	308	313	503	3,316	3,071	689	401	198	90	322	449	602,500
AFTER BLUE MESA													
1965	454	404	487	2,114	4,439	7,196	5,212	1,475	1,081	670	144	141	1,439,100
1966	143	155	248	564	722	859	355	257	244	251	214	267	258,600
1967	323	319	315	210	216	300	250	155	315	218	1,149	2,040	351,200
1968	1,246	1,150	534	271	537	764	178	227	353	360	1,500	1,837	540,200
1969	1,835	821	1,796	1,465	995	588	454	781	773	1,010	1,461	1,319	804,100
1970	1,474	1,325	1,861	1,224	2,165	3,942	1,926	871	1,178	1,513	1,888	2,128	1,314,200
1971	2,544	3,153	3,278	2,538	575	847	999	1,179	1,015	871	1,379	1,674	1,202,600
1972	1,609	1,533	908	292	265	299	162	230	308	288	1,278	1,881	546,300
1973	1,833	799	676	455	1,240	1,645	856	1,356	687	741	749	2,048	792,800
1974	2,732	2,892	2,224	445	501	327	198	183	208	277	1,396	1,397	763,900
1975	1,522	1,398	1,190	1,639	3,099	1,637	532	228	324	674	1,529	1,863	943,000
1976	1,712	1,119	898	294	269	333	524	266	465	379	1,186	1,485	511,400
1977	1,411	778	413	237	239	233	194	236	237	228	307	310	289,914
1978	443	523	408	232	418	1,211	963	463	670	685	838	1,493	504,272
1979	1,720	2,202	2,541	2,328	1,694	1,575	1,331	953	1,050	769	783	1,764	1,125,953
1980	1,701	1,776	1,931	1,619	2,124	1,852	1,049	812	770	512	1,782	1,784	1,066,554
1981	1,725	1,241	691	231	226	234	240	259	391	512	490	646	413,349
1982	667	1,558	1,448	452	420	759	763	754	1,048	1,279	1,627	1,746	752,908
1983	1,743	1,704	1,291	850	1,148	4,175	4,197	2,000	1,156	1,261	1,397	1,822	1,611,320
1984	2,314	2,609	3,068	2,380	4,465	8,020	4,510	1,750	1,476	1,586	1,850	1,607	2,148,361
1985	2,614	2,843	2,798	3,162	3,022	3,837	1,751	1,190	1,135	1,614	1,772	1,921	1,664,120
1986	2,278	2,245	1,893	1,456	2,385	1,263	3,016	1,287	1,562	1,487	1,818	2,165	1,379,843
1987	2,228	2,332	2,407	1,112	1,242	996	1,339	943	633	978	1,502	1,563	1,039,906
1988	1,545	1,612	1,601	795	397	353	355	395	574	386	340	341	524,089
1989	324	324	398	335	343	347	364	381	451				

Table B.2
Summary statistics of monthly mean discharges, in ft3/s, for the Gunnison River below the East Portal of the Gunnison Tunnel, USGS Station No. 091280 (1903 - 1988)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. volume, acre-feet
						Before Gunnison Tunnel Period: 1903 - 1909							
Average	428	429	738	1,897	4,995	7,781	3,485	1,624	1,187	854	556	443	1,478,829
Maximum	470	460	990	2,500	7,160	10,800	6,620	2,400	2,600	1,270	640	475	2,048,251
Minimum	330	340	535	1,217	2,690	3,292	1,103	1,130	560	519	491	340	912,355
Std.dev.	56	47	147	474	1,695	3,051	2,157	467	741	267	64	51	468,337
						Before Taylor Park Reservoir Period: 1910 - 1937							
Average	437	457	699	1,672	5,065	6,287	1,973	782	469	544	599	483	1,176,292
Maximum	620	580	1,730	3,703	8,613	11,235	4,456	2,097	2,447	2,114	979	700	1,768,933
Minimum	340	370	435	324	657	208	63	34	8	16	116	350	256,334
Std.dev.	63	53	246	882	2,004	2,763	1,293	585	551	478	191	72	408,223
						After Taylor Park Reservoir but before Aspinall Unit Period: 1938 - 1964							
Average	390	397	549	1,271	3,520	4,605	1,455	428	197	263	465	443	1,150,161
Maximum	543	544	926	3,032	8,060	11,670	8,468	2,237	705	1,017	884	878	2,150,408
Minimum	294	279	307	177	696	123	61	69	24	36	216	321	563,282
Std.dev.	67	73	143	813	1,833	2,517	1,572	393	153	183	136	113	371,106
						After Aspinall Unit Period: 1965 - 1988							
Average	1,576	1,520	1,483	1,086	1,326	1,744	1,269	745	724	773	1,182	1,517	1,094,012
Maximum	2,732	3,153	3,322	3,162	4,439	8,020	5,212	2,000	1,562	1,614	1,888	2,165	2,148,361
Minimum	143	155	336	210	216	233	162	155	237	218	144	141	289,914
Std.dev.	728	854	910	917	1,355	2,128	1,418	643	942	434	545	599	477,146

Source: USGS, 1988.

In response to comments from the National Park Service and the Bureau of Land Management, Reclamation requested the Sponsors to expand a portion of the hydrologic model to incorporate data from 1984 through 1988. This expansion modeled only the flows entering the Canyon; no additional modeling was performed. Expanded versions of tables 3.6 through 3.11 are presented on the following page as table B.3.

Table B.3
Summary of flows entering Black Canyon
(1984-1988; ft^3/s)

Year	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Annual average
						ALTERNATIVE A							
1984	2,314	2,809	3,068	2,380	4,465	8,020	4,510	1,750	1,476	1,586	1,850	1,607	2,983
1985	2,614	2,843	2,798	3,162	3,022	3,837	1,751	1,190	1,135	1,614	1,772	1,921	2,299
1986	2,278	2,245	1,893	1,456	2,385	1,263	3,016	1,287	1,562	1,487	1,818	2,165	1,906
1987	2,228	2,332	2,407	1,112	1,242	996	1,339	943	633	978	1,502	1,563	1,436
1988	1,545	1,612	1,601	795	397	353	355	395	574	386	340	341	724
						ALTERNATIVE B							
1984	1,179	1,674	1,933	1,485	4,465	8,020	4,131	1,700	1,180	750	715	472	2,202
1985	1,479	1,708	1,663	2,285	2,297	3,280	1,751	1,190	823	869	637	786	1,545
1986	1,143	1,110	758	1,188	2,052	899	2,817	1,287	1,225	814	683	1,030	1,254
1987	1,093	1,197	1,324	811	871	844	1,339	849	471	518	367	428	839
1988	410	477	466	385	353	353	355	395	360	300	300	300	359
						ALTERNATIVE C							
1984	1,179	1,674	1,933	1,320	4,465	8,020	3,966	1,379	1,015	585	715	472	2,106
1985	1,479	1,708	1,663	2,120	2,132	3,115	1,484	946	658	704	637	786	1,449
1986	1,143	1,110	758	1,023	1,887	734	2,652	1,117	1,060	649	683	1,030	1,157
1987	1,093	1,197	1,324	646	706	679	1,142	684	306	353	367	428	743
1988	410	477	466	300	300	300	300	300	300	300	300	300	337
						ALTERNATIVE E							
1984	1,364	1,859	2,118	1,485	4,465	8,020	4,131	1,700	1,180	750	900	657	2,279
1985	1,664	1,893	1,848	2,285	2,297	3,280	1,751	1,190	823	869	822	971	1,622
1986	1,328	1,295	943	1,188	2,052	899	2,817	1,287	1,225	814	868	1,215	1,330
1987	1,278	1,382	1,509	811	871	844	1,339	849	471	518	552	613	916
1988	595	662	651	385	353	353	355	395	360	300	300	300	405
						ALTERNATIVE F							
1984	1,179	1,674	1,933	1,485	4,465	8,020	4,131	1,700	1,180	750	715	472	2,202
1985	1,479	1,708	1,663	2,285	2,297	3,280	1,751	1,190	823	869	637	786	1,545
1986	1,143	1,110	758	1,188	2,052	899	2,817	1,287	1,225	814	683	1,030	1,254
1987	1,093	1,197	1,324	811	871	844	1,339	849	471	518	367	428	839
1988	410	477	466	385	353	353	355	395	360	300	300	300	359

Source: HDR, personal communication, 1989.

ATTACHMENT C

WATER QUALITY AND BIOLOGICAL DATA

Table C-1.--Results of macroinvertebrate sampling in riffle habitats on the Gunnison River, Colorado, 1981. Numbers are averages/ft^2 (Bio/West, Inc., 1981)

	April				May				June				July				August				September			
	Upper		Lower		Upper		Lower		Upper		Lower		Above		Below		Above		Below		Above		Below	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera																								
Baetidae																								
Baetis sp.	3.9	2.8	18.3	7.0	394.8	224.9	501.7	467.3	83.3	37.9	91.0	30.0	5.5	5.0	12.0	8.0	9.7	11.7	11.9	2.9	20.0	13.9	29.0	13.6
Ephemerellidae																								
Ephemerella inermis	97.6	55.8	37.5	28.8	170.0	.6	300.0	113.4	19.9	14.4	21.0	18.0												
Heptageniidae																								
Heptagenia sp.							12.0	10.3					0.3	0.5	1.0	1.4					4.5	7.7	3.7	5.7
Rhithrogenia sp.			0.3	0.5																				
Leptophlebiidae																								
Choroterpes sp.																	1.4	1.0						
Traverella albertana													2.8	3.6	3.0	2.6	0.7	0.8	0.8	1.6			3.0	3.8
Tricorythidae																								
Tricorythodes sp.	4.0	8.0	0.8	1.0	4.0				6.0	7.7	2.0	2.3	19.0	19 0	6.3	6.7	22.3	10.4	8.3	3.2	51.8	38.0	28.8	8.3
Trichoptera																								
Hydropsychidae																								
Cheumatopsyche sp.	65.0	94.3	22.5	38.6	20.0	24.0	20.0	40.0	7.2	5.3	18.0	23.0	17.3	13.0	13.3	16.0	9.5	5.9	6.7	7.6	22.8	16.2	11.4	22.0
Hydropsyche spp.	447.7	509.3	320.0	379.0	489.0	389.9	1280.0	665.9	184.0	86.9	299.0	149.8	255.0	102.5	414.3	218.6	86.2	87.2	106.3	60.0	205.2	141.9	294.7	252.8
Hydroptilidae																								
Hydroptila sp.																	0.9	0.7	4.8	5.5	1.3	2.7		
Trichoptera pupae					8.0	11.3			5.6	2.0	16.0	18.8	2.3	2.5	0.8	1.5	0.5	1.0					3.3	4.0
Hemiptera																								
Veliidae																								
Rhagovelia sp.																					0.3	0.5		
Coeleoptera																								
Elmidae																								
Microcylloepus sp.[1]	4.3	7.9	18.0	18.8	4.0	8.0	10.0	15.1	8.2	10.7	23.0	15.1	12.3	8.4	21.0	10.4	3.7	4.1	16.3	16.4	0.7	1.4	18.7	19.6
Microcylloepus sp.	3.2		6.5	7.9	9.0	10.5	48.0	36.4	4.6	3.5	107.0	58.2	33.0	33.6	73.3	53.2	26.4	22.7	149.1	70.9	50.8	26.5	229.0	122.5
Optioservus sp.															2.0	2.3								
Plecoptera																								
Perlodidae																								
Isoperla spp.	32.6	32.7	16.0	8.2	36.0	32.3	57.0	10.5	0.8	1.6														
Odonata			0.3	0.5			0.3	0.5																
Diptera																								
Ceratopogonidae					7.0	8.3	2.0	4.0																
Chironomidae	78.0	36.8	72.5	16.1	1883.0	690.9	2834.0	613.3	452.8	257.8	724.0	82.4	45.8	22.4	17.5	15.3	132.1	17.8	227.9	144.5	296.0	73.0	470.3	147.2
Empididae	7.3	3.8	5.0	4.7																1.0	2.0			
Simuliidae																								
Simulium sp.			1.3	1.9	18.0	33.4	2.0	4.0	3.6	7.2													0.7	1.4
Unknown					1.0	2.0																		
Chironomidae pupae																					35.5	19.6	33.0	10.5
Athericidae																								
Atherix sp.																					0.3	0.5		
Decapoda																								
Astacidae																								
Orconectes sp.							0.8	0.5							0.3	0.5	0.8	1.0			0.3	0.5	0.3	0.5
Hydracarina			0.3	0.5																	18.5	11.7	18.0	16.2
Oligochaeta	1.2	2.4	6.3	12.5											1.8	3.5	13.0	26.0			17.0	8.9	212.0	147.3
Nematoda	0.5	1.0																						
Total Numbers	782.9	732.5	539.0	513.9	3158.0	1238.3	5196.0	1254.4	777.0	291.0	1310.3	224.2	394.0	168.3	569.0	297.4	284.1	109.8	588.0	254.2	726.3	291.6	1307.4	336.5
Diversity d̄	1.8		2.04		1.70		1.76		1.75		1.9		18.2		1.47		2.31		2.02		2.45		2.52	

[1]Adults

Table C-1.--Results of macroinvertebrate sampling in riffle habitats on the Gunnison River, Colorado, 1981. Numbers are averages/ft^2 (Bio/West, Inc., 1981)--(Continued)

RUN	April				May				June				July				August				September			
	Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera																								
Baetidae																								
Baetis sp.					6.7	3.1	32.3	13.5	7.0	5.4	26.0	12.7	3.5	5.7	4.3	1.9	10.8	5.1	14.0	8.1	12.3	4.8	17.3	12.0
Ephemerellidae																								
Ephemerella inermis			8.8	9.0	29.3	11.0	29.0	17.9	6.0	3.2	5.0	5.6												
Heptageniidae																								
Heptagenia sp.			1.8	2.9			2.0	1.4	1.8	1.7			0.5	0.6	1.0	1.4	2.0	2.3	0.3	0.5	1.0	0.8	3.0	3.8
Leptophlebiidae																								
Choroterpes sp.																	1.5	0.6						
Traverella sp.															0.5	1.0			3.5	1.3			0.7	1.4
Tricorythidae																								
Tricorythodes sp.			1.3	1.9	8.0	5.6	4.0	1.6	9.5	3.0	4.5	4.0	20.3	10.8	4.3		41.3	13.8	3.8	2.6	81.0	46.3	15.5	8.1
Trichoptera																								
Hydropsychidae																								
Cheumatopsyche sp.			6.8	13.5	1.7	2.9	20.3	14.0			5.0	10.0	3.8	0.5	7.0	2.5	2.3	1.5	8.8	4.5			16.0	8.6
Hydropsyche sp.			47.1	60.0	11.7	8.3	342.8	68.7	13.8	7.4	137.8	95.3	13.8	9.3	127.0	73.2	14.5	6.8	68.0	16.8	4.5	3.1	116.2	65.3
Hydroptilidae																								
Hydroptila sp.																	1.3	1.3						
Trichoptera pupae									0.8	0.5	10.5	9.7											0.7	1.4
Coeleoptera																								
Elmidae																								
Microcylloepus sp.[1]			0.3	0.5			14.0	14.8			14.0	12.2	0.5	0.6	6.8	2.8			2.8	1.9			11.0	10.6
Microcylloepus sp			2.0	2.2	1.0	1.7	34.3	27.5	1.0	1.2	24.0	8.7	1.5	1.7	47.8	18.3	6.3	2.6	47.0	29.4	2.5	2.7	109.2	46.7
Optioservus sp.																					0.5	1.0		
Plecoptera																								
Perlodidae																								
Isoperla spp.			6.8	6.7	0.3	0.6	18.8	10.9																
Diptera																								
Ceratopogonidae			0.3	0.5			2.0	4.0																
Chironomidae	13.8	14.2	57.0	50.8	181.3	80.9	386.0	100.6	66.8	52.2	93.5	41.6	6.5	2.5	5.3	2.6	76.5	23.8	72.8	10.6	135.8	80.0	394.7	158.6
Empididae			1.8	2.4																				
Tipulidae																								
Simuliidae																								
Simulium sp.					0.7	1.2																		
Chironomidae pupae																					10.0	8.8	18.7	12.6
Decapoda																								
Astacidae																								
Orconectes sp.							0.8	1.0							1.3	1.5	0.5	0.6			0.3	0.5	1.3	1.5
Hydracarina																							18.0	13.3
Oligochaeta	5.3	5.1	39.0	36.8	3.0	5.2			1.3	2.5											67.5	32.4	140.8	44.0
Nematoda																					0.5	1.0		
Total Numbers	19.0	10.6	169.8	113.5	235.0	101.1	928.5	102.1	108.3	53.6	334.3	151.1	50.3	20.7	204.3	84.0	155.3	43.5	222.8	42.9	317.5	170.5	893.3	287.3
Diversity d̄	0.9		2.40		1.19		2.08		1.91		3.10		2.27		1.70		2.10		2.24		1.92		2.42	

[1]Adults

Table C-1.--Results of macroinvertebrate sampling in riffle habitats on the Gunnison River, Colorado, 1981. Numbers are averages/ft^2 (Bio/West, Inc., 1981)--(Continued)

	April				May				June				July				August				September			
	Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower		Upper		Lower	
	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
Ephemeroptera																								
Baetidae																								
Baetis sp.	1.3	2.3							6.7	11.5	1.3	2.3												
Ephemerellidae																								
Ephemerella inermis					2.7	2.3																		
Tricorythidae																								
Tricorythodes sp.																								
Tricoptera																								
Hydropsychidae																								
Cheumatopsyche sp.									5.3	9.2							2.0	2.8						
Hydropsyche sp.	1.3	2.3			4.0	6.9									1.3	2.3								
Coeleoptera																								
Elmidae																								
Microcylloepus sp.															1.3	2.3								
Hemiptera																								
Corixidae																								
Hespacorixa sp.							1.3	2.3	12.0	20.8					42.7	37.2								
Diptera																								
Ceratopogonidae							1.3	2.3			4.0	0					2.0	2.8			4.0	6.9	6.0	6.0
Chironomidae	6.7	4.6	40.0	26.2	164.0	194.0	74.7	24.4	668.0	1001.7	597.3	34.0	56.0	72.8	124.0	176.8	6.0	2.8	57.3	72.0	52.0	25.0	172.0	76.0
Chironomidae pupae																					6.7	2.8	1.3	2.3
Unknown larvae																			1.3	2.3				
Decapoda																								
Astacidae																								
Orconectes sp.									5.3	9.2			1.2	2.3										
Oligochaeta	10.7	12.2	28.0	24.9	5.3	9.2	8.0	13.9	10.7	18.5	62.7	28.9	38.7	60.2	128.0	137.6	6.0	2.8	192.0	160.6	234.7	182.1	665.3	176.0
Gastropoda																								
Physidae																								
Physa sp.							1.3	2.3																
Total	20.0	12.0	72.0	16.0	176.0	197.7	86.7	26.7	708.0	980.4	665.3	58.9	96.0	131.9	297.3	346.0	16.0	5.7	247.3	229.2	297.3	212.1	848.0	207.5

Table C-2.--Relative abundance of net plankton from two areas in the mainstream Gunnison River, 4/81-9/81. "Upper" location was upstream of Delta, Colorado. "Lower" location was near Grand Junction, Colorado

	4/81		5/81		6/81		7/81		8/81		9/81	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Cyanophyta												
Gleocapsa							I	I				
Oscillatoria	I		I							I	I	I
Chlorophyta												
Pediastrum									I		I	
Scenedesmus				I		I	I	I	I			
Chrysophyta												
Anomoeoneis								I				I
Cocconeis	I	C	C	I			I		I	I		I
Cymatopleura	I		I				I	I				
Cymbella				I		I	I	I	I	I	I	I
Diatoma	I	C	I	I		I				I		I
Gyrosigma										I		
Melosira							I	I			I	I
Navicula	C	C	A	C		C	C	C	C	C	C	C
Nitzschia	C	C	C	I		C	C	C	I	I	C	I
Pinnularia			I									
Rhoicosphenia		I		I		I	I	I				
Surirella				I				I				
Synedra		I					I	I		I	I	

B - greater than 9,000
A - 3,000-9,000
C - 500-3,000
I - less than 500 cells/liter

Source: Bio/West, Inc., 1981.

Table C-2.--Relative abundance of net plankton from two areas in the mainstream Gunnison River, 4/81-9/81. "Upper" location was upstream of Delta, Colorado. "Lower" location was near Grand Junction, Colorado--(Continued)

	4/81		5/81		6/81		7/81		8/81		9/81	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Cyanophyta												
Gleocopsa												
Oscillatoria		I		I		C	I	I	I	I	I	
Chlorophyta												
Ankistrodesmus						C						
Chlorococcum							A	C				
Closterium							I					
Pediastrum										I		
Scenedesmus							I	I				
Spirogyra												B
Chyrysophyta												
Amphora									I			
Anomoeoneis												
Cocconeis		I	I	I		I	I	I	I	I	I	
Cyclotella						I						
Cymatopleura				I		I						
Cymbella	I	I	I	I		I			I	I	I	
Diatoma				I		I						
Gomphonema										I		
Gyrosigma										I		I
Melosira		I		I								
Navicula	C	C	C	C		A	C	C	A	B	C	C
Nitzschia	C	C	I	I		A	A	A	A	B	C	C
Pinnularia		I										
Rhoicosphenia	I	I	I	I		I	I	I				
Surirella	I	I		I								
Synedra	I			I			I	I		I		I

B - greater than 9,000; A - 3,000-9,000; C - 500-3,000; I - less than 500 cells/liter
Source: Bio/West, Inc., 1981.

Table C-2.--Relative abundance of net plankton from two areas in the mainstream Gunnison River, 4/81-9/81. "Upper" location was upstream of Delta, Colorado. "Lower" location was near Grand Junction, Colorado--(Continued)

	4/81		5/81		6/81		7/81		8/81		9/81	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Euglenophyta												
Euglena	I		I	I		I	I	I	B	I		

B - greater than 9,000 c/l
A - 3,000-9,000 c/l
C - 500-3,000 c/l
I - less than 500 c/l

Souce: Bio/West, Inc., 1981.

Table C-3.--Periphyton density (mg/m^2 of chlorophyll) at two stations on the Gunnison River in 1981

Date	Upper station[1]	Lower station[2]
April	164	143
May	577	427
June	183	213
July	116	124
August	157	135
September	118	39

[1] Station located upsteam of Delta.
[2] Station located near Grand Junction.
Source: Bio/West, 1981.

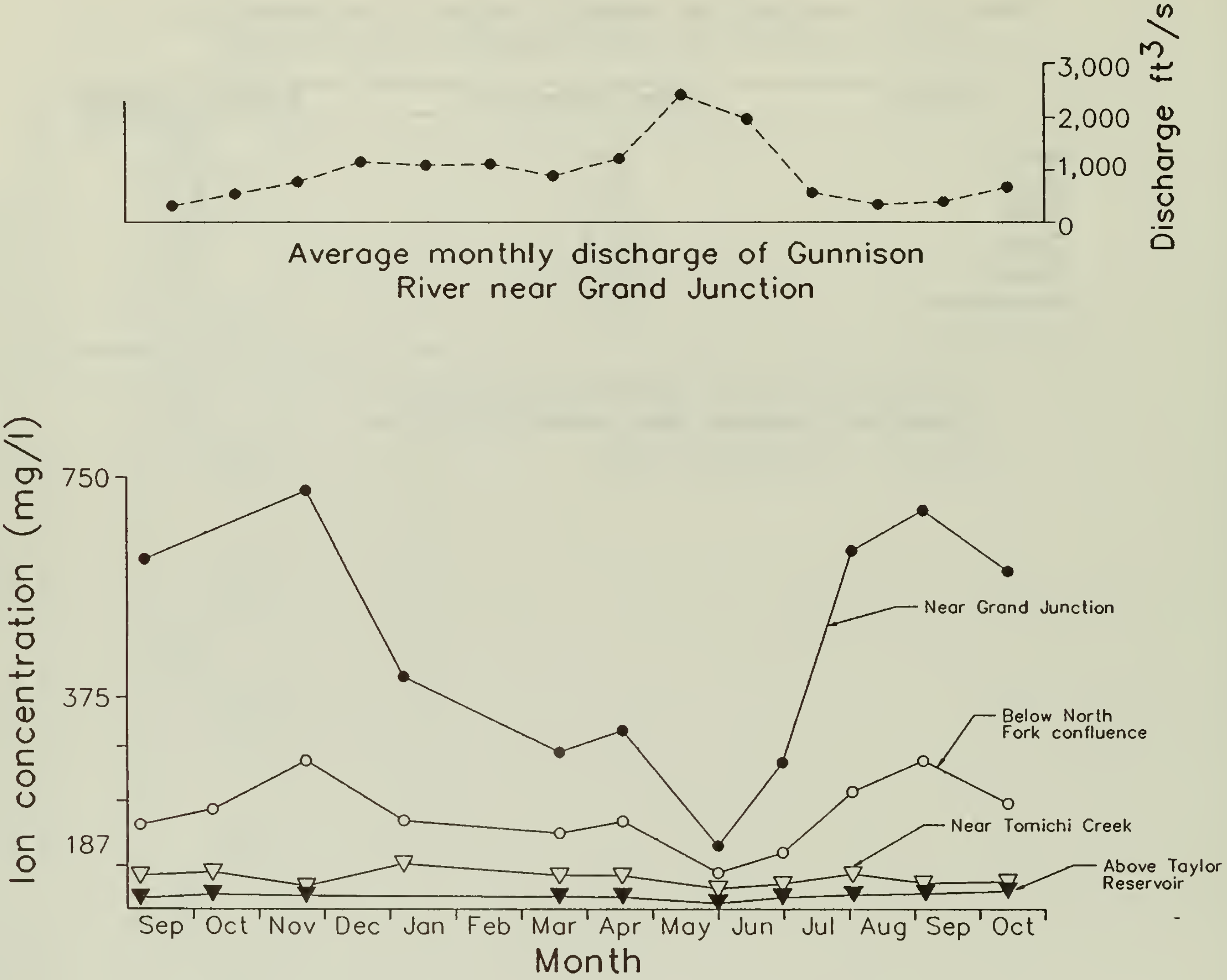
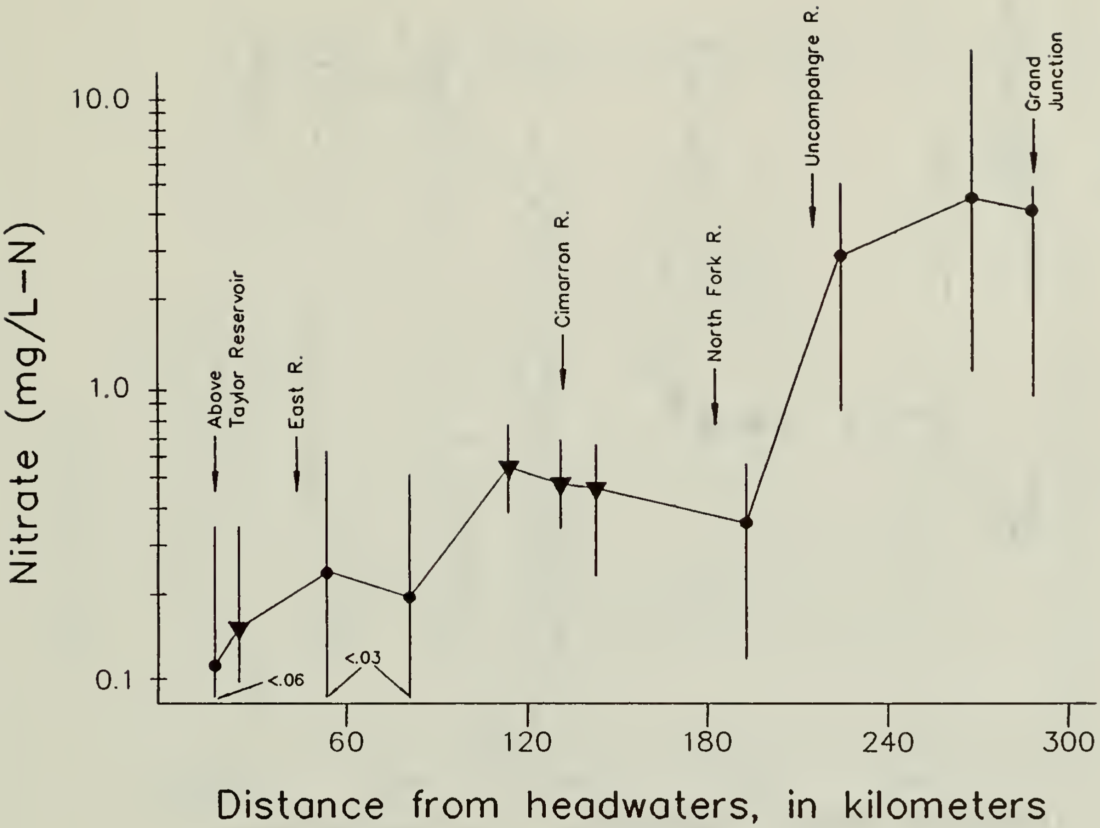


Figure C-1. Concentration of major ions (sum of calcium, magnesium, sodium and sulfate) in the Gunnison River. Data are mean monthly values collected from 1979-80. (modified figure from Stanford and Ward, 1981).



Legend

Inverted triangles indicate tailwater sites below mainstream dams.

Bars indicate range of values for 11 sampling periods during 1979—80.

Figure C-2. Mean annual nitrate concentrations on Gunnison River (Stanford and Ward, 1981).

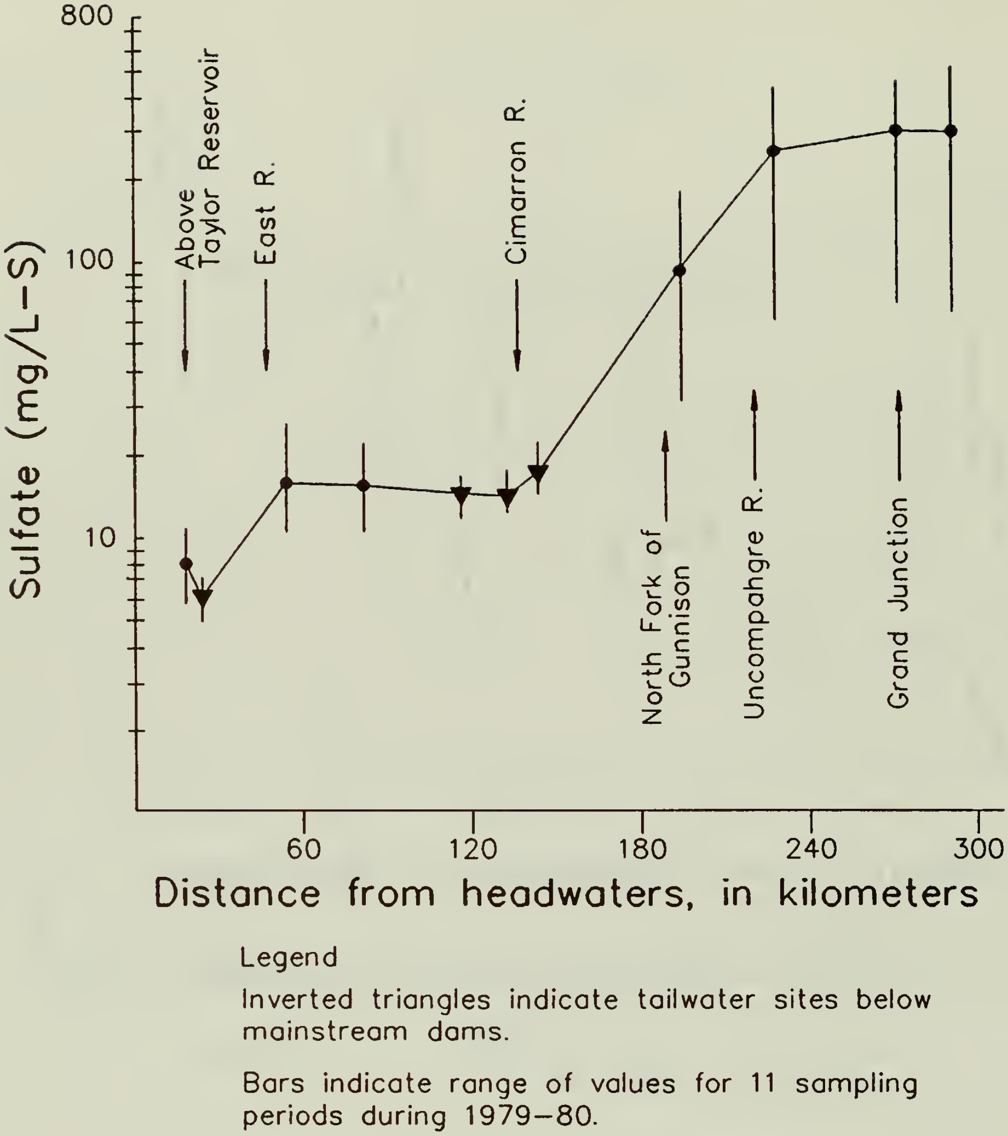
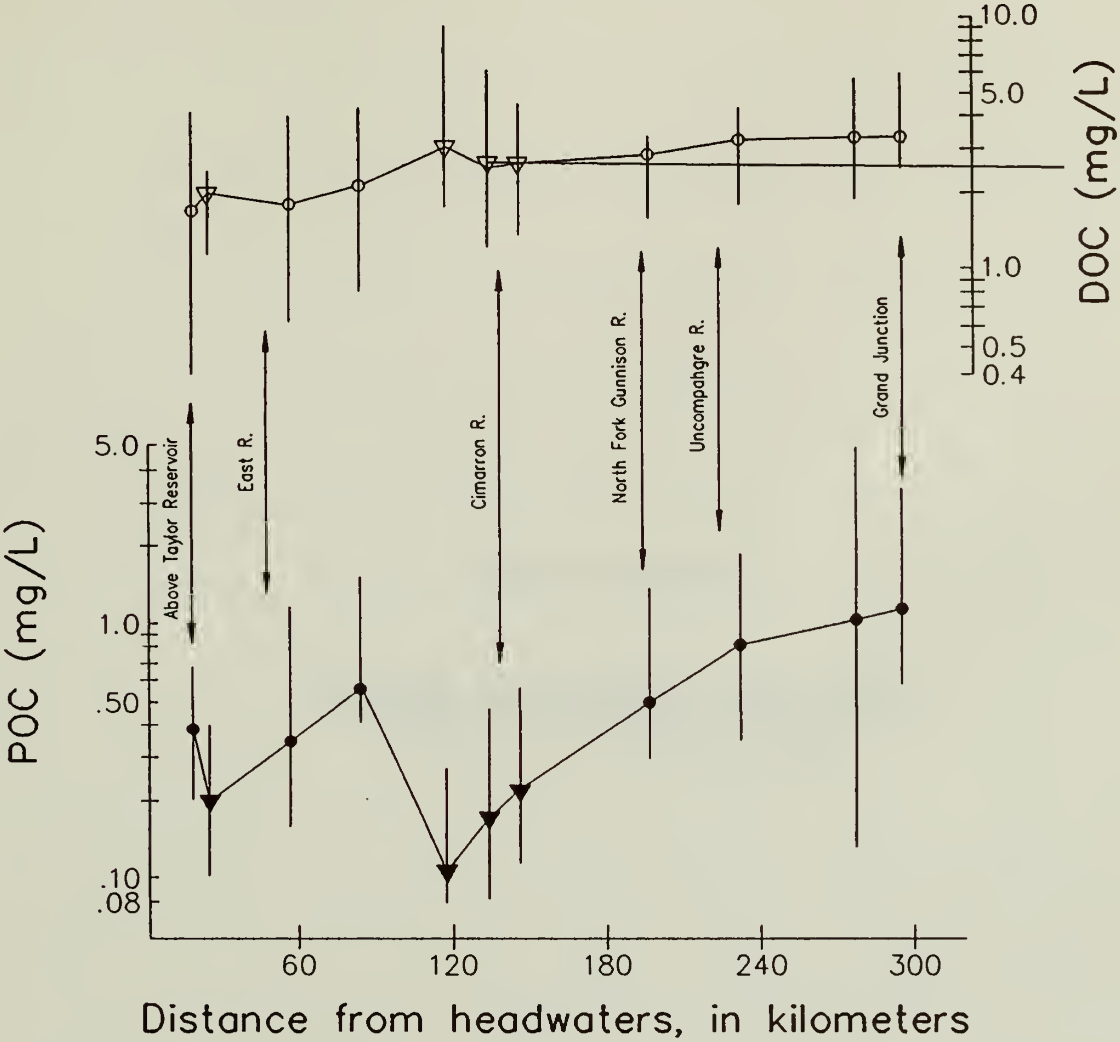


Figure C-3. Mean annual sulfate concentrations on the Gunnison River (Stanford and Ward, 1981).



Legend

Inverted triangles indicate tailwater sites below mainstream dams.

Bars indicate range of values for 11 sampling periods during 1979–80.

Figure C-4. Mean dissolved organic carbon (DOC) and particulate organic carbon (POC) on the Gunnison River (Stanford and Ward, 1981).

ATTACHMENT D

WATER QUANTITY DATA FOR STUDY ALTERNATIVES

Table D.1
Average annual water balances for existing conditions and development alternatives (acre-feet)

Location:	Model node (1)	Existing Conditions	B	C	D	E	F	F-3	F-4	F-5	F-6	G	H
			ALTERNATIVE										
Gunnison River:													
Below Crystal Dam	GUN	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038
Diverted through Tunnel	DIV	337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
Entering Black Canyon	REM	798,214	443,612	407,729	386,417	473,536	447,786	451,006	454,305	455,420	474,462	489,877	443,612
South Canal:													
Entering Canal	DIV	337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
AB Lateral demands	ABD	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112	18,112
Cedar Creek wasteway demands	CED	11,077	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210	11,077	1,210
AB Lateral Unit	ABP	- NA -	508,128	544,011	565,323	478,204	502,986	499,766	496,467	495,351	476,309	- NA -	528,393 (2)
At Rating Cable	SCG	308,634	164,977	164,977	164,977	164,977	165,945	165,945	165,945	165,945	165,945	616,972	673,104
West Canal demands	WCD	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177	49,177
Other laterals demands	SCD	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210	28,210
Exiting Canal	SCU	231,247	87,589	87,589	87,589	87,589	88,557	88,557	88,557	88,557	88,557	539,585	67,324
Uncompahgre River:													
River at Colona	UNC	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685	168,685
Private demands above South Canal	UP1	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955	10,955
River above South Canal	UNA	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730	157,730
South Canal flows	SCU	231,247	87,589	87,589	87,589	87,589	88,557	88,557	88,557	88,557	88,557	539,585	67,324
River below South Canal	UN1	391,157	247,499	247,499	247,499	247,499	248,467	248,467	248,467	248,467	248,467	699,494	227,234
Montrose & Delta Canal demands	MCD	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326	163,326
River below M & D Canal	UN2	225,718	82,060	82,060	82,060	82,060	83,028	83,028	83,028	83,028	83,028	534,055	61,795
Inflow from Horsefly Creek	HFY	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189	7,189
Loutzenhizer Canal demands	LCD	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925	42,925
Private demands below South Canal	UP2	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482	11,482
River gains from return flows	UGN	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248	12,248
River entering Montrose	UN3	190,681	47,024	47,024	47,024	47,024	47,991	47,991	47,991	47,991	47,991	499,019	555,151
AB Lateral Unit inflows	ABP	- NA -	508,128	544,011	565,323	478,204	502,986	499,766	496,467	495,351	476,309	- NA -	528,393 (3)
Selig Canal demands	SCD	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081	60,081
Cedar Creek inflow	CER	10,351	484	484	484	484	484	484	484	484	484	10,351	484
River below Cedar Creek	URM	140,952	495,554	531,437	552,750	465,631	491,381	488,161	484,862	483,746	464,704	449,290	495,554
System balances													
Gunnison River: Inflows		1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038	1,136,038
Outflows		337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
Balance		798,214	443,612	407,729	386,417	473,535	447,786	451,006	454,305	455,420	474,462	489,877	443,612
South Canal: Inflows		337,824	692,426	728,309	749,621	662,503	688,253	685,033	681,734	680,618	661,576	646,161	692,426
Outflows		106,576	604,837	640,720	662,032	574,913	599,695	596,475	593,176	592,060	573,018	106,576	625,102
Balance		231,248	87,590	87,590	87,590	87,590	88,558	88,558	88,558	88,558	88,558	539,585	67,325
Uncompahgre River: Inflows		429,720	784,323	820,206	841,518	754,399	780,149	776,929	773,630	772,514	753,472	738,057	784,323
Outflows		288,768	288,768	288,769	288,769	288,769	288,768	288,768	288,768	288,768	288,768	288,768	288,769
Balance		140,952	495,554	531,437	552,749	465,630	491,380	488,161	484,862	483,746	464,704	449,289	495,554

Notes: (1) See Figure D.1 for location of nodes.
(2) Hydropower flows for Alternative H diverted from South Canal below rating cable.
(3) Hydropower flows for Alternative H enter Uncompahgre River upstream from Loutzenhizer Canal.

Source: HDR, 1989a

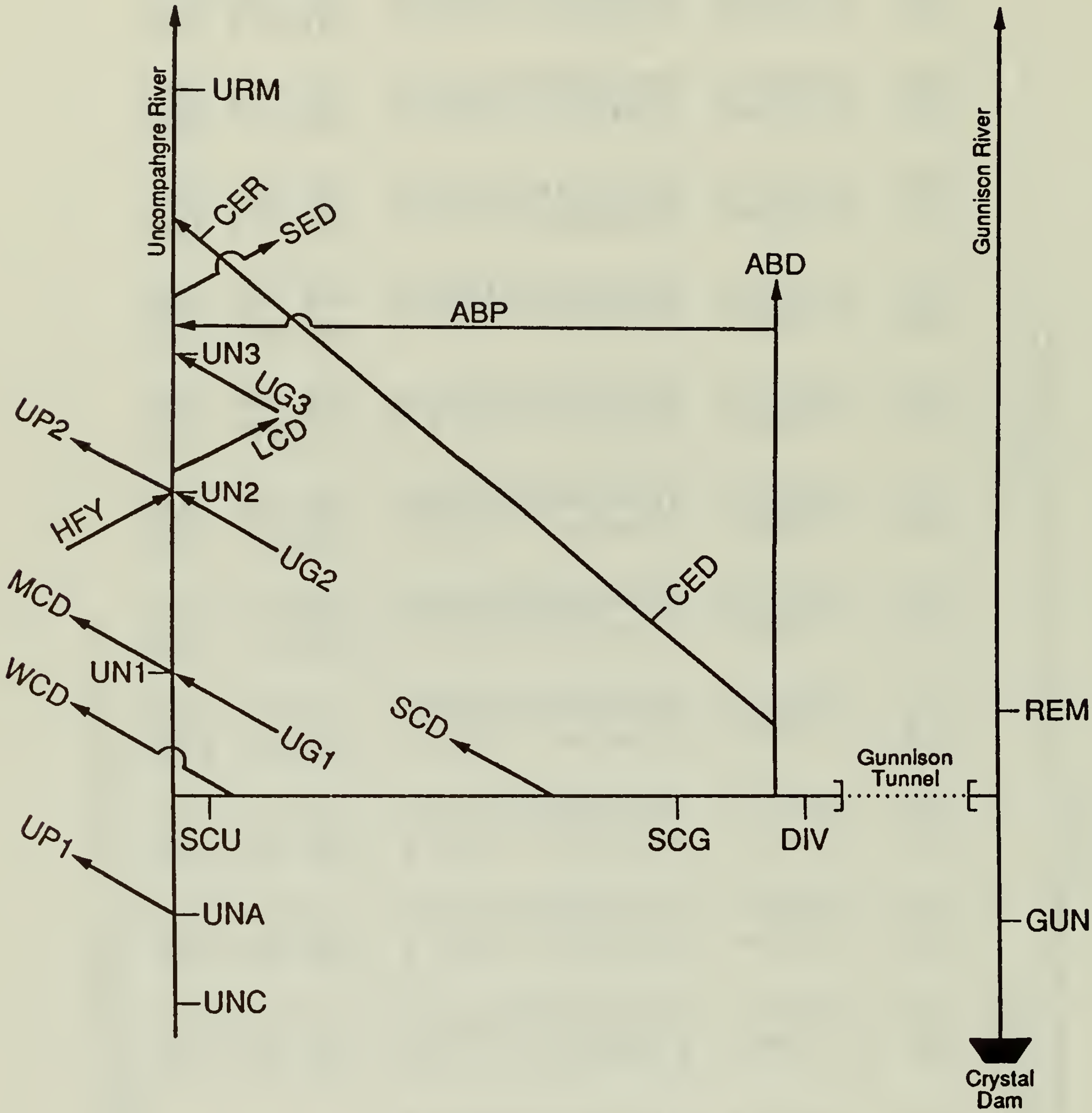
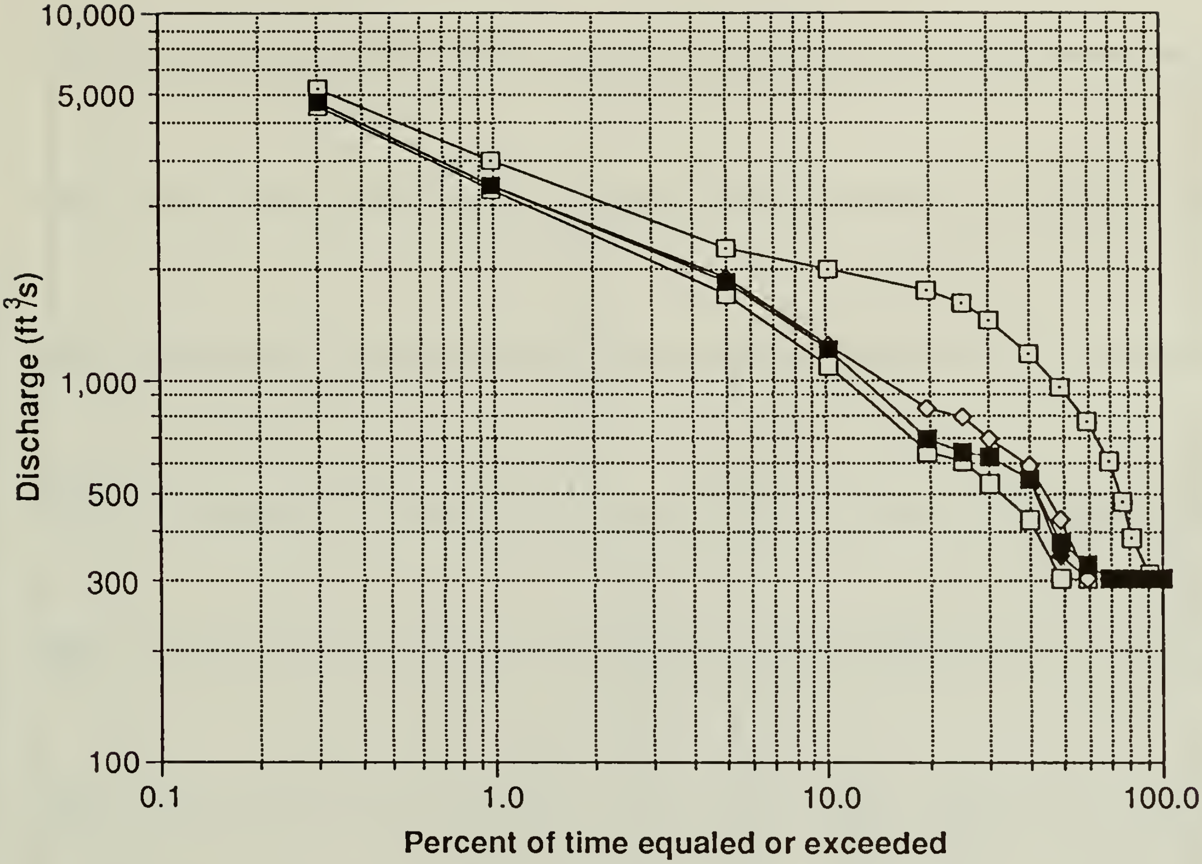


Figure D.1. Flow schematic for system water balances.



Legend

	Percent at which 300 cfs is reached
Alternative A (no action)	92.2
Alternative B	53.6
Alternative C	50.0
Alternative E	58.1
Alternative F	62.0

Figure D.2. Duration curve of flows entering Black Canyon for no-action and development alternatives.

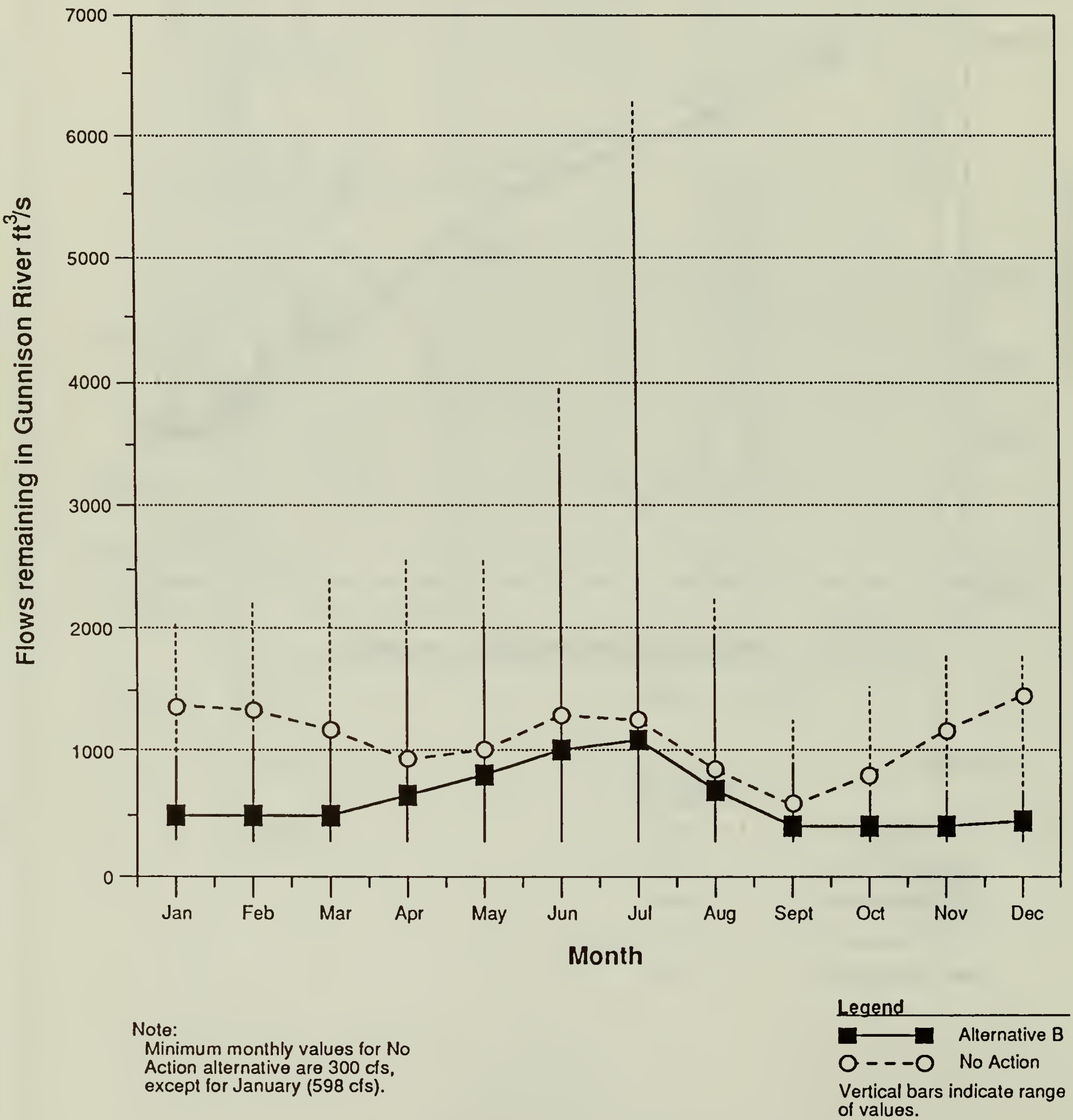


Figure D.3. Mean monthly flows and flow ranges for Alternative B compared to no-action alternative.

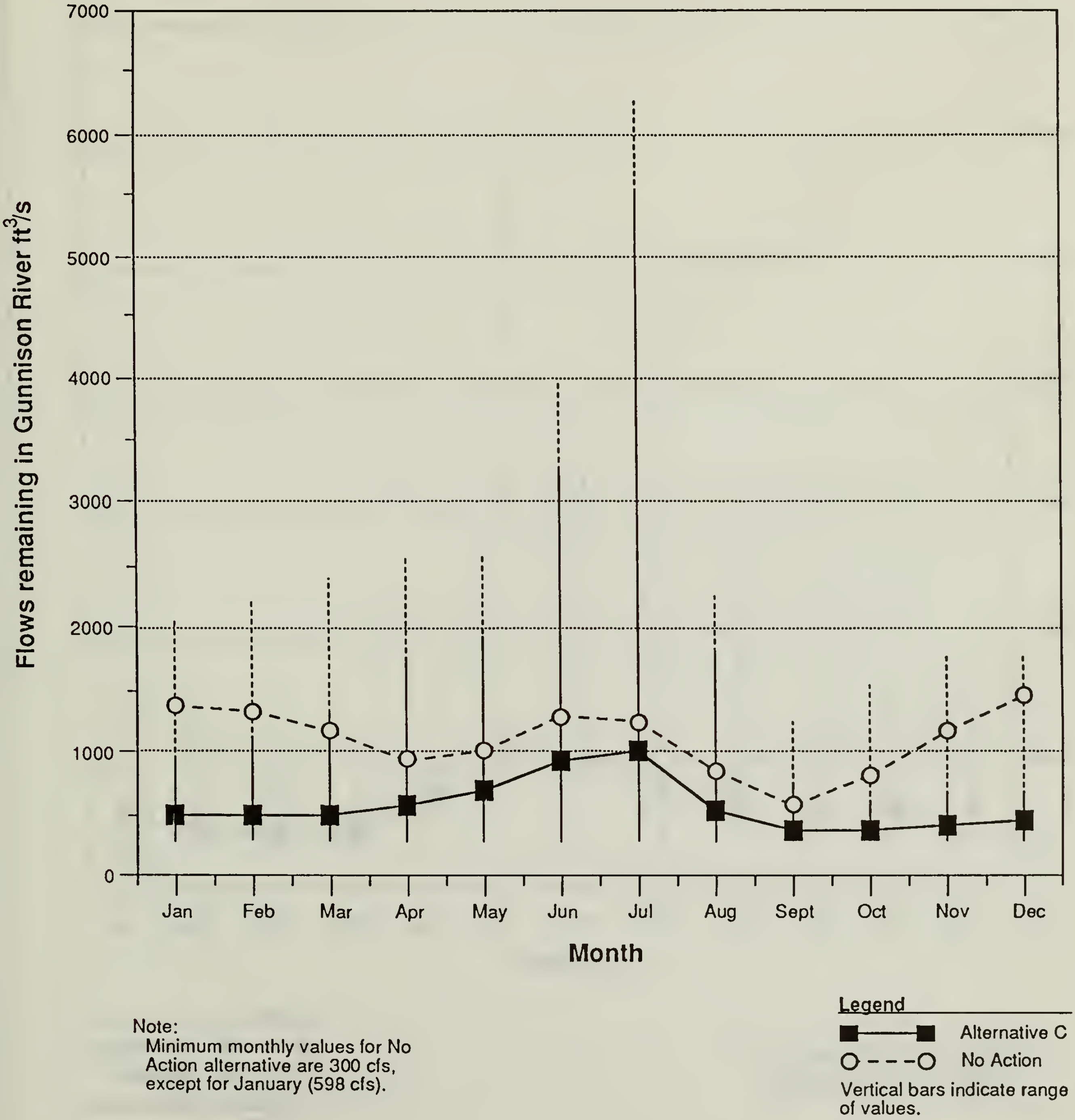
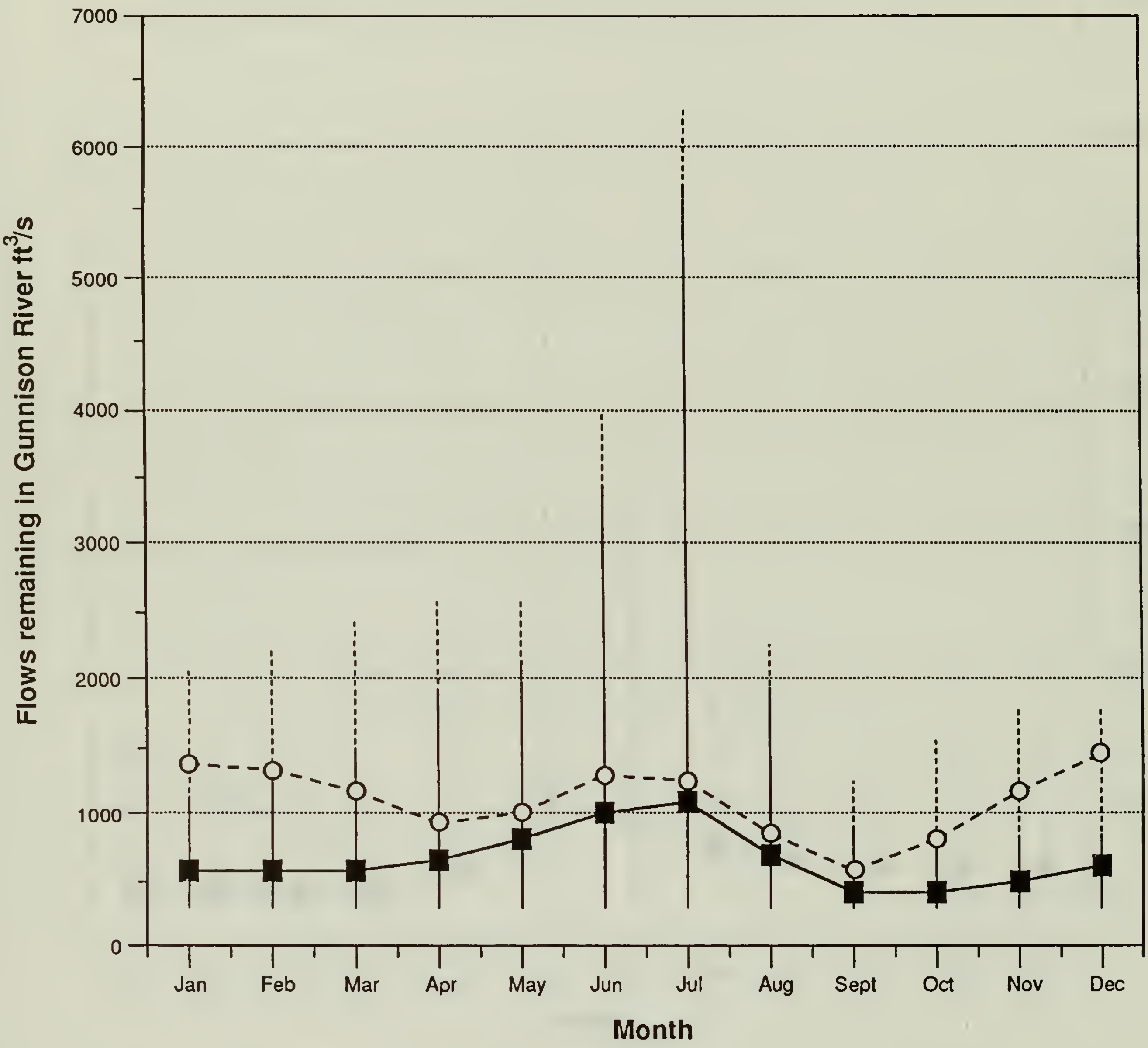


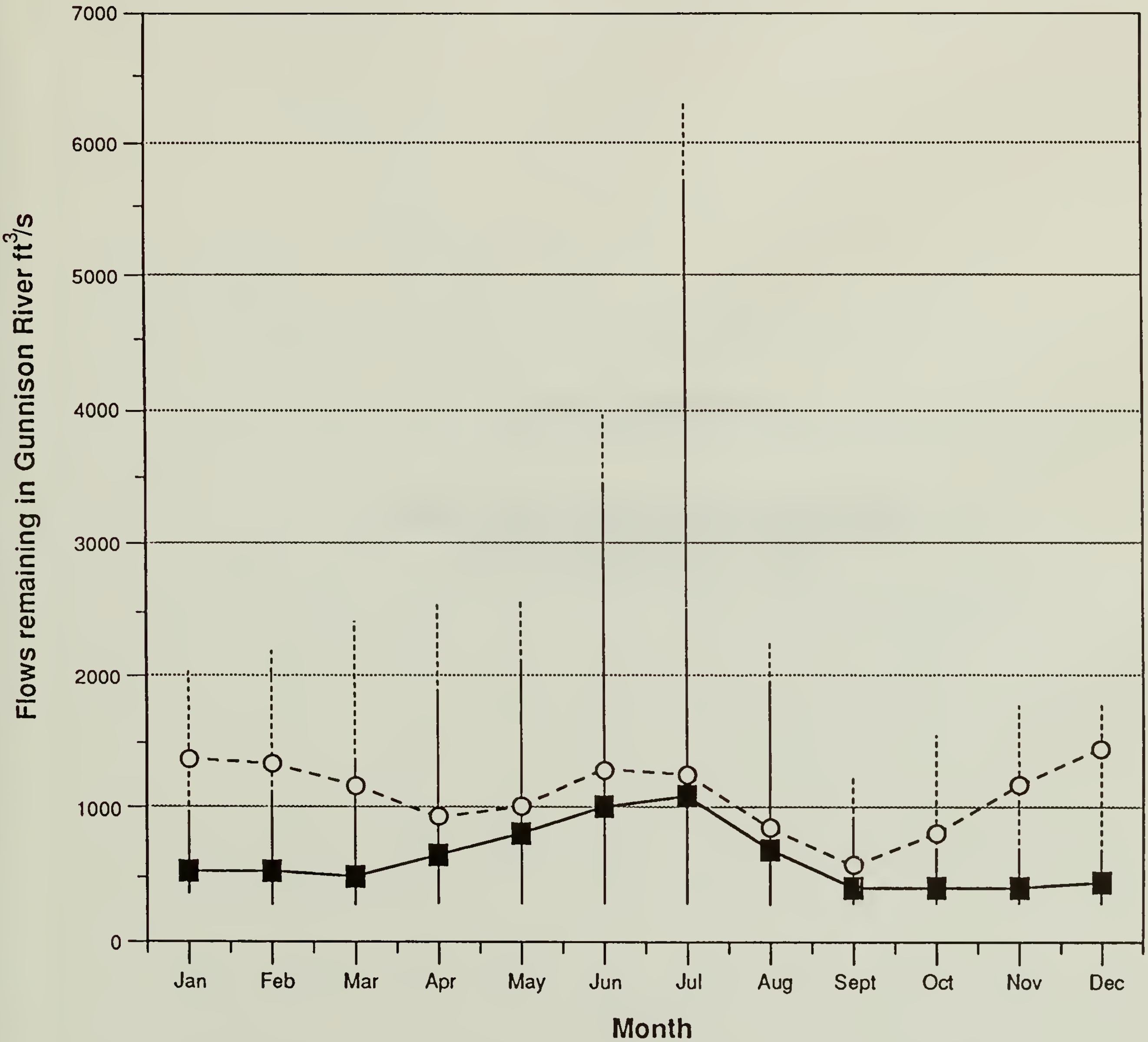
Figure D.4. Mean monthly flows and flow ranges for Alternative C compared to no-action alternative.



Note:
Minimum monthly values for No Action alternative are 300 cfs, except for January (598 cfs).

Legend
Alternative E
No Action
Vertical bars indicate range of values.

Figure D.5. Mean monthly flows and flow ranges for Alternative E compared to no-action alternative.



Note:
Minimum monthly values for No Action alternative are 300 cfs, except for January (598 cfs).

Legend
■——■ Alternative F
O - - - O No Action
Vertical bars indicate range of values.

Figure D.6. Mean monthly flows and flow ranges for Alternative F compared to no action alternative.

ATTACHMENT E

FISH AND WILDLIFE SERVICE RECOMMENDATIONS

ATTACHMENT E

FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The following are Fish and Wildlife Service recommendations on the project:

1. Reduce potential impacts to prey species of wintering bald eagles by increasing winter minimum flows, as described in alternative F.

2. Provide "in-kind" replacement of habitat types, with a minimum of 1:1 acre replacement, in the wetlands mitigation plan.

3. Consider wetland impacts not directly associated with revetment activities and propose appropriate mitigation.

4. Quantify impacts to riparian habitat associated with bank stabilization measures and propose appropriate mitigation.

5. Reduce potential impacts to waterfowl and other migratory birds by increasing winter minimum flows, as described in alternative F.

6. Provide some type of public easement for fishing along the South Canal.

7. Establish a minimum flow of 60 to 80 ft^3/s from July 1 through September 30 from the Loutzenhizer Canal to the tailrace.

8. Continue fisheries studies in the Gunnison Gorge to determine any project impacts. Include provisions in the proposed project for any measures determined necessary to protect trout populations.

9. Provide more water in the Gunnison or Uncompahgre rivers, as described in alternative E.

10. Reduce impacts to river otters by increasing winter minimum flows, as described in alternative F.

11. Incorporate wildlife escape structures into the design of the concrete-lined AB Lateral.

Of the development alternatives, the Fish and Wildlife Service recommends the formulation of an alternative that provides additional water as described in alternative E and provides increased winter flows in the Gunnison as described in alternative F. A combination of alternatives E and F should be developed that incorporates additional water as outlined in alternative E and increased winter flows in the Gunnison River as outlined in alternative F.

Recommendations 2, 3, 4, and 11 are included in all of the development alternatives. Recommendations 1, 5, and 10 would be partially accomplished by alternative F. Though not releasing a designated winter flow supplement, alternative E would nonetheless provide an average of 81-ft^3/s additional flow to the Gunnison River than alternative F during December through February. Although alternatives E and F are not the same, alternative E should on the whole provide more insurance against winter impacts than alternative F and would avoid abrupt and possibly damaging flow changes.

Recommendation 6 has not been included in the alternative plans because Reclamation does not consider the South Canal fishery a responsibility of the AB Lateral Project. Also, because of safety and land ownership considerations, encouraging greater recreational use of the South Canal is not presently proposed.

The flow levels of recommendation 7 would not be met. The 1,000-acre-foot South Canal bypass in alternatives E and F would reduce impacts and go farthest toward meeting the recommended flow level.

The fishery study (recommendation 8) is expected to be continued by resource management agencies regardless of the AB Lateral Project. The Sponsors and Reclamation would initiate annual interagency meetings to discuss any unanticipated problems on the Gunnison River.

Recommendation 9 has been incorporated into alternative E.

ATTACHMENT F

FISH AND WILDLIFE SERVICE
BI0LOGICAL OPINION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
FISH AND WILDLIFE ENHANCEMENT
COLORADO STATE OFFICE
529 25½ Road, Suite B-113
GRAND JUNCTION, COLORADO 81505
(303) 243-2778

88001493

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

(FWE) April 18, 1988

6-CO-88-F-03

4/22 Rec ISO
ISO

MEMORANDUM

TO: Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

Copy to GJ

FROM: State Supervisor, Fish and Wildlife Enhancement, Fish and Wildlife Service, Grand Junction, Colorado

THROUGH: Field Supervisor, Fish and Wildlife Enhancement, Fish and Wildlife Service, Salt Lake City, Utah

SUBJECT: Biological Opinion: AB Lateral Hydropower Facility---Uncompahgre Valley Hydropower Project, Colorado

This biological opinion is in response to your December 7, 1987, biological assessment on the AB Lateral Hydropower Facility---Uncompahgre Valley Hydropower Project, Montrose County, Colorado. The Federal action triggering consultation is the Bureau of Reclamation's proposed issuance of a lease of power privilege (contract) which would permit use of Uncompahgre Valley Hydropower Project features for the purpose of generating hydroelectric power. This biological opinion is based on project information obtained from the biological assessment dated December 7, 1987, and portions of the draft environmental impact statement received February 18, 1988. This opinion has been prepared in accordance with the Section 7 Interagency Cooperation Regulations, 50 CFR 402, and the Endangered Species Act (Act), 16 U.S.C. 1531 et seq.

BIOLOGICAL OPINION

The issuance of a lease by the Bureau of Reclamation (Bureau) to permit the construction of the AB Lateral Project which includes a penstock, powerhouse, tailrace, transmission line, access roads, and modifications of existing Uncompahgre Project features is not likely to jeopardize the continued existence of the clay-loving wild-buckwheat (Eriogonum pelinophilum) and the bald eagle (Haliaeetus leucocephalus). We concur with your "no effect" finding for the peregrine falcon (Falco peregrinus), black- footed ferret (Mustela nigripes), Colorado squawfish (Ptychocheilus lucius), humpback chub (Gila cypha), and the bonytail chub (Gila elegans). Conservation actions have been adopted by the Bureau of Reclamation and the proponent, and additional conservation recommendations are presented in this document, pursuant to Section 7(a)(1) of the Act.

PROJECT DESCRIPTION

Montrose Partners, which includes Mitex, Inc. and the Uncompahgre Valley Water Users Association, proposes to design, construct, and operate the AB Lateral Hydropower Facility as part of the Uncompahgre Valley Hydropower Project (Uncompahgre Project), to develop its hydropower potential. The Uncompahgre Project is a federally constructed irrigation project that diverts water from the Gunnison and Uncompahgre Rivers for irrigation of more than 76,000 acres in the Uncompahgre Valley. The Bureau has authority to contract for the development of hydropower production on the Uncompahgre Project.

The project would consist of diversion and intake works, penstock, powerhouse with turbines and generators, electrical switching equipment, excavated tailrace, transmission lines, and access roads. The project is located in westcentral Colorado near the city of Montrose and extends approximately 10 miles east of Montrose along Highway 50.

Water for the project would be obtained from the Gunnison River, by way of the existing Gunnison Tunnel, South Canal, and an enlarged AB Lateral. These are existing features of the Uncompahgre Project. The turnout from the South Canal to the AB Lateral would be modified and the first 7,100 feet of the AB Lateral enlarged and concrete lined, thus increasing the AB Lateral capacity to 1,100 cubic-feet-per-second (cfs) from the present capacity of 170 cfs. A penstock intake structure would direct flows of up to 1,100 cfs into a buried penstock, constructed of steel pipe approximately 11 feet in diameter, and approximately 7.4 miles in length. The penstock would be buried to a depth of at least 4 feet in a trench approximately 13 feet wide and 16 feet deep. The construction right-of-way necessary for the penstock would be 200 feet in width and would be used for stockpiling excavated material, site access, and temporary storage of pipe and equipment. A maintenance road would be constructed along portions of the penstock route.

To reduce losses of the clay-loving wild-buckwheat, special restrictions would be placed on the construction of the penstock in portions of a 2-mile reach where the penstock crosses sites of the plant. Special construction specifications would be developed for these areas. These would include but not be limited to the following: construction rights-of-way would be marked with temporary fencing and reduced to 100 feet in width in selected areas; access roads would be selected to avoid the plants and clearly marked to prevent off-road travel; storage, mobilization, and soil waste areas would not be located in these areas unless the areas were surveyed and confirmed not to contain the plant; topsoil would be separately stockpiled and replaced after the pipeline was placed; the pipeline would be designed to reduce the need for maintenance access in these two areas.

In addition, the proponents will implement 1 of 2 conservation actions. The first choice would be to acquire and turn over to the Bureau of Land Management (BLM) approximately 80-100 acres of Eriogonum pelinophilum and Penstemon retrorsus (a candidate plant also impacted by the construction of the penstock) habitat identified by the Fish and Wildlife Service on private land near Olathe. This population will be threatened by developmental and recreational pressures. Transferring it to federal ownership will provide the plants the protection of the Endangered Species Act since endangered plants receive no protection on private land (except for action involving federal permits, funds, etc.). If this measure could not be implemented, the proponents would fund the BLM to fence existing Natural Areas that have been set aside for the plants. Approximately 3 to 5 miles of fencing would be required.

The penstock would carry water to the project powerhouse located along the Uncompahgre River in the northwestern part of Montrose. The powerhouse would contain two Francis or Pelton turbines producing a maximum of approximately 33,500 horsepower each under a rated head of 636.5 feet and a turbine full gate discharge of 565.5 cfs for each unit. Power would be generated at 13.8 kV and transmitted through a new 115 kV, three-phase line to an interconnection at the Delta-Montrose Electric Association's existing North Mesa Substation. The line would run generally parallel to U.S. Highway 50 for approximately 2.1 miles. To reduce the possibility of raptor electrocution, the transmission line would be constructed with a raptor proof design as recommended in the document entitled Suggested Practices for Raptor Protection on Powerlines - the State of the Art, 1981: Raptor Research Report #4.

Water leaving the powerhouse would enter a stilling basin designed to reduce water velocity. An earth-lined tailrace, approximately 1,600 feet long, would be constructed to convey water from the stilling basin to the Uncompahgre River.

Existing irrigation flows from the Gunnison River would be used for the power facility. When available, additional flows would be diverted from the Gunnison River in accordance with established water rights. The project would be operated approximately 11 months a year. Existing irrigation supplies and minimum instream flows would be protected.

BASIS FOR OPINION

Clay-loving Wild-buckwheat

The clay-loving wild-buckwheat is known from the western flank of the Rocky Mountains in Colorado in the area between the Grand Mesa and the Uncompahgre Plateau. The species occurs in a north-south line from approximately 10 miles ENE of Delta to a point about 3 miles ESE of Montrose. Elevation ranges from 5180 feet to 6240 feet. The clay-loving wild-buckwheat, a low rounded subshrub with white flowers, grows on the adobes, a badlands of fine-textured soils derived from the Mancos Shale Formation, in a mixed desert shrub community with shadscale, black sage, bud sage, and woody aster. Two federal candidate species, adobe penstemon (Penstemon retrorsus) and adobe desert parsley

(*Lomatium concinnum*), also occur on the adobes with or near the clay-loving wild-buckwheat, respectively. Between Delta and Montrose the Mancos Shale forms a broad band on the east side of the valley between the rim of the Black Canyon of the Gunnison and the alluvial soils along the old floodplains of Loutsenhizer Arroyo and the Uncompahgre River in the bottom of the valley. Within this broad band the clay-loving wild-buckwheat's habitat generally occurs in a narrow 2-3 mile wide strip on the toe slopes between the highly contoured adobe hills on the east and the level plain, on the west, with mat saltbrush. This more or less concentric banding of soil microhabitats is apparently the result of a similar degree of erosion and distance of transport of material from the receding residual adobe hills (Potter et al. 1985a). The often abrupt ecotone of just a few meters between mixed desert shrub communities at the base of the adobe hills and pure stands of mat saltbrush on the plains is correlated with a very large increase (more than tenfold) in soil sulfate level. Sodium level also increases across this ecotone (Potter et al. 1985b). While the adobes form a wide band between Delta and Montrose, the clay-loving wild-buckwheat is apparently restricted to patches in this narrow ecotonal strip.

The many small occurrences of the clay-loving wild-buckwheat form six meta-populations. Since all of these sites are within the Uncompahgre Valley, there are no major topographic barriers (with the exception of the Gunnison River which only separates one meta-population, the type locality) between any of them. Approximately one-fourth of the sites are on BLM (public) land and the rest are on private land. Total population and habitat estimates for the species are 45,000-50,000 plants and 400-450 acres. However, the Uncompahgre Valley has a hopscotch pattern of agriculture (mainly irrigated hay meadows), residential development, and the remaining areas of adobes. Consequently, the habitat of the clay-loving wild-buckwheat has been fragmented and several of the occurrences on private land are less than 4 hectares (10 acres) in size with 300 plants or less. These remnant sites may not be viable for recovery, especially if they are surrounded by developments. Although one-fourth of the sites are on BLM land, these larger rangeland sites contain nearly half of the total numbers; and approximately half of the total numbers are contained on just the two largest meta-populations, the type locality on private land 10 miles east of Delta and the BLM South Canal locality 3 miles southeast of Montrose (USDI 1987).

Bald Eagle

The bald eagle is a large, long-lived bird of prey restricted in distribution to North America. Sexual maturity is reached at four to six years of age, but the birds may be considerably older before they breed for the first time. Many birds probably do not reach sexual maturity and few are likely to live until age 30 (USDI 1983).

Wintering bald eagles occur throughout the country but are most numerous in the west and the midwest. An abundant, readily available food supply associated with one or more suitable night roost sites is the primary characteristic of winter bald eagle habitat. Survival of individual bald eagles, particularly those in their first year of life, is heavily influenced by conditions they encounter during the wintering period. The physiological condition of adults at the beginning of each breeding season, an important factor influencing reproductive success, also is affected by how well their energy demands are met in wintering areas. Thus, the survival and recovery of nesting populations largly depends on available and suitable wintering habitat (USDI 1983).

Assuming that the presence of birds indicates presence of required habitat, wintering areas in Colorado that meet the following criteria should be considered essential habitat (USDI 1983):

1. Locations used annually by 15 or more eagles for two years or longer.

2. Locations used by bald eagles during periods of extremely harsh weather, when suitable feeding areas and night roost sites are limited in number. (The minimum two week period of use does not apply to this criterion).

Because there is no way to measure the importance of particular wintering sites to bald eagle survival and reproduction, it is suggested that consideration be given to factors such as the length of time an area is occupied by eagles each year, the amount of use it receives and its potential for supporting more use, the regularity of use over a period of years or during extreme weather when suitable habitat is most limited, and the number and extent of other wintering areas in the vicinity. Preserving such areas is suggested to ensure the survival and recovery of the bald eagles (USDI 1983).

A total of 536 wintering bald eagles were counted in Colorado in 1981 (USDI 1983). Generally, wintering bald eagles occur in Colorado from November through March. Although intensive statewide surveys are not conducted on an annual basis, wintering areas meeting the "essential habitat" criteria above, have been located. The Gunnison river upstream of the North Fork confluence appears to qualify as essential bald eagle habitat (USBR 1987, USDI 1983).

IMPACT ANALYSIS

Clay-loving Wild-buckwheat

Occurring in a broad river valley setting, the clay-loving wild-buckwheat is threatened by agricultural and residential development and associated secondary impacts. Expansion of the Montrose and Delta areas has caused residential encroachment onto habitats previously occupied by the plant. Much of the actual agriculture of irrigated hay meadows and pastures is on the alluvial soils in the valley but farming has encroached onto habitat on the east of the valley. Farm houses and livestock pastures tend to be on low shale ridges of potential habitat between the irrigated fields or mat saltbrush flats. The habitat is dissected by roads, paved and unpaved, and a dense network of irrigation canals and ditches; the canals tend to follow the contour of the toe slopes, the microhabitat of the plants. The adobe badlands are particulary attractive to off-road vehicle use and susceptible to its impacts. Since the narrow strip of clay-loving wild-buckwheat habitat lies adjacent to these towns, it has been and will increasingly be subject to heavy off-road and all-terrain vehicle use within the plants' habitat. These combined impacts have resulted in a fragmentation of the clay-loving wild-buckwheat's habitat into smaller, possibly nonviable population remnants.

In a survey of the penstock corridor by the proponents (Mariah 1986), approximately 435 clay-loving wild-buckwheat plants were found in small scattered locations within and adjacent to the penstock route. Because some of these plants grow on ridges and small ravines that run perpendicular to the penstock route, changing the penstock location would not avoid all the plants. Therefore, a portion of the estimated 435 plants would be destroyed in the 150 foot wide construction right-of-way. If all of these plants were lost, it would conservatively represent less than 5 percent of the known population of the plants and should not affect the overall survival of the species.

Bald Eagle

The Bureau's biological assessment for the AB Lateral suggests that eagle use on the Gunnison and Uncompahgre Rivers will likely be enhanced through project development. Reduced flows in the Gunnison River coupled with improved water quality on the Uncompahgre River are expected to increase habitat values and productivity of the area's salmonid fishery. Moreover, the biological assessment suggests that decreased flows in the Gunnison River will be beneficial to a sizeable winter concentration of waterfowl. The Bureau's assessment infers that salmonid fishes and waterfowl represent the primary prey of bald eagles along the Gunnison River. However, no quantitative or qualitative data on bald eagle prey use were provided in the assessment and are assumed to be unavailable.

It is highly possible that bald eagles are exploiting other non-game fishes in the Gunnison River. A recent Section 7 biological opinion rendered for the Two Forks project on Colorado's eastern slope exemplifies the problems of bald eagle prey use charachterization simply from available (visible) prey associations. A large concentration of wintering bald eagles forage on unknown species of fish on Cheesman Reservoir but seldom utilize the tailwater immediately below Cheesman dam, a South Platte River reach which supports perhaps the greatest trout bio-mass in the western United States.

The Service is also concerned over the possibility of project related ice-up on the Gunnison River and the resultant effects on bald eagles. The Bureau's assessment paints a rather cloudy view of icing potential on the Gunnison following increased diversions for the AB Lateral. The Gunnison presently provides available habitat and suitable prey for bald eagles throughout the winter months. If changes in flow on the Gunnison River result in significant freezing, particularly during a severe winter, it would occur at a time of greatest stress to over-wintering eagles. Given these concerns and biological uncertainties, the Service finds that the effects of project development on bald eagles are incalculable at the present time. Consequently, we have provided conservation recommendations below which will aid in further assessments of impacts following project development and which provide contingencies to minimize adverse impacts to bald eagles.

CONSERVATION RECOMMENDATIONS

Clay-loving Wild-buckwheat

Conservation actions involving modifications in construction procedures along the penstock route to avoid as many plants as possible and protection of additional habitat are described in the project description above.

Bald Eagle

1. The project proponent/Bureau should perform a standardized aircraft or river survey of the Gunnison River channel below the Black Canyon National Monument to the confluence of the North Fork each year for three years following project initiation; and in one year of any subsequent year that may be representative of an abnormally severe winter (provided a severe winter is not represented in the initial three year study period). A single survey should be conducted approximately every two weeks from January through the first of March (five total surveys/year). The surveys should be performed by qualified biologists with raptor survey experience and should assess: (A) species, number and age classes of eagles, (B) waterfowl or other potential prey numbers, and (C) extent of ice build up.

2. The project proponent/Bureau should provide to the Service annual and final progress reports. Any significant impacts or problems noted during the course of eagle surveys should be brought immediately to the attention of the Service.

3. In an effort to better document prey use on the Gunnison River, ground/river observations of foraging eagles should be accomplished by the proponent/Bureau. No less than 14 man-days of observation by a qualified observer should be conducted over the months of January through March and should record all observations of eagle hunting activity and species of prey captured (whenever possible). Attempts should be made to locate day and night perches/roosts in order to collect and analyze eagle castings.

4. If impacts to prey species or icing impacts are projected or are realized during the course of the study, appropriate measures should be designed through consultation with the Service to ameliorate adverse effects. Such measures may include water augmentation during periods of extreme cold to prevent icing conditions or degredation of habitat conditions for favored prey.

INCIDENTAL TAKE

Section 9 of the Act prohibits any taking (killing, harming, or harassment) of listed species without special exemption. Under the terms of Section 7(b)(4)(iii) and 7(a)(2) of the Act, taking that is incidental to and not a purpose of the agency action (in this case construction and operation of a hydropower facility) is not considered taking within the bounds of the Act, provided that such taking is in compliance with the terms and conditions set forth in the Biological Opinion.

Bald eagles may be "taken" by operation of the proposed hydropower facility through increased icing of the Gunnison River as a result of decreased winter flows resulting in a reduced prey base and foraging opportunities, thus causing displacement of these bald eagles. Due to the uncertainties of icing effects on bald eagle behavior, we cannot now predict a level of incidental take that may occur. Therefore, the Service establishes that no incidental take associated with the proposed hydropower facility is authorized and no incidental take statement is provided.

CONCLUSION

Reinitiation of consultation under Section 7 of the Act is required if this project is modified in ways that affect listed species beyond the scope of this opinion, if new or proposed or listed species may be affected by the project, if new information becomes available which reveals impacts not considered in this consultation, or if incidental take of bald eagles results from project construction or associated activities.

We appreciate working with the Bureau and the proponents in conserving the clay-loving wild-buckwheat and the bald eagle.

Literature Cited

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Potter, L.D., C. Reynolds, Jr., and E.T. Louderbaugh. 1985a. Mancos shale and plant community relationships: Field observations. J. of Arid Environments 9:137-145.

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USDI, Fish and Wildlife Service. 1983. Northern states bald eagle recovery plan. U.S. Fish and Wildlife Service.

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ATTACHMENT G

RIVER DEPTH VERSUS FLOW
(GUNNISON RIVER)

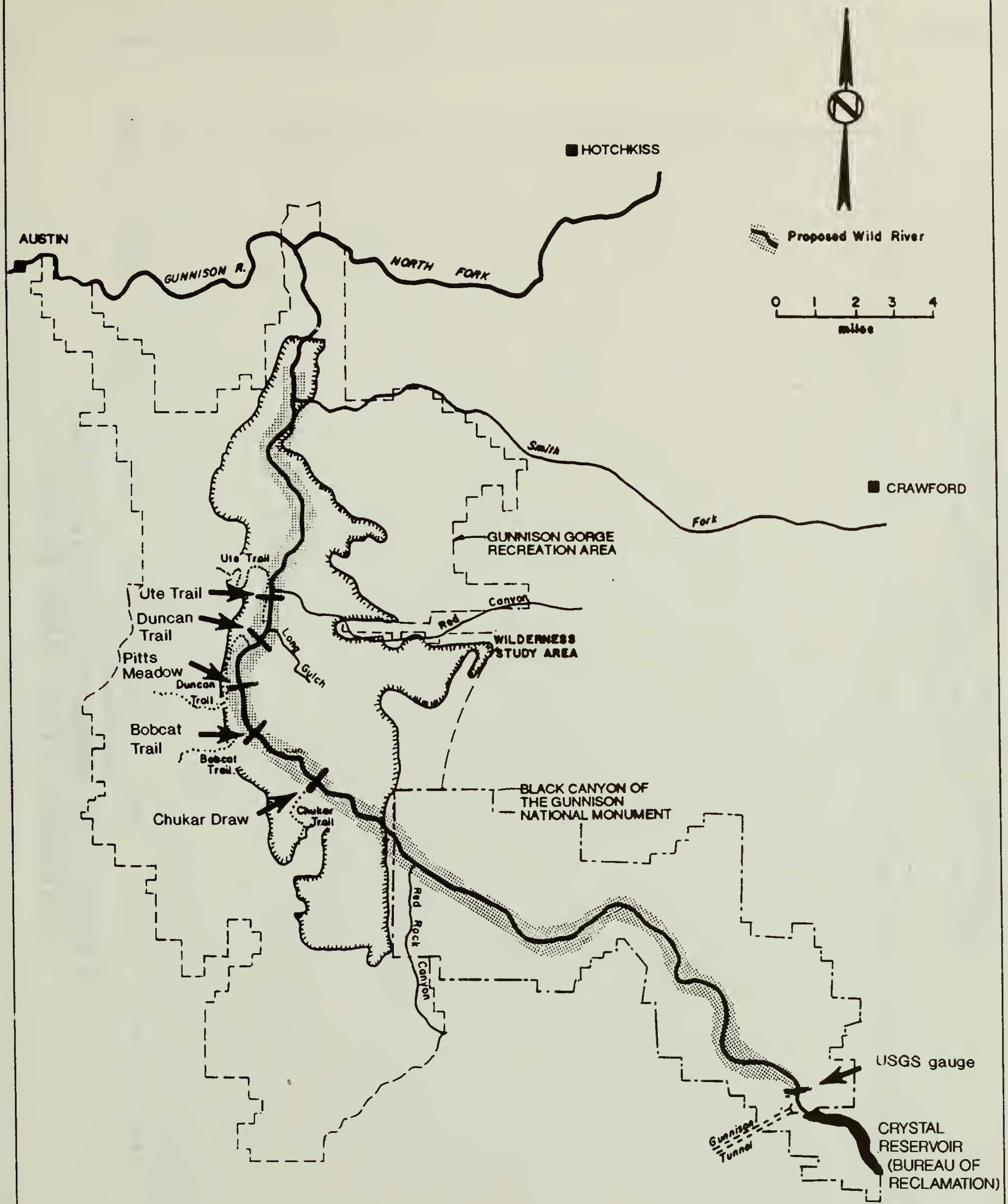

Figure G-1. Gunnison River cross sections.

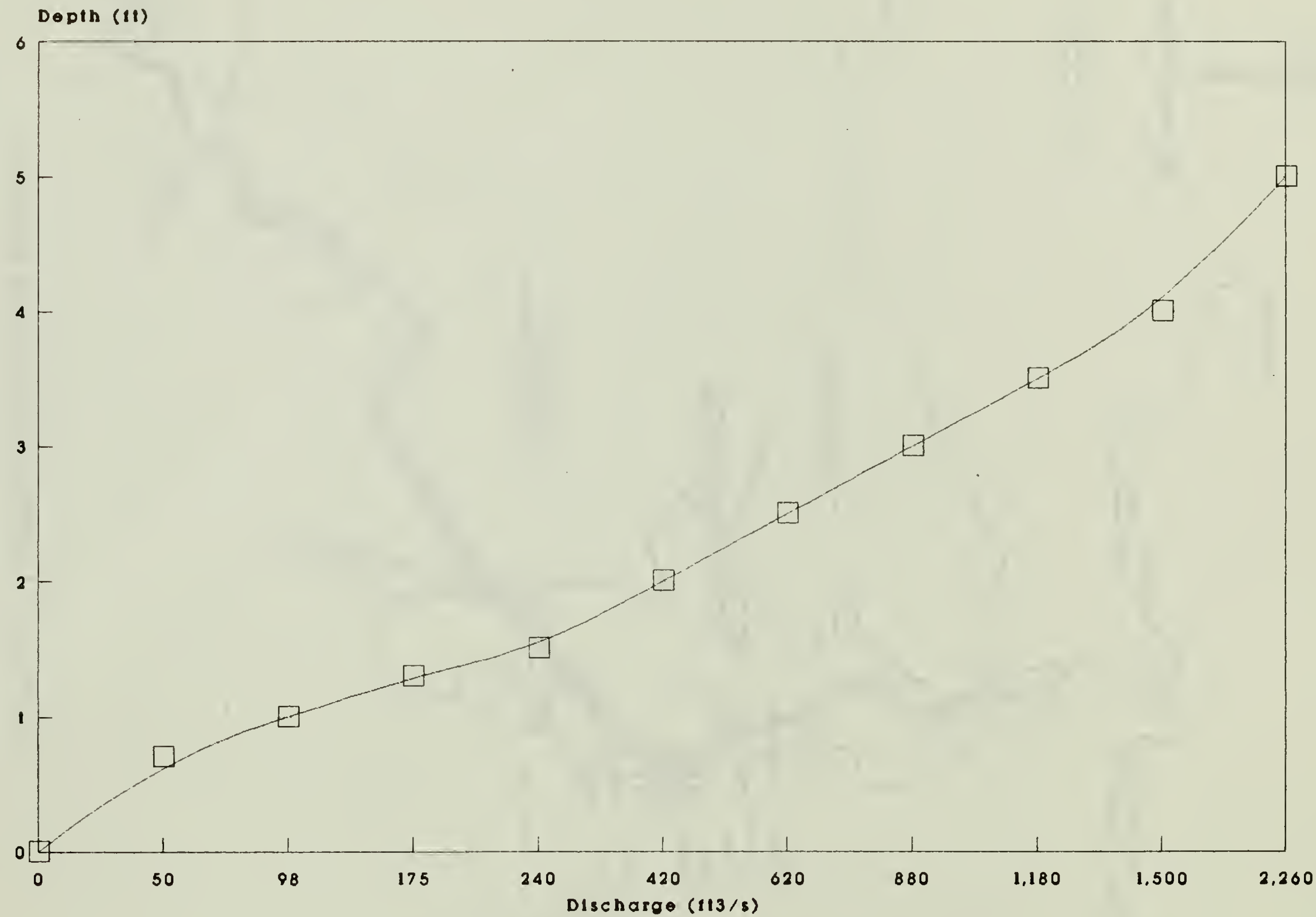

Figure G-2. Stage/discharge curve (Gunnison River, USGS gauge).

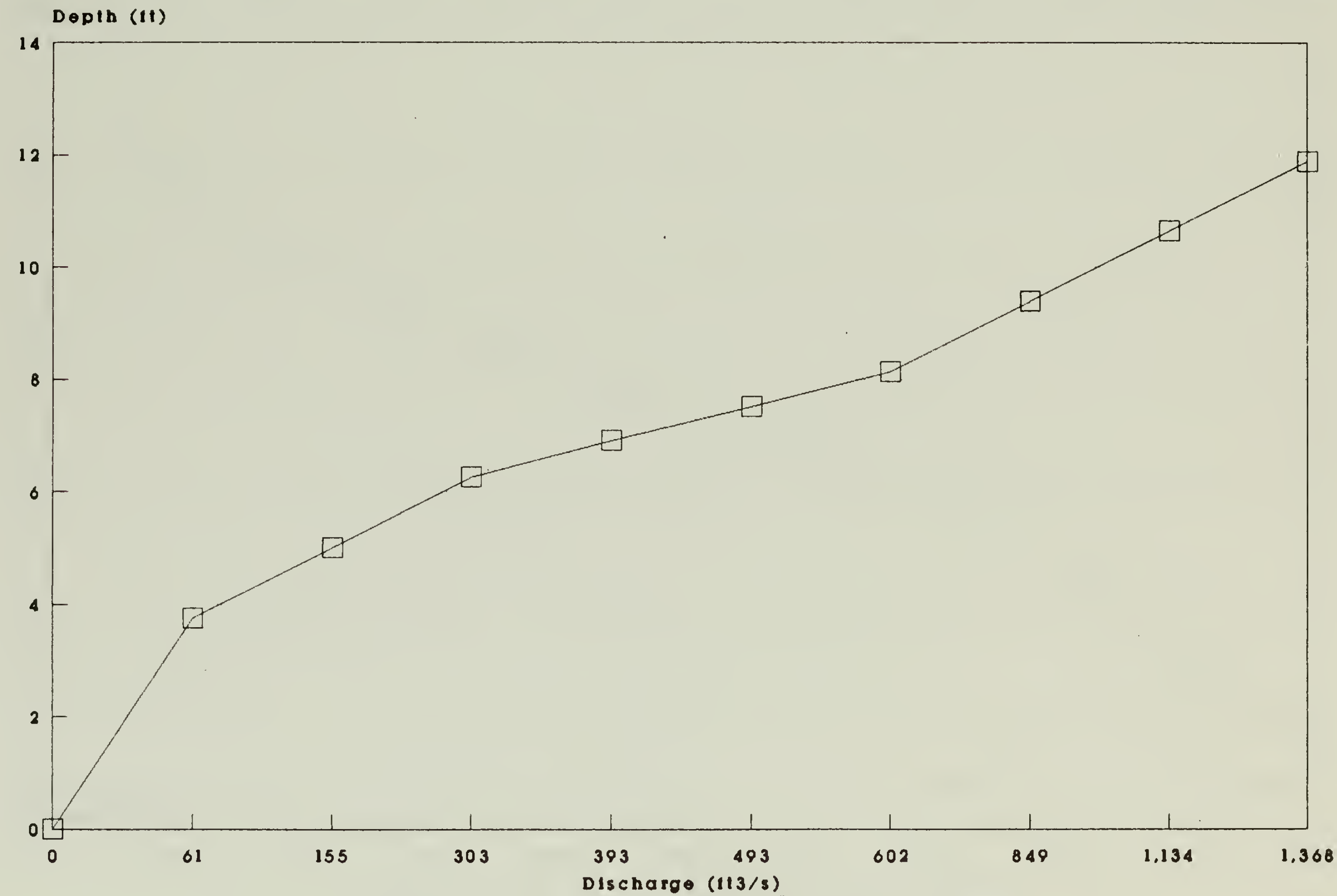

Figure G-3. Stage/discharge curve
(Gunnison River, Chukar Draw).

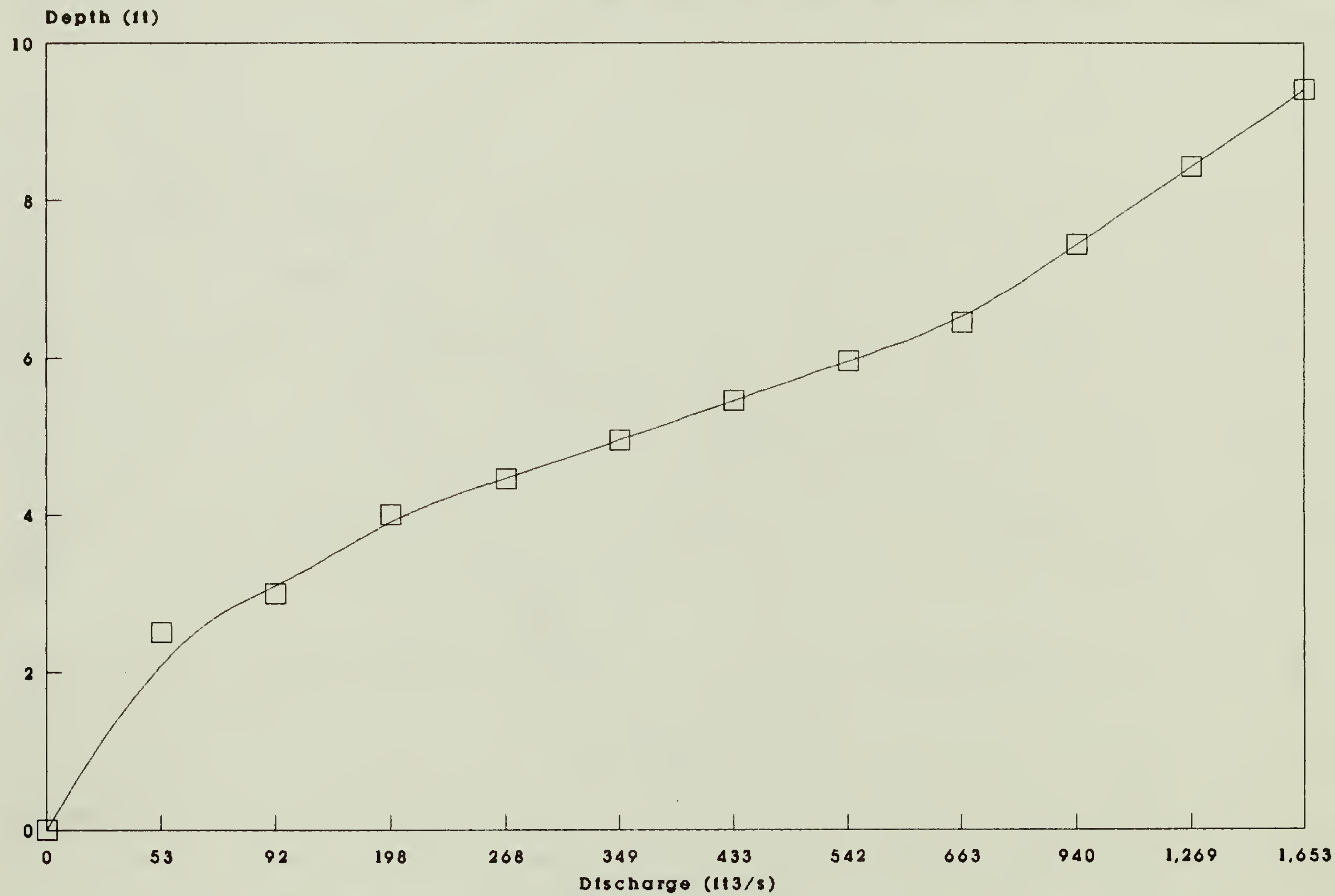

Figure G-4. Stage/discharge curve (Gunnison River, Bobcat Trail).

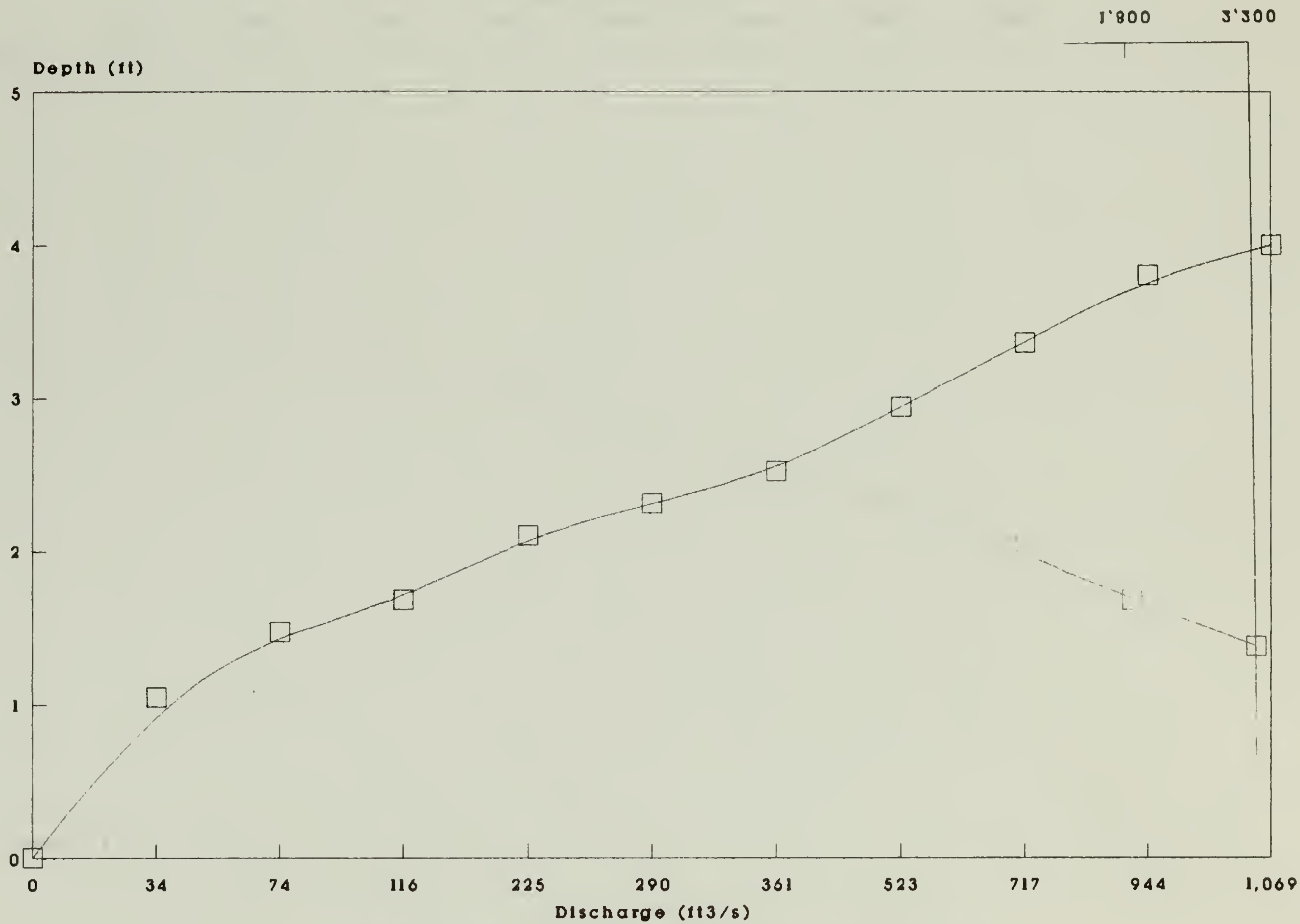

Figure G-5. Stage/discharge curve (Gunnison River, Pitts Meadow).

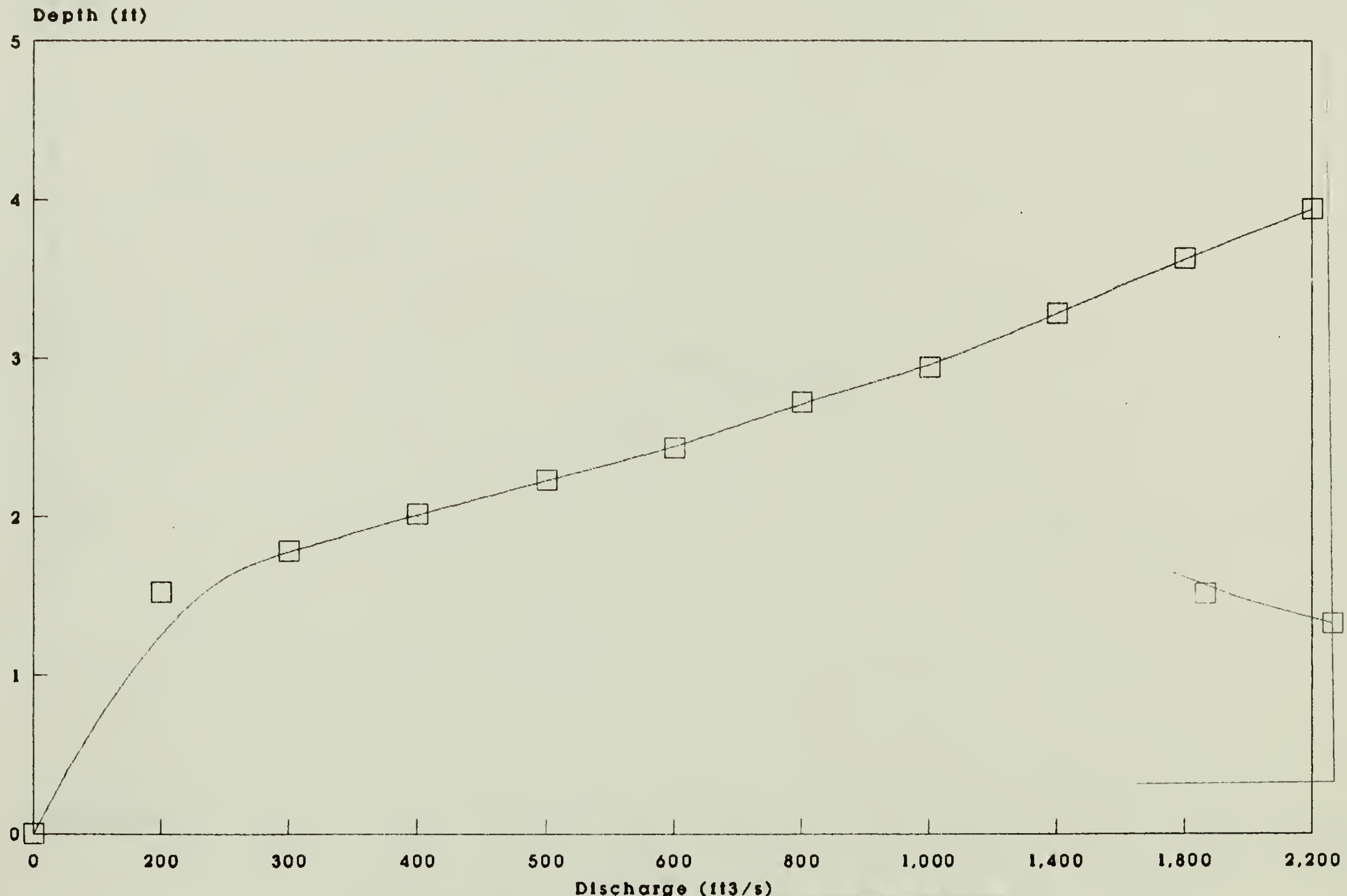

Figure G-6. Stage/discharge curve (Gunnison River, Duncan Trail (FWS))

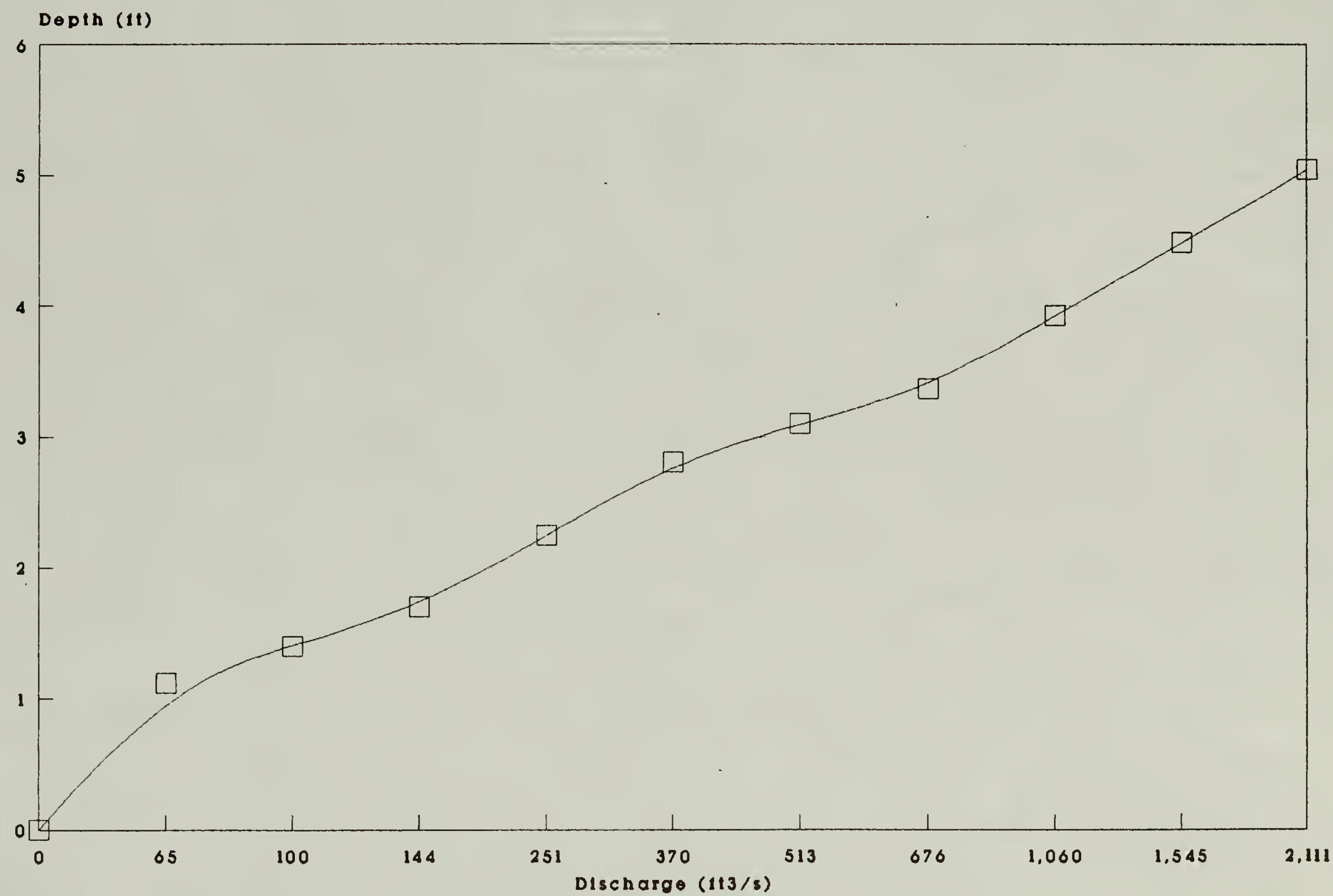

Figure G-7. Stage/discharge curve (Gunnison River, Ute Trail).