MIDDLE FORK POWDER RIVER

Final Combined Level III Report on

Potential Aquatic and Terrestrial Wildlife Impacts

PRESENTED TO:

STATE OF WYOMING

WYOMING WATER DEVELOPMENT COMMISSION

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TABLE OF CONTENTS

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INTRODUCTION

This report provides a quantified assessment of existing aquatic and terrestrial wildlife resources which may be impacted by development and/or operation of a reservoir on the Middle Fork Powder River (Middle Fork) near Kaycee, Wyoming. This report also defines the kind and extent of those impacts. Where unavoidable wildlife losses will occur, mitigation recommendations are presented. Certain aspects of this project may directly or indirectly benefit wildlife resources and recommendations are made which will enhance those resources. This report does not provide an economic benefit analysis based on recreational use of the facilities.

PROJECT DESCRIPTION

The primary component of this project consists of a 1,276 acre reservoir containing 50,000 acre-feet on the Middle Fork at T43N, R83W, S33. This reservoir will store Middle Fork water for future industrial and agricultural uses. Although firm industrial uses for developed water have not presently been identified, design specifications call for conveying all industrial waters to the industrial site(s) in a pipeline originating at the dam at a constant rate of up to 33.5 cfs throughout the year. Agricultural releases would be at least 89 cfs from July 15 to September 1 and would be made directly into the stream channel. The proposed release schedule would result in a flow of about 5 cfs immediately

below the dam from October 1 through April. Based on conversations with the Wyoming Water Development Commission (WDC), we assume that, until firm industrial uses for developed water are established, releases will approximate the existing monthly discharge pattern (minus evaporation losses) once the reservoir has filled.

METHODS

Fisheries

Existing Fisheries Resources

Fisheries field data were obtained from three sites on the Middle Fork (Figure 1) in 1984. Data for determining instream flow recommendations and stream fish habitat impacts were collected at T42N, R83W, S3 (M1). This study site was typical of the stream habitat and fish community structure of the stream segment between the proposed dam site and the river's confluence with the Red Fork. A study site located near the projected upstream limit of the reservoir at T42N, R84W, S12 (M3) was used to calculate potential stream fish habitat losses which will occur when the river is flooded.

Additional fishery information for parts of the Middle Fork between M1 and M3 was obtained from investigations conducted in previous years by Wyoming Game and Fish Department (WGF) biologists. These data were collected near the mouth of Beaver Creek (M2 in Figure 1).

Fishery data were obtained for two sites on Beaver Creek. A fish population estimate was done in 1984 at one study site located on Beaver Creek (B1) near its mouth (T43N, R83W, S32). Data were also obtained from a 1974 population estimate near Barnum at T43N, R84W, S35 (B2).

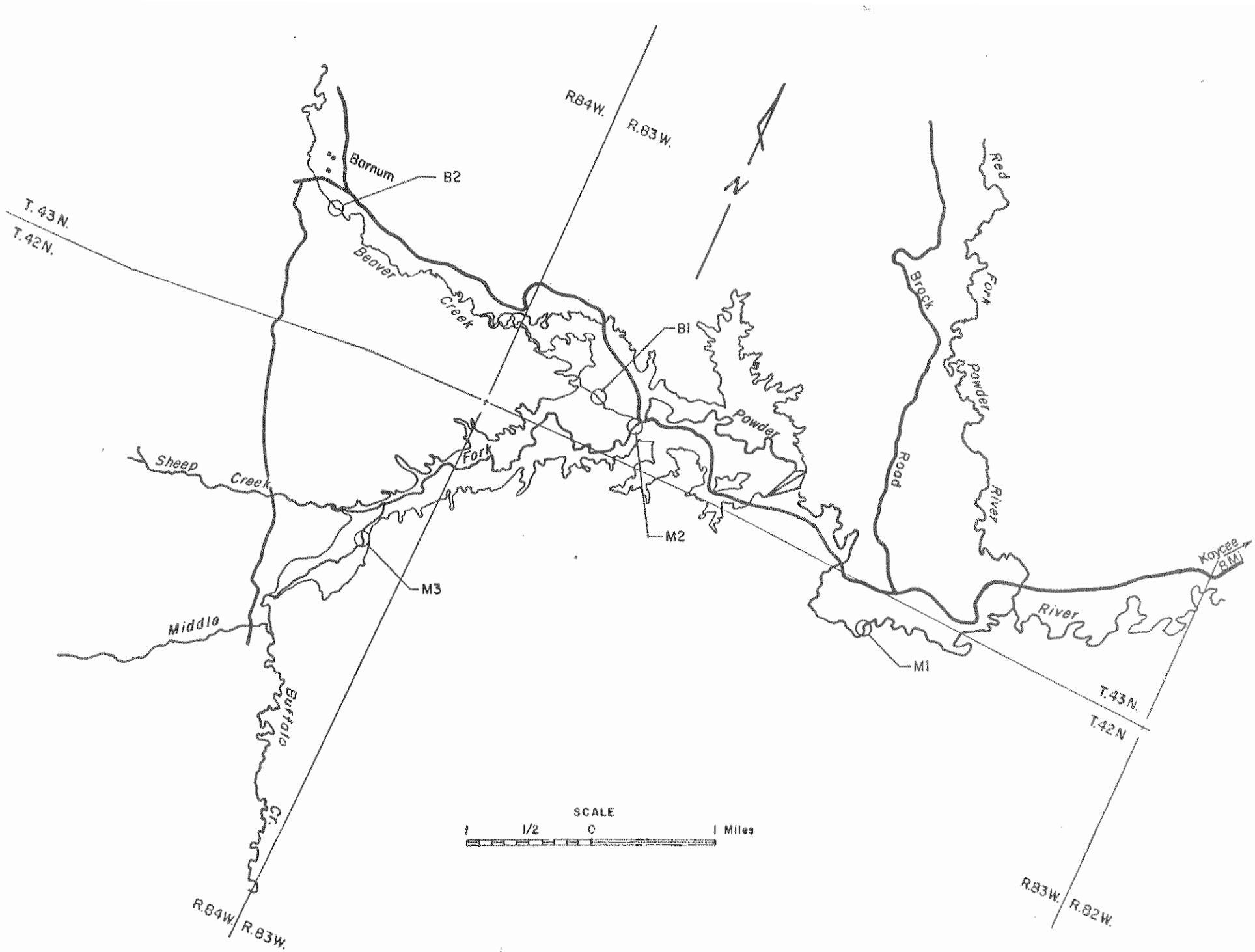

Figure 1. Location of reservoir and fishery study sites.

Instream Flows

Flows necessary for trout to be able to move into and through riffle areas in search of food, spawning areas, etc. and for trout food production (aquatic insects) were determined using a computer model that simulated various hydraulic characteristics over a range of flows (Milhous 1978). Data analysis was based on a method developed by the Colorado Division of Wildlife (Nehring 1979) and refined for use in Wyoming (Annear and Conder 1983). This flow is referred to as a maintenance flow meaning it is a flow necessary to maintain a given trout population at all times of the year or when higher flows are not required to meet other fish habitat requirements.

A physical habitat simulation model developed by the U.S. Fish and Wildlife Service (USFWS) (Bovee and Milhous 1978) was used to determine potential trout habitat dynamics over a range of flows at M1. The stream below the dam will be managed for rainbow trout after completion of the project and as a result only habitat preference data for rainbow trout were used. This model provided recommendations for spawning habitat (April to June) and habitat for adult, juvenile, and fry during mid to late summer (July to October). This model was used primarily to identify ranges of flow which provide adequate amounts of useable area or physical habitat for fish. The model is incapable of providing more refined fishery impact assessments relating to potential densities of fish at different flows.

The potential density of trout at various flows within the preferred range identified by the IFG-4 model was calculated using the Habitat Quality Index or HQI (Binns and Eiserman 1979). Results from this model are in habitat units

(HU). A HU is defined as the amount of habitat necessary to produce a one-unit change in trout standing crop. Where the IFG-4 model measures only physical habitat, the HQI measures chemical and biological habitat components in addition to physical variables.

In a well-established fishery where trout are able to complete all phases of their life cycle (from experiencing adequate spawning success to having appropriate habitat for adult fish) the measured population density (pounds per acre) normally approximates the number of HU's in the stream. Discrepancies may occur, however, for one or more of several reasons. These include such instances as where habitat for one component of the trout's life cycle is missing, where rare, unpredictable environmental events limit standing crop, or where angling mortality is suppressing actual trout densities. Although it is usually more accurate to measure habitat quality for impact analyses, actual fish population estimates may be substituted where HQI analyses are not available.

Measurements over a range of flows were taken for the HQI at M1 to predict HU dynamics over a range of potential late summer releases. Data for HQI analysis were also collected at M3 to assess the number of HU's in this segment which will be lost when flooded by the reservoir.

Habitat unit losses in Beaver Creek were determined by converting trout density (pounds per acre) to HU's. Habitat unit analyses at M4 were also based on measured trout densities collected over several years.

Reservoir Fishery Analysis

The Morphoedaphic Index (MEI) (Ryder 1965) was used as an estimator of productivity for the proposed reservoir enlargement. Many variables affect the

density of game fish in a reservoir. The MEI estimates are based on some of these variables. While the MEI was developed to address lake habitat, work done by WGF (Facciani 1976) showed that the MEI could be applied to fluctuating reservoirs in Wyoming. Newly constructed or enlarged reservoirs exhibit high productivity for approximately five to seven years after filling. This extra productivity is due to nutrients leaching from flooded soils and stimulating productivity. Analyses using the MEI are indicative of the productivity of the reservoir after nutrient levels have stabilized.

A minimum pool recommendation was based on depth requirements, morphological configuration of the reservoir basin, and consultation with WGF area biologists.

After construction of this reservoir, morphological changes in the stream channel below the dam will occur which could affect fishery resources and instream flow recommendations. A preliminary analysis addressing this concern was conducted by the USFWS and is contained in Appendix A.

Other data contained in this report were obtained from the WGF Lake and Stream Inventory, previous fishery studies, and communication with WGF area management fishery biologists stationed in the Department's Buffalo area office.

The WGF has established management objectives for fisheries in this part of the state which call for maintaining or increasing the existing supply and diversity of stream fishing opportunity (Wyoming Game and Fish Department 1983B). Where a given activity will reduce the quantity of a specific resource, we recommend that efforts be made to replace that loss with an equal or greater amount of that resource type.

In addition, the USFWS has developed a mitigation policy which pertains to any project requiring Federal involvement (Table 1) (Federal Register 1981). This policy is consistent with WGF management objectives.

Table 1. U.S. Fish and Wildlife Service resource categories and mitigation planning goals.

Resource category	Designation criteria	Mitigation planning goal
1	High value for evaluation species and unique and irreplaceable.	No loss of existing habitat value.
2	High value for evaluation species and scarce or becoming scarce.	No net loss of in-kind habitat value.
3	High to medium value for evaluation species and abundant.	No net loss of habitat value while minimizing loss of value.
4	Medium to low value for evaluation species.	Minimize loss of habitat value.

Rare Fish

Three species of fish that are considered rare in Wyoming are found in the Powder River downstream from the proposed reservoir. These species include the sturgeon chub, shovelnose sturgeon, and goldeye (WGF 1977). Field and office studies were begun in 1983 and continued through the 1984 field season to evaluate potential impacts of this or other proposed Powder River projects on these species.

Information and potential impacts on sturgeon chubs were obtained from a study by Stewart (1981). No additional field studies were conducted relative to this species.

Very little is known about shovelnose sturgeon or goldeye in Wyoming. Sturgeon were thought to be near extinction in the state until several were

collected by WGF in 1983. In light of the numbers of sturgeon which have been captured in the past two years, the WGF is reviewing the status of this species in Wyoming. In states where it is abundant, it is generally classified as either a game or commercial fish. As the public has become more aware of the existence and desirability of sturgeon,fishing pressure has increased. One fish was submitted in 1984 for listing as a state record and we expect angling pressure to increase in the future. Field studies in 1984 focused on evaluating the relative abundance and movement patterns of sturgeon and goldeye. Hoop nets and gill nets were fished in the mouths of Clear Creek and Crazy Woman Creek and in the Powder River near those streams. We were unable to sample over a larger area of the river to better define the distribution of these species. These studies will be expanded in 1985.

Office studies of potential impacts on goldeye and shovelnose sturgeon consisted of a preliminary literature review.

Terrestrial

Habitat

Habitat types on the project area were delineated from color infra-red aerial photographs supplied by the Bureau of Land Management. Habitat type lines were field verified and the habitat types identified. Descriptive data were collected including slope, dominant species of vegetation and condition of the habitat. In riparian areas, one 10 hectare (25 acre) sample plot was randomly sampled during the growing season. Information gathered included tree canopy cover, amount of bare ground, number and species of snags (dead trees), and livestock grazing pressure. A 100 meter line intercept was used to sample the tree and shrub understory in each plot.

The acreage of each habitat type on the reservoir site was determined by planimetering and a map was drafted showing habitat types and the acreages which will be lost.

Wildlife

Mule Deer and White-tailed Deer

Data on deer numbers is from two sources: 1) the computer based Wildlife Observation System, which contains past information collected during aerial surveys, and 2) estimated densities of big game in Wyoming (Wyoming Game and Fish 1983). Deer distribution is based on aerial survey and field observation data. Herd unit, hunt area and management objectives were taken from District III Annual Big Game Herd Unit Reports. Harvest information for 1983 is from the Wyoming Game and Fish Department's Annual Report of Big Game Harvest, field checks and landowner interviews.

Turkey, Pheasant, Gray and Chukar Patridge, Small Game and Furbearers

Information on distribution and numbers was collected by field observation and interviews with Department personnel and landowners. Harvest data for 1983 was taken from the Wyoming Game and Fish Department's Annual Report of Upland Game and Furbearer Harvest, furbearer tag reports and landowner interviews.

Nongame Birds

Each major habitat to be inundated by reservoir development was sampled for bird species occurrence and density. A sample plot of 10 hectares in size (approximately 25 acres) was randomly selected in each habitat and two censuses

were conducted per habitat type during the breeding season according to guidelines in the Handbook of Biological Techniques (Wyoming Game and Fish Department 1982). The sample plot, 100 meters wide by 1,000 meters long, was walked at a slow pace and all species within the plot and their location were recorded on field forms.

Riparian habitats and cliffs which could support raptor nests were surveyed by traversing the project area along the river and recording all nests and pairs of raptor species observed. This survey was conducted in early May when both early and late spring nesters were present on nest territories.

Additional information on bird species in the project area was compiled from the Wildlife Observation System and private contributors.

Nongame Mammals

Small mammal populations were sampled in each major habitat on the project area. Trapping was conducted according to guidelines in the Handbook of Biological Techniques (Wyoming Game and Fish Department 1982). A random sample was achieved by locating 30 trap stations each containing 4 traps along a line with approximately 20 meters between stations. Trap lines were in place at least one night (120 trap nights) and occasionally 2 nights (240 trap nights). Density information for small mammals is difficult to calculate because of wide fluctuation in population size and different catchability rates between species.

Endangered Species

Bald eagle roosts were monitored twice during the winters of 1983 and 1984. Past information on the major roost was supplied by the Endangered Species

Office of the U.S. Fish and Wildlife Service. All endangered species data presented in this report was reviewed and approved by the Endangered Species Office of the U.S. Fish and Wildlife Service.

RESULTS

Fisheries

Existing Fishery Resources

Beaver Creek

The proposed reservoir would inundate a 2.25 mile segment of this stream. A waterfall located one-half mile above the mouth of the stream serves as a barrier to fish movement. Distinctly different fisheries occur above and below the falls. The segment downstream from the falls is classified as Class 4 according to the WGF stream classification system (Table 2). Waters in this category typically have low productivity, but may still be locally important. These streams in general cannot support high fishing pressure.

Table 2. Summary of the Wyoming Game and Fish Department's stream classification system.

Stream Class	Description
1	Premium or blue ribbon trout waters of national importance
2	Very good trout waters of statewide importance
3	Important trout waters of regional importance
4	Low production waters frequently of local importance but generally incapable of sustaining substantial fishing pressure
5	Very low production waters often incapable of sustaining a fishery

This stream receives approximately 22 fishermen days of fishing pressure per mile of stream per year. Trout densities are relatively low in this segment,

the fish community being comprised primarily of nongame fish (Table 3). The most common trout species found here is brown trout; however, rainbow trout were also captured during 1984 field sampling. This stream segment fall within the USFWS category 3 (Table 1).

Table 3. Electroshocking results from Beaver Creek (B1) on September 19, 1984.

	Brown Trout	Rainbow Trout	Flathead Chubs	Mountain Suckers	Longnose Suckers
Number per mile	65	16	>1,700	>2550	163
Pounds per acre	14.5	1.2	> 108	> 148	48
Mean length (in)	10.60	7.10	6.95	6.33	11.10
Mean weight (lbs)	0.42	0.14	0.12	0.11	0.56

The 1.75 mile segment upstream from the falls is a Class 3 trout stream which supports approximately 123 pounds per acre of trout as well as moderate densities of mountain suckers and longnose dace. This segment receives 38.9 fisherman days of fishing pressure per mile of stream per year and is considered a category 2 resource (Table 1).

Middle Fork Powder River

The fishery in this river shows a significant change between the proposed dam site and the maximum high water line (MHWL) of the reservoir. Changes are most rapid at and downstream from the mouth of Beaver Creek due to the large amounts of sediment that are discharged by this stream during times of the year. As a consequence, potential fishery impacts were determined separately for one segment located from the mouth of Beaver Creek upstream to the MHWL, for another located between the mouth of Beaver Creek and the proposed dam site, and for another between the proposed dam site and the Middle Fork's confluence with the Red Fork Powder River.

In addition to fishery information which has been collected by WGF near the mouth of Beaver Creek (M2) in past years, data were collected at two other stations in 1984. Station M1 was located approximately two miles downstream of the proposed reservoir and station M2 was established about three miles upstream from the mouth of Beaver Creek (Figure 1).

Game fish and nongame fish population densities were low at M1 (Table 4). No fishery investigations have been conducted in this portion of the river in recent times; however, the landowner noted that trout have been seen and caught here with regularity over at least the past ten years.

Table 4. Results of a fish population estimate for the Middle Fork Powder River at M1 on September 18, 1981.

	Brown Trout	White Sucker	Longnose Sucker	Mountain Sucker	Flathead Chub	Longnose Dace
Number captured	1	10	10	8	Numerous	Numerous
Mean length (in)	8.00	9.55	8.40	4.95	6.3	-
Mean weight (lbs)	0.23	0.44	0.39	0.07	0.11	-

Densities of both game fish and nongame fish were considerably higher at M2 (Table 5). This density of trout is fairly typical of densities found in other good trout streams in this part of the state, which rank as some of the most productive in Wyoming. Further evidence of the high productivity of this stream segment is the finding that the stream supports over 600 pounds per acre of nongame fish in addition to the 126 pounds per acre of trout found here.

Table 5. Fish population estimates for the Middle Fork Powder River at M3 on September 19, 1984.

	Brown Trout	Rainbow Trout	Longnose Sucker	White Sucker	Mountain Sucker
Pounds per acre	73.4±7.2	52.7±2.2	520±9.0	89.1±2.2	12.0±0.28
Number per mile	670±66	538±22	2,536±44	450±11	461±11
Mean length (in)	10.7±0.69	10.4±0.66	13.7±0.72	13.4±0.45	6.5±0.50
Range (in)	5.9±17.9	6.1±14.0	-	-	-
Mean weight (lb)	0.47±0.09	0.42±0.07	0.87±0.13	0.84±0.09	0.11±0.02

Table 6 contains a summary of WGF file information for fisheries near the Middle Fork's confluence with Beaver Creek. Habitat Quality Index analyses were not conducted on this portion of the Middle Fork so the estimated density of trout here was converted to HU's for determining fishery impacts. The mean trout density (HU's) at M2 was averaged with the measured HU's at M3 to reference stream fishery impacts above the mouth of Beaver Creek. Trout density estimates for the Middle Fork below the mouth of Beaver Creek to the proposed dam site were based only on the average of the data in Table 4. The mean density of trout in this stream segment is 23.4 pounds/acre.

Table 6. Summary of WGF file information regarding estimated trout densities in the Middle Fork Powder River near the mouth of Beaver Creek.

Stream Segment	Date of Study	Trout Density (lbs./acre)
Middle Fork upstream from Beaver Creek	1963-1966	18.9
Middle Fork upstream from Beaver Creek	1955	29.1
Middle Fork downstream from Beaver Creek	1974	26.5
Middle Fork downstream from Beaver Creek	1955	19.0
Mean		23.4

The Middle Fork segment referenced by M3 falls under resource category 2 (Table 1) which calls for no net loss of in-kind habitat value. The remaining potentially impacted stream segments on the Middle Fork are resource category 3.

Instream Flow

Instream flow analyses were conducted only at the M1 study site. Although the fishery in this stream segment is presently quite limited, the water released from the proposed reservoir will probably be better quality than in this stream segment now and should result in a substantially better trout

fishery. Improvement of the fishery here will be one of the areas where mitigation for lost stream habitat flooded by the reservoir will be possible. Analyses at this site addressed 1) stream flows necessary to allow for fish movement between different habitats, 2) the impact of various releases on spawning conditions for rainbow trout, 3) the impact of various releases on habitat for motile life stages of rainbow trout, 4) flows necessary for production of trout food (aquatic insects), and 5) the number of mitigation benefits that will be generated under different release schedules.

Maintenance Flow

The term "maintenance flow" (MF) refers to that discharge which is necessary to maintain a viable population of trout. This flow is identified by determining the discharge which meets defined hydraulic criteria (average depth, average velocity, and wetted perimeter). These criteria vary according to stream width and are based on the amount of flow necessary for fish passage and aquatic insect production (Nehring 1979). Analyses were based on the results of hydraulic simulation modeling of four riffle areas at M1.

Results from these analyses showed that a continuous flow of at least 33 cfs is necessary to maintain a population of trout during periods of the year when higher flows are not required (Table 7).

Table 7. Summary of instream flow recommendations for the Middle Fork Powder River.

Time Period	General Release Recommendations (cfs)[a/]	Preferred Release (cfs)
October 1 to March 31	≥33	≥33
April 1 to June 30	33-160	<100
July 1 to September 30	33-100	75

a - Any flow within this range will provide adequate habitat for rainbow trout. The preferred release schedule will minimize stream fishery losses caused by the reservoir when it is filled.

Spawning and Incubation Requirements

Both brown and rainbow trout will probably be present in the Middle Fork below the proposed dam; however, the stream will be managed primarily for rainbow trout. The spawning habitat simulation results plotted in Figure 2 are for rainbow trout only. Recommendations based on this information apply only to the time of year when this species is spawning and eggs are incubating in stream gravels, which is normally between April and the end of June.

These data show that rainbow trout spawning and incubation habitat is maximized at 100 cfs. Reductions in flow result in relatively gradual habitat reductions to 30 cfs. The model shows that small incremental reductions in flow below 30 cfs result in relatively large reductions in spawning and incubation habitat. To realize any successful spawning, fish must be able to reach spawning areas and thus require a flow of at least 33 cfs for passage even though spawning habitat may be present at lower flow.

Spawning and incubation habitat is also lost at a relatively gradual rate with increases in flow above 100 cfs. An inflection point in the habitat versus

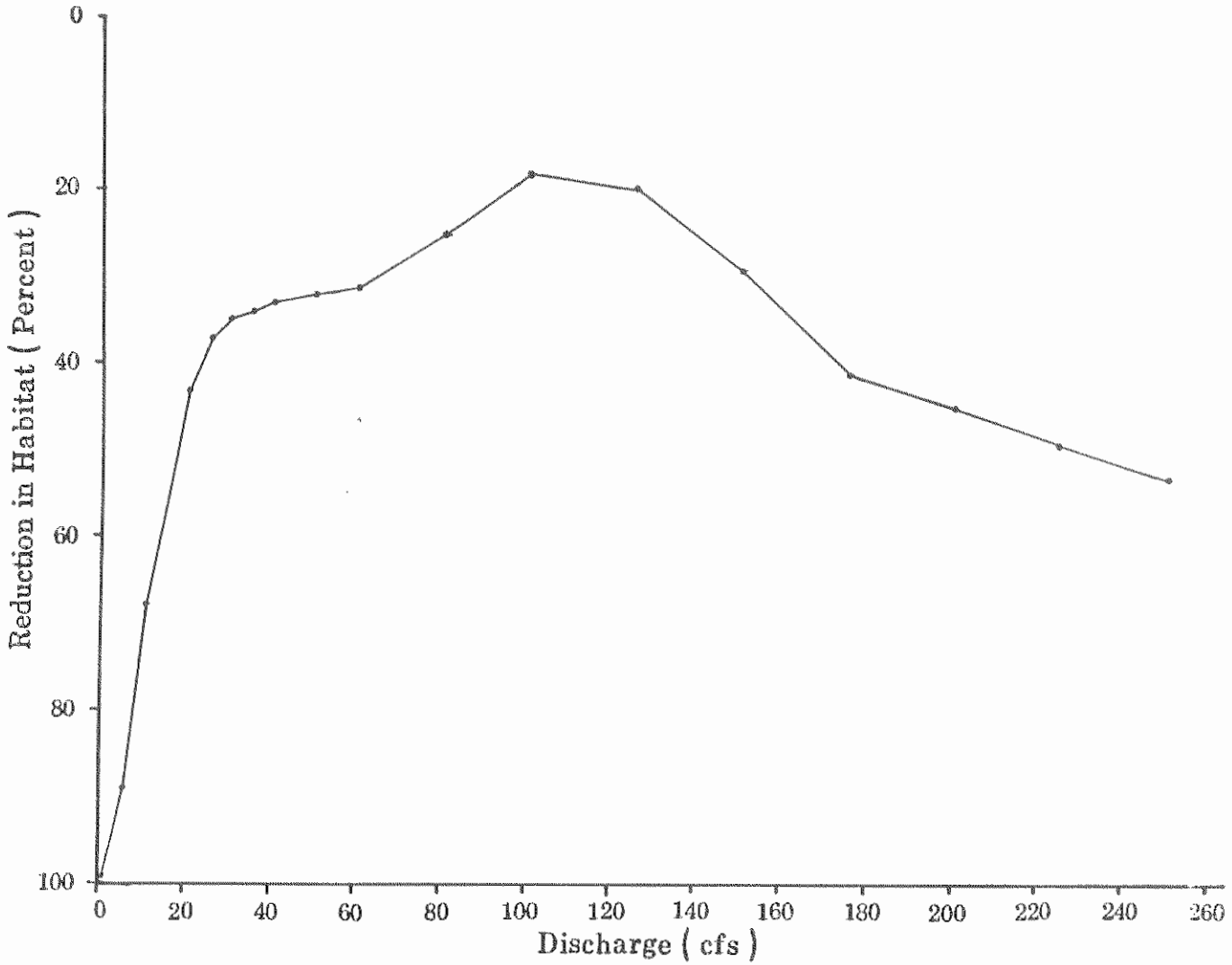

Figure 2. Results of habitat modeling showing changes in spawning and incubation habitat for rainbow trout with changes in discharge in the Middle Fork downstream from the proposed dam site.

discharge curve as noted at 30 cfs was not recorded for higher discharges; however, habitat does continue to decrease with higher flows according to the model. Habitat at high flow should be reduced no more than habitat at 30 cfs. The corresponding high flow is 160 cfs. Although the recommended instream flow range from April 1 to June 30 is for releases between 33 and 160 cfs, stream bank erosion will be greater with higher flows. This could impact spawning success more than the model indicates. To minimize this risk, we would prefer that releases within the recommended range be less than 100 cfs.

Adult, Juvenile and Fry Habitat

Model results plotted in Figure 3 show that habitat for motile forms of rainbow trout is maximized at 30 cfs. These data indicate little change in the amount of useable area at flow reductions to 20 cfs. Flows lower than this result in rapid habitat loss. Although this model shows nearly the same amount of habitat at 20 cfs as at 30 cfs, it does not address the ability of fish to move through riffle areas or the productivity of riffles in terms of aquatic insects. In this instance, the model is detailing habitat dynamics in the pools and runs which dominate this river segment. To maintain a trout population in the stream and provide the minimum level of adequate physical habit, we recommend that flows not fall below 33 cfs at any time from July 1 to September 30.

Though habitat decreases noticeably with increased flow above 30 cfs, higher flows are not usually as detrimental as the model indicates in late summer. Temperature modeling has not been done for the Middle Fork, but in general,

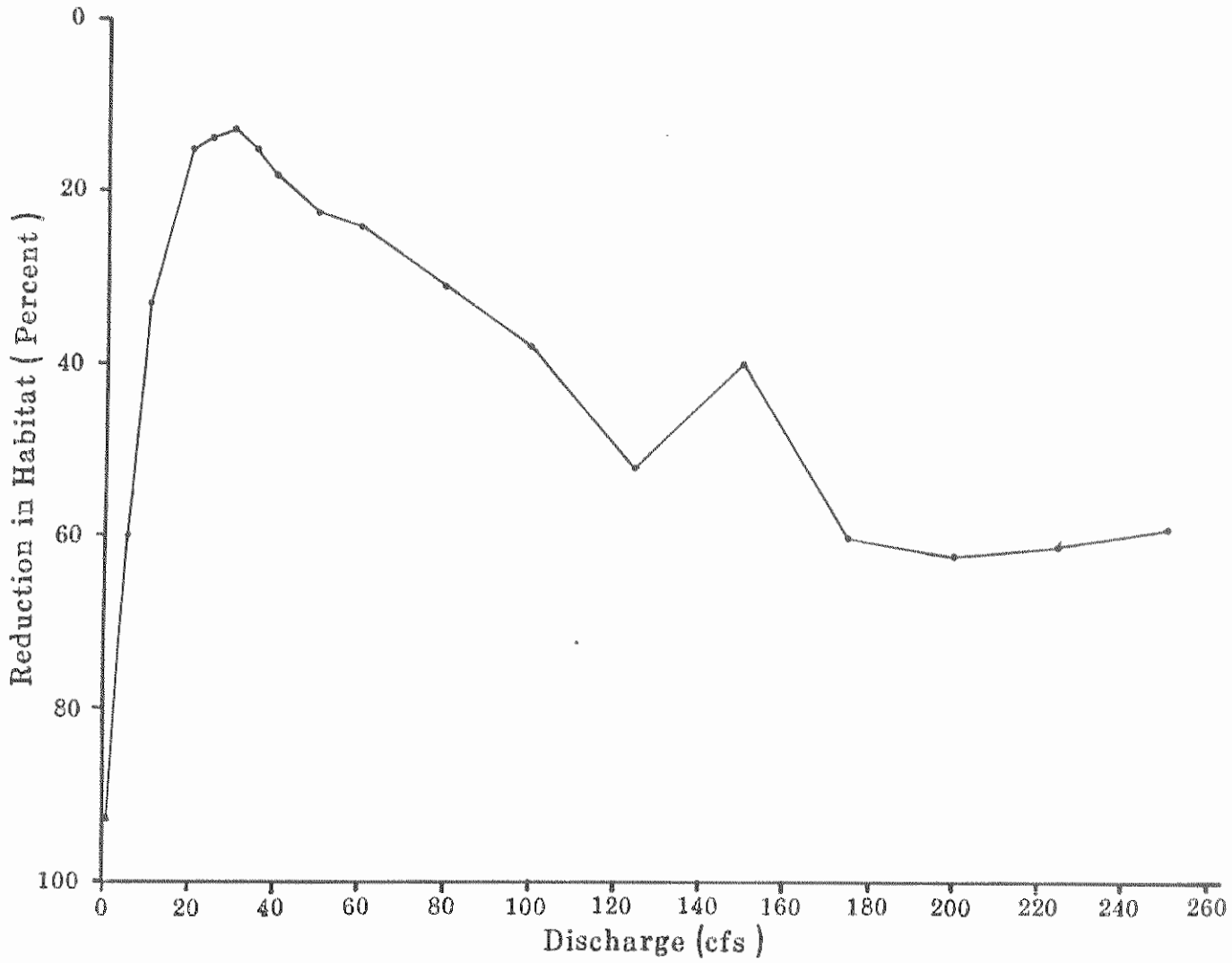

Figure 3. Results of habitat modeling showing changes in physical habitat for adult, juvenile, and fry rainbow trout over a range of flows in the Middle Fork Powder downstream from the proposed dam site.

higher flows tend to enhance water temperatures for trout. Other studies indicated that flows up to 75 cfs will provide fishery gains. Gradually diminishing fishery benefits will result at flows above 75 cfs up to 100 cfs. As a consequence, we recommend that summer flows not exceed 100 cfs. A range of preferred instream flows of between 33 and 100 cfs will provide suitable physical habitat for trout; however, the single preferred flow of 75 cfs is based on an analysis of HU gains and losses under various reservoir release rates. This analysis is presented in the following section.

Habitat Units

Results from HQI analyses show that the segment of the Middle Fork between the mouth of Beaver Creek and the mouth of the Red Fork supports 8.7 HU's per acre (Table 8). The segment of the Middle Fork upstream from the mouth of Beaver Creek to the MHWL presently supports 52.3 stream HU's per acre based on an average of the HQI analysis at M3 and measured standing crop at M2. Studies also showed that the portion of Beaver Creek downstream from the falls presently supports about 15.5 HU's of trout per acre and the segment upstream from the falls supports 122.7 HU's per acre.

Table 8. Summary of the number of HU's in potentially impacted portions of Beaver Creek and the Middle Fork Powder River at present and after completion of the project.

Study Site[a]	Existing Habitat Units/Acre	Habitat Units/Acre after completion of project 40 cfs	75 cfs	100 cfs
M1	8.7	52.5	65.7	61.9
M2	23.4[b]	0	0	0
M3	81.2	0	0	0
B1	15.5[b]	0	0	0
B2	122.7[b]			

a - See Figure 1
b - Based on measured trout population density

After completion of the proposed reservoir, water quality and temperature characteristics will change in the river below the dam. These changes were estimated and substituted into the HQI model (Table 8). The total potential impact of the project on the stream fishery in the Middle Fork was determined by calculating the area of each potentially impacted stream segment over a range of flows (where appropriate) and multiplying it times the number of stream HU's found there. The number of HU's in the Middle Fork upstream from the mouth of Beaver Creek were determined by averaging results in Table 5 for M2 and M3. Table 9 contains a summary of these analyses.

Table 9. Summary of existing stream habitat units (HU) and projected HU's which may result from various releases from a reservoir on the Middle Fork Powder River.

	Stream Segment				
	a	b	c	d	Net Impact
Existing Flow	+128.2	+192.4	+883.9	+420.4	
Projected 5 cfs	+ 57.9	-192.4	-883.9	-420.4	-1,567.0
Projected 10 cfs	+139.6	-192.4	-883.9	-420.4	-1,485.3
Projected 20 cfs	+326.4	-192.4	-883.9	-420.4	-1,298.5
Projected 40 cfs	+773.2	-192.4	-883.9	-420.4	- 851.7
Projected 50 cfs	+957.2	-192.4	-883.9	-420.4	- 667.7
Projected 60 cfs	+1,058.0	-192.4	-883.9	-420.4	- 566.9
Projected 75 cfs	+1,193.1	-192.4	-883.9	-420.4	- 431.8
Projected 100 cfs	+1,154.4	-192.4	-883.9	-420.4	- 470.5

a - Middle Fork from mouth of Red Fork to dam site
b - Middle Fork from dam site to mouth of Beaver Creek
c - Middle Fork from mouth of Beaver Creek to maximum high water line of reservoir
d - Beaver Creek

These figures show that under existing conditions, the potentially impacted portions of the Middle Fork and Beaver Creek provide 1,624.8 stream habitat units. The majority of these HU's are found between the MHWL and the mouth of Beaver Creek.

Preliminary WDC estimates of reservoir release rates imply that critical period releases could be as low as 5 cfs if industrial water is piped from the

dam. Information in Table F9 shows that this would result in more than a 95% reduction in total stream HU's. Increased releases will result in increases in HU's in the stream segment between the proposed dam site and the Red Fork if adequate releases are also made for fisheries at all other times of the year. Habitat unit losses are minimized at 75 cfs; however, the net impact of the project still shows a loss of over 25 percent of existing stream HU's. Mean monthly releases both higher and lower than 75 cfs would result in greater negative impacts. On this basis, we recommend releases of 75 cfs from July 1 to September 30 (Table 7) to partially mitigate stream HU losses caused by the impoundment of the river. Additional fishery mitigation alternatives are presented later in this report to more fully mitigate (and/or enhance) stream fishery losses.

Minimum Pool and Reservoir Fishery Analysis

A preliminary minimum pool estimate was made for this proposed reservoir and presented to WDC in 1982. Our estimate at that time called for a minimum pool of 12,900 acre-feet (25.8% of capacity) based on morphology of the reservoir basin, depth constraints, and projected sedimentation rates (Table 10). This recommendation is still valid for the reservoir according to its present design. The size of the recommended minimum pool would remain the same if the storage capacity of the reservoir were enlarged unless the enlargement was based on storage of diverted Red Fork water. Diversion of Red Fork water to the proposed Middle Fork Reservoir could substantially increase projected sedimentation rates in the reservoir which would necessitate a larger minimum pool than the one recommended in this report.

Table 10. Minimum pool recommendation and fishery analysis for the proposed Middle Fork Reservoir.

Contour Elevation	Area (Acres)	Capacity (Ac-ft)	Percent Capacity	Projected Trout Standing Crop (lbs./acre)
4,966'	491	12,900	25.8	88.4

Analyses of the potential fishery in the reservoir show that the reservoir will support approximately 88.4 pounds of fish per acre. This density of trout is relatively high for reservoirs of this size in Wyoming. The effect of minimum pool size on the relative productivity of trout (MEI * Area) is shown in Figure 4. This figure was not used to help determine the minimum pool size but it does show the general anticipated relationship between minimum pool size and the relative density of trout in the proposed reservoir. It does not address the effect of pool size on dissolved oxygen concentration, temperature, or other environmental variables on reservoir trout populations. Reductions in minimum pool size will generally result in less productivity while higher minimum pools will increase the productivity of the reservoir.

Estimates of the amount of fisherman use the reservoir will receive were based on fishing pressure survey results for other similar reservoirs in this part of the state. These estimates show that the reservoir will receive about 7,260 days of fisherman use per year if an adequate minimum pool and public access are provided.

Rare Fish

Sturgeon Chub

The following was excerpted from Stewart (1981):

"In 1979, the biology and distribution of the sturgeon chub, Hybopsis gelida (Girard), in Wyoming was investigated in order to gain information on life history, growth rates and the effect of habitat changes on population dynamics.

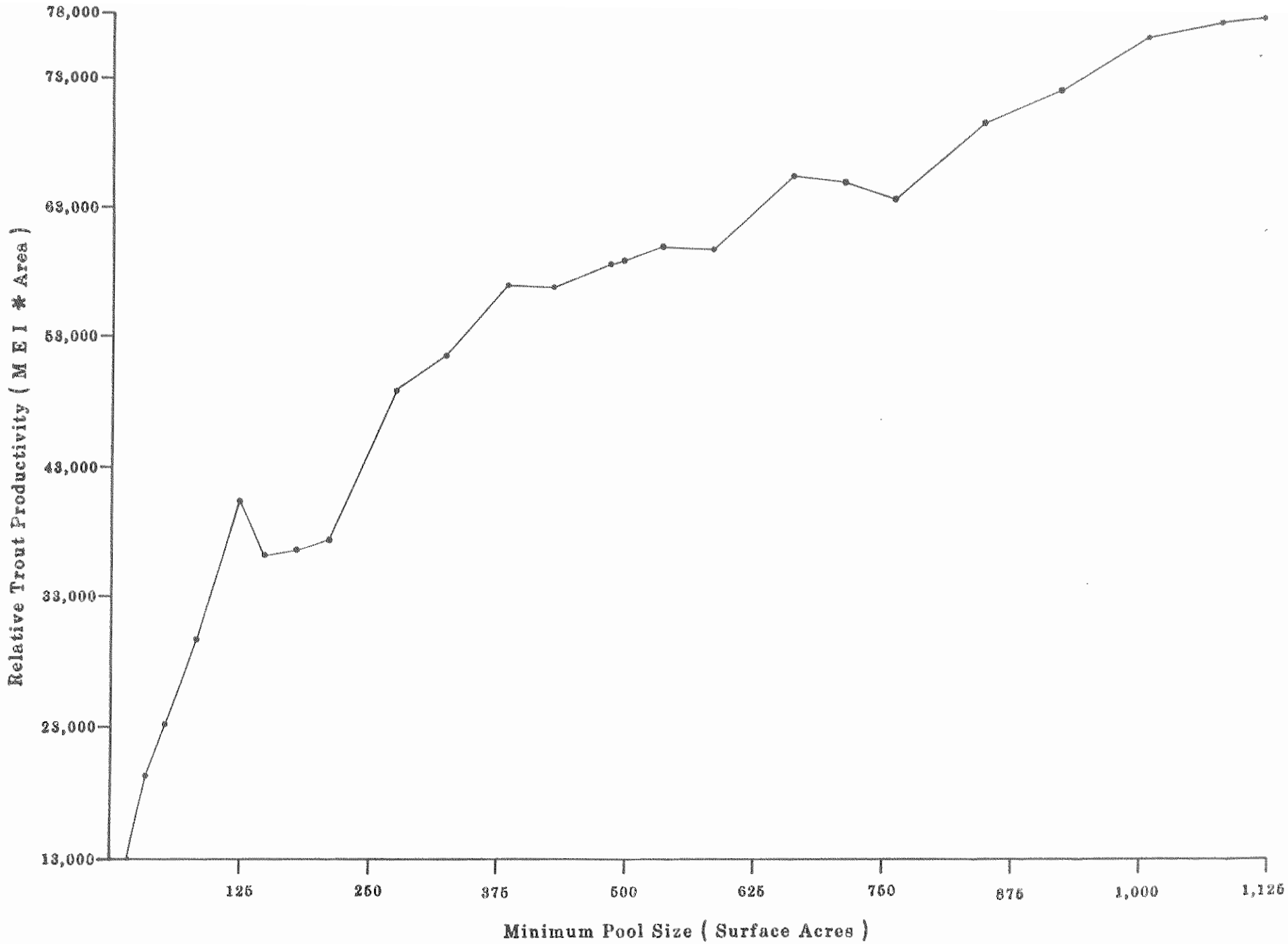

Figure 4. The relationship between minimum pool size (surface acres) and relative trout density (pounds).

Originally native to the Missouri River drainage, the range of this minnow has been reduced in recent years due to habitat destruction. In Wyoming it now appears to be restricted to the Powder and Bighorn Rivers. Populations are apparently still present in Illinois, Missouri, Iowa, Kansas, Nebraska, South Dakota, North Dakota, Montana and Louisiana. A member of the second largest minnow genus in North America, Hybopsis gelida is characterized by a highly developed cutaneous sensory system and exhibits morphological characteristics suitable for life in fast, highly turbid rivers.

Studies revealing the remarkable cutaneous sense system and several other morphological as well as physiological structures have been made by several investigators. It appears the extensive taste bud system, pustulose gular region, unique epidermal keeled scales and other characteristics possessed by the sturgeon chub restricted it quite rigidly to shallow, turbid riffles in rivers.

No sturgeon chubs were collected in any tributaries to the Powder River and it was found that this minnow ranges no further upstream than the confluence of Salt Creek with the Powder River. Above this point, approximately 25.7 km east of Kaycee, Wyoming, turbidity decreases significantly and the sturgeon chub is no longer present. Preferred habitat consists of highly turbid water and rock, riffle zones with an average depth of 22.9 cm and an average velocity of 1.83 fps (0.55 mps).

Seven fish species were found in association with the sturgeon chub. The longnose dace appears to inhabit the same niche as the sturgeon chub. The flathead chub, which is found in great abundance in the Powder River, lives on the edges of the preferred habitat of the sturgeon chub. This species appears to be the only potential predator but there is no evidence that it habitually preys upon on the sturgeon chub. Total numbers of sturgeon chubs in the Powder River were generally low in comparison to other fish present, but when optimum habitat is available, sturgeon chubs are usually present. There is no evidence that, at present, this species has been reduced to dangerously low population levels.

Aging fish by length is difficult due to high variability in lengths at each age class. It appears that the female sturgeon chub reaches sexual maturity at age II. A single fish whose age was assessed from scale markings was assessed at age IV, suggesting that few fish survive beyond four years.

The sturgeon chub is an insectivorous minnow feeding on the small invertebrates that live on the rocky substrate in riffle zones. It begins spawning in early June and the principle spawning activity is during July and apparently all the eggs produced in the ovary during this period are shed. Behavioral observations revealed habits similar to other bottom-dwelling, carnivorous minnows. The sturgeon chub positions itself in the rubble substrate such that it minimized the current effects and will swim on its side to feed along the substrate. When removed from its native habitat and placed in an aquarium, it appears to lose its equilibrium and becomes highly stressed."

Shovelnose Sturgeon

Field studies were conducted during June of 1983 and were expanded in 1984. Sampling was begun in early May of 1984 and continued through the first week of July. Sampling was concentrated at the mouth of Crazy Woman Creek and Clear Creek primarily to refine capture techniques, determine the relative abundance of sturgeon, and develop a general idea of sturgeon movement patterns.

Seven sturgeon were captured in 1983 and six of these were captured in Crazy Woman Creek (Table 11). Sixty-four sturgeon were captured in 1984 with the majority of the fish being collected during the last two weeks of June. No statistically significant difference in size was found between the two years. Sixty-two of the fish captured in 1984 were tagged with numbered Monel strap tags. Recapturing these fish will provide important information regarding parts of the fish's life history in the Powder River system.

It appears that these fish are moving to spawning areas as all fish captured were sexually mature and several males and females were "ripe." Sturgeon have been reported to spawn during this period in other parts of the country although specific details of their spawning habits are unknown. Sturgeon movements into Crazy Woman Creek appeared to be related to changes in water temperature. Very few fish were captured before maximum daily water temperatures reached 60°F or after maximum daily water temperatures exceeded 70°F. This pattern is similar to what was observed by Elser et al. (1977) for shovelnose sturgeon in the Tongue River, Montana. Although temperature appears to be one environmental variable affecting sturgeon movements, other factors may also be important.

Table 11. Summary of shovelnose sturgeon capture data from 1983 and 1984.

	1983	1984
Number Captured	7	64
Mean Fork Length (in)	30.14± 1.86	28.55± 0.70
Range (in)	33.0 -28.0	34.9 - 23.2
Mean weight (lbs)	2.87± 0.77	3.66± 0.31

Relatively little information regarding potential impacts of reservoir construction on sturgeon was found in the literature. A study by Moos (1978) indicated that sturgeon moved upstream in the Missouri River to Gavins Point dam during their spawning season (early summer). Spawning activity was not documented in that study and no young sturgeon or sturgeon eggs were collected. River habitat below Gavins Point dam consists mostly of shifting sands similar to habitat in the mainstem Powder River. Since he collected no evidence of successful sturgeon reproduction, Moos hypothesized that this type of habitat may be unsuitable for sturgeon spawning.

A study by June (1977) in Oahe Reservoir on the Missouri River found that adult shovelnose sturgeon could survive in portions of that reservoir, but that these fish were unable to spawn successfully. Over a period of time, these fish will no longer occur in that reservoir because of natural mortality and a lack of recruitment.

A report published by the American Fisheries Society (Anonymous 1982) found that the monetary value of shovelnose sturgeon is $1.00 per inch for fish under 30.0 inches long and $57.00 per pound for fish over 30.0 inches long. The monetary value concept presented in that report was based on the premises that: "1) fish are resources and have tangible values to the public and the aquatic ecosystem; 2) when fish are destroyed and blame can be documented, compensation

to the public agency responsible for management is required, and 3) hatchery production costs provide the most reasonable source of fish value information." Based on this system alone, the potential value of shovelnose sturgeon in the Powder River system in Wyoming is substantial.

Goldeye

Adult goldeye were relatively common in Clear Creek in both field seasons and seemed generally less abundant in Crazy Woman Creek (Table 12). No statistically significant difference in size was found between years or sampling areas.

Table 12. Summary of goldeye capture data from 1983 and 1984.

	Crazy Woman Creek		Clear Creek	
	1983	1984	1983	1984
Number captured	4	22	19	29
Mean length (in)	12.78±0.62	12.7±0.45	12.28±0.52	12.23±0.58
Mean weight (lbs)	0.44±0.18	0.53±0.06		0.45±0.04

No goldeye smaller than eight inches long was found at either site and no young fish have been captured anywhere in the state by WGF biologists. As a result, very little is known about their spawning habits.

Historically, goldeye were found in the North Platte, Bighorn, Powder and Little Missouri River drainages. Today there are found only in the latter two of these drainages (Baxter and Simon 1970). In the Powder River, they occur as far upstream as the mouth of Salt Creek near Kaycee. Goldeye are found in both lakes and streams and can tolerate generally more turbid waters than their taxonomically close relative the mooneye (which is not found in Wyoming). In new reservoirs they tend to inhabit areas near the inflow where currents are still

detectable (Elrod and Hassler 1971). They are not routinely found in all new reservoirs where they become trapped as evidenced by the fact that goldeye are not found in any part of the North Platte River or mainstem reservoirs where they once existed.

In reservoirs where goldeye do become established, they often make extensive migrations upstream to spawn. Nelson (1980) documented spawning movements of over 100 miles upstream from Lake Oahe, South Dakota. Goldeye abundance in this Missouri River reservoir was closely related to the adequacy of stream flow into the reservoir as it related to the ability of goldeye to reach upstream spawning areas. Shelton (1970) also found that when lake-dwelling goldeye are prevented from ascending streams to spawn, their populations decline.

The American Fisheries Society has established the monetary value of goldeye as 63 cents per pound.

Terrestrial

Habitat

General Description

The proposed reservoir site lies in the foothills along the east slope of the Big Horn Mountains. Big sagebrush/grassland dominates the uplands. Stands of mountain mahogany occur along bluffs and canyon walls, and juniper dominates the high ridges rising toward the mountains. Rubber rabbitbrush, black greasewood and silver sagebrush occur along Beaver Creek and intermittent creeks where the moisture level is slightly higher than on slopes and ridges. Riparian vegetation including cottonwood, boxelder and willow is present along most of

the Middle Fork of Powder River and along stretches of the tributary streams, especially near the mountains. Sub-irrigated meadows, bottomland grasslands and agricultural lands occur on the floodplain of the Middle Fork. The croplands and some of the meadows are irrigated by the river water.

Reservoir Site Description

Habitat types which occur within the proposed reservoir include: riparian cottonwood, willow/boxelder maple, juniper, moist meadow, greasewood/rabbitbrush, grassland, sagebrush/grassland and mountain mahogany.

Assuming a normal high water line of 5,013 feet, the reservoir will inundate approximately 1,160 acres of land (Figure 5). The habitats inundated and their approximate acreage are shown in Table 13.

Table 13. Habitat types which will be inundated, the approximate acreage of each, and the relative abundance of the habitat.

HABITAT TYPE	ACRES INUNDATED	RELATIVE ABUNDANCE[2]
Big sagebrush/grassland	516	Abundant
Moist meadow grassland[1]	290	Rare
Riparian cottonwood	106	Rare
Juniper	80	Abundant
Grassland	67	Abundant
Willow/boxelder maple	44	Rare
Greasewood/rabbitbrush	36	Abundant
Mountain Mahogany	21	Rare
	1,160	

[1]includes irrigated meadows
2based on the acreage of each habitat in southern Johnson County

All of the habitat which will be lost has value to wildlife, and the value is not directly related to its abundance in the project area.

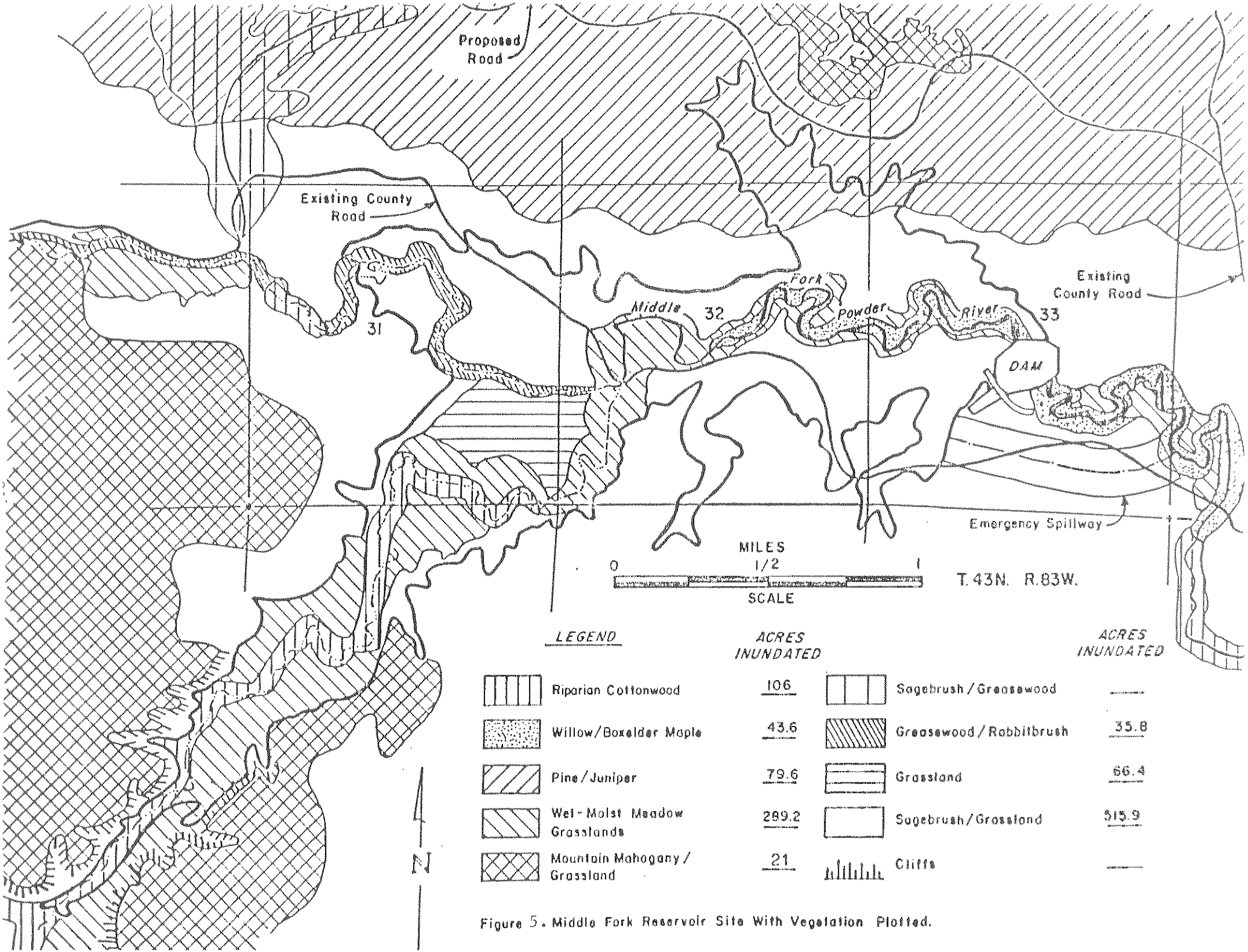

Figure 5. Middle Fork Reservoir Site With Vegetation Plotted.

Road Relocation Description

The proposed road traverses sagebrush/grassland, juniper with sagebrush understory and sagebrush/greasewood habitat types (Figure 5). Loss of at least 70 acres of habitat is anticipated.

Habitat Composition and Quality

Most of the habitat types listed in Table 13 are self descriptive and indicate the major plant species of importance to wildlife which occur in the type. Since plant species composition and habitat quality are important factors when discussing wildlife carrying capacity, a detailed description of the most important habitats and their relative quality follows.

Riparian

Riparian cottonwood stands in the upper end of the reservoir on land owned by the Bar C Ranch are lightly grazed as evidenced by the presence of low growing shrubs and cottonwood regrowth. Plant species present are shown in Table 14.

A randomly chosen sample site in this habitat had a cottonwood and willow canopy cover of approximately 80%, with less than 5% of the sample area bare ground which supported no tree, shrub or grass cover. Narrowleaf cottonwood snags are randomly distributed in the habitat type, and occurred at a rate of about .4 snags/acre (1 snag/Hectare) in the sample plot. A randomly selected browse intercept contained 11.5 feet (3.5 M) of willow intercept on a 328 foot (100 M) sample line.

Table 14. Plant species composition in cottonwood riparian habitat in good-excellent condition.[1]

	HEIGHT			
	% Under 20'	% Over 20'		% of Total
Trees:				
Narrowleaf Cottonwood	5%	95%		92%
Boxelder Maple	-	100%		1%
Willow spp.	-	100%		7%
	HEIGHT			
	0-3'	3-6	6+'	
Shrubs:				
Willow spp.	-	-	100%	99%
Gooseberry	-	100%	-	1'
Grasses and Forbs				
Smooth Brome				60%
Kentucky Bluegrass				30%
Downy Brome				5%
Other				5%

[1] sample area = 25 acres (10 hectares)

Riparian cottonwood stands along the Middle Fork on the Taylor and Johnson Ranches are heavily grazed. Although they contain similar trees, these stands are lower quality wildlife habitat. Canopy cover is less and cottonwood regrowth is very sparse. The shrub understory and diversity of grasses which provide cover for wildlife farther upstream are much less apparent. Most grassland is dominated by downy brome (cheatgrass), annual forbs and bare ground; especially downstream around the mouth of Beaver Creek. Trampling and bank erosion are very evident.

Willow/boxelder habitat in the lower segment of the reservoir is grazed and regrowth of willow and boxelder has been largely retarded. Herbaceous cover includes a few perennial species but is mostly annual forbs and grasses.

Shrub and tree cover is almost non-existent along Beaver Creek on the reservoir site. Greasewood and rabbitbrush growing next to the creek are heavily grazed by sheep and provide low quality wildlife cover.

Upland

Mountain mahogany stands on limestone outcrops and ridges along the upper part of the reservoir are in good condition and apparently escape heavy livestock grazing pressure because of their dry, somewhat remote location. Since this habitat is important mule deer winter range, vegetation sampling was done in detail. Plant species present are shown in Table 15.

Table 15. Plant species composition in mountain mahogany habitat in good condition.[1]

	HEIGHT			
	% Under 20'		% Over 20'	% of Total
Trees:				
Juniper	-		100%	100%
	HEIGHT			
	0-3'	3-6'	6+'	
Shrubs:				
Curlleaf Mt. Mahogany	50%	50%	-	96%
Silver Sagebrush	100%	-	-	2%
Skunkbrush Sumac	-	100%	-	2%
Big Sagebrush	-	100%	-	Trace
Grasses and Forbs:				
Needle and Thread Grass				50%
Indian Ricegrass				15%
Bluegrass spp.				10%
Other grasses				25%

[1] Sample area = 25 acres (10 hectares)

Shrub canopy covered approximately 40% of the sample plot and 27-50% of the site was bare limestone. All of the mountain mahogany stands shown in Figure 5 are in approximately the same range condition.

Big sagebrush, sagebrush/greasewood and juniper/sagebrush habitats on and near the reservoir site appear to have been degraded by heavy livestock grazing. The majority of upland habitat on the slopes and ridges is in good condition although it is grazed to some extent by both sheep and cattle.

Cliffs and steep canyon walls, mostly unvegetated, occur along both sides of the reservoir site (Figure 5). This habitat is unique along the Middle Fork since it is the only location where high canyon walls overlook a wide floodplain containing riparian vegetation and meadows. This combination creates high quality raptor and golden eagle nesting habitat.

Wildlife

General Description

The only big game on the reservoir site are mule deer and white-tailed deer. Game birds include chukar, turkey, hungarian (gray) partridge, mourning dove, pheasant and several species of waterfowl. Furbearers present include beaver, muskrat, mink, badger, bobcat and weasel. Cottontail rabbit and red squirrel are the only small game species which occur on the site. Numerous nongame birds and mammals, including the endangered bald eagle, use the area seasonally.

Species Description

All big game populations in Wyoming are managed by herd units and hunt areas. A herd unit is defined as a distinct population of a particular species which has recognizable boundaries on the range it occupies. This range, or occupied area, is further broken down into winter range, summer range, and yearlong range. Big game herds do not occupy all parts of their range in equal concentrations, but from the estimated population of the herd unit and the acreage of useable range, we calculated average densities. High value habitats and those classified as critical range and/or winter range have higher than

average concentrations of animals. Herd units are further broken down into hunt areas to allow manipulation of big game harvest to meet the management objectives for the herd unit.

The following species are present on the Middle Fork project area and will be impacted as described.

Mule Deer

The project is located in the Upper Powder River mule deer herd unit, hunt area 33. Habitat preferences are influenced by weather conditions, precipitation patterns, livestock grazing methods and hunting pressure. However, most of the mule deer in the vicinity of the reservoir site spend the summer, fall, and early winter on riparian areas or sagebrush and mountain mahogany covered slopes adjacent to the Middle Fork of Powder River. The average density of mule deer on summer range in this herd unit is 9.51 square mile (Wyoming Game and Fish Department 1983C). Approximately 5 square miles of summer range will be impacted by project development, so an estimated 50 mule deer will be displaced. Foods taken by deer on summer range include a number of succulent grasses and forbs which occur only along the river bottom. In late summer, these plants begin to dry up and mule deer increasingly begin to browse on shrubs on slopes adjacent to the river.

In winter, most of the mule deer in this herd move from the Middle Fork bottom and tributary creeks to brush and juniper covered slopes north and west of the proposed reservoir.

The average density of mule deer on winter range in this herd unit is 11.82/square mile (Wyoming Game and Fish Department 1983C), so this habitat is

of greater importance than summer range. Project development will impact approximately 3 square miles of winter range and affect not only deer which summer on the Middle Fork but also 50-100 which summer elsewhere but winter in shrub stands along the proposed new road (Wilson, personal communication).

From January-May mule deer are almost exclusively dependent upon browse including mountain mahogany, sagebrush and rabbitbrush. Winter is a high stress period and winter range where deer can feed undisturbed is important for survival.

White-tailed Deer

The project is located in the Powder River white-tailed deer herd unit, hunt area 33. White-tailed deer only inhabit riparian zones supporting tree and shrub growth. On the project area they are found along the Middle Fork only where food and cover are available (Figure 5), and inhabit approximately the same area yearlong. The average density of white-tailed deer in good habitat in this herd unit is 13.5/square mile (Wyoming Game and Fish Department 1983C). This estimate is based on deer/square mile and is valid even though whitetails may inhabit only a small segment, i.e., the riparian zone, in a given section of land. Approximately 4 square miles of moderate to low quality yearlong range will be impacted by project development, so habitat for an estimated 45 white-tailed deer will be permanently eliminated.

Small Game and Game Birds

All small game and game birds in Wyoming are managed by management area. Populations show wide fluctuation in distribution and size between years.

Management objectives are based on harvest by species by management area rather than densities.

Harvest information for each species was taken from the annual report of upland game and furbearer harvest (Wyoming Game and Fish Department, 1983A), and is an indication of relative species abundance in the Management Area 37.

Chuckar Partridge

An estimated 406 hunter days were spent harvesting 482 birds in management area 37 in 1983. Chukar are occasionally found on the reservoir site, but are known to move long distances in a very short period of time.

Chukars concentrate along the river bottom where they feed on alfalfa leaves, Russian olive berries, small grains and weed seeds during the season of availability.

Gray (Hungarian) Partridge

There was no reported harvest of gray partridge in management area 37 in 1982. Gray partridge are found on the project area in small numbers and utilize the seeds of a number of small grains and bottomland weed species.

Mourning Dove

An estimated 130 hunter days were spent harvesting 749 birds in management area 37 in 1983. Doves inhabit riparian areas, nearby small grain fields, juniper stands and, to a lesser extent, sagebrush grasslands. They are present on the project area from May to September, nesting in low growing trees and shrubs along the Middle Fork River and juniper trees at higher elevations.

Censuses conducted in 1983 indicated 2 nesting territories per 25 acres (10 hectares) in cottonwood habitat. When this figure is extrapolated to include the 106 acres of cottonwood habitat which will be inundated, it shows a loss of 4.24 nest territories. Mourning doves normally nest 2-5 times during the summer season. Since the census period only encompassed one nest cycle, a total of at least 12.72 nests, each producing an average of 2 birds (assuming 100% nest success), or a minimum of 25 young birds and 8 adult birds will be permanently displaced by habitat loss.

Censuses conducted in boxelder maple habitat in 1984 indicated 4 nesting territories per 25 acres (10 hectares). When this figure is extrapolated to include the 44 acres of boxelder habitat which will be inundated, it shows a loss of 7.04 nest territories. Multiplying 7.04 territories times 3 nest attempts per year indicates a loss of approximately 21.12 nests each producing an average of 2 birds (assuming 100% nest success), or a minimum of 42 young birds and 14 adult birds permanently displaced by habitat loss.

Nest densities in juniper habitat are unknown, but since this habitat is abundant in the project area, adequate unused nesting areas may be available to accomodate birds displaced by inundation of juniper habitat.

Based on census data, habitat loss on the project area due to inundation will eliminate habitat for a minimum of 90 mourning doves.

Turkey

An estimated 42 hunter days were spent harvesting 28 turkeys in the spring of 1983 in Management Area 7 (Kaycee). There was no fall hunting season in

1983. Turkeys inhabit riparian areas and meadows adjacent to the Middle Fork River in the project area and range freely up and down the river. Based on landowner estimates and field observations, approximately 5-10 turkeys inhabit the cottonwood stands in the segment of the reservoir above the Taylor Ranch headquarters during the spring and summer. A flock of about 30 turkeys ranges between the Middle Fork Canyon above the project area and the Harlan Ranch just below the proposed reservoir. Most, if not all, of this flock winters along the Middle Fork River on or below the Harlan Ranch.

Pheasant

Pheasant numbers are very low in the project area although put-and-take hunting on the Bar C Ranch results in annual stocking. Habitat is not present to sustain a huntable pheasant population from year to year, so project development impact on pheasant habitat will not be significant.

Waterfowl

Common merganser, mallard, teal, wigeon, gadwall, pintail and shoveller use the Middle Fork River and Beaver Creek during migration and nesting season. Mallards are the most common nesting species. There are no oxbows or marshes adjacent to the streams so the fast flowing riverine habitat is the only habitat type which will be lost by inundation. The average duck breeding pair density in the breeding ground survey area in the southern Johnson-northern Niobrara County area is 2.70 pairs/square mile (Saul 1983). The reservoir site is less desirable duck habitat and probably has a small density. Ducks inhabit only streams and ponds within the area but density information is based on square miles of sample area. The proposed reservoir will impact 5 square miles of free

flowing stream and eliminate habitat which supports 5-14 nesting pairs of ducks. With an average clutch size of 10 eggs and nest success of 30%, an estimated 15-42 ducklings are currently produced on the reservoir site. Ducks also use the streams during the fall and early winter because warm springs retain open water in the upper end of the reservoir site.

Canada geese currently make little if any use of the Middle Fork River or Beaver Creek on the reservoir site.

Furbearers

Beaver, mink, and bobcat are the legally classified furbearers most common on the reservoir site. Predators including coyote, raccoon, red fox, and skunk are also regularly taken for their furs. Population estimates are based on harvest information.

Small Game

Cottontail rabbits are moderately abundant over the project area, and red squirrels inhabit higher elevations where conifer trees are present. Population estimates are based on harvest information.

Nongame

Birds - One hundred sixty-seven (167) bird species could potentially occur in the project area based on their general distribution in Wyoming. A number of these require specialized habitats not currently found on the reservoir site. Appendix C lists 82 species which are known to inhabit the proposed reservoir site. Most census work was conducted during the breeding season in May and

June, so some winter residents and birds using the area for short periods during spring and fall migration may not appear on the list. At most, an additional 10-20 species may use the area.

Appendix D lists the bird species observed on censuses conducted during the breeding season in June of 1983 and 1984. A few species known to occur in these habitats were not seen on censuses. These species probably occur at a very low density and/or are difficult to observe on walking census routes.

Density calculations could be made for each species observed on censuses, but for the purposes of this report an overall bird density is given for each habitat. This density is based on the mean number of birds observed during two census in June. Two censuses may yield only 70% of the total species present, but will probably include at least 90% of the total birds present. The average bird density in the habitats sampled was as follows: boxelder maple - 2.37 birds/acre (5.85 birds/Hectare); riparian cottonwood - 2.53 birds/acre (6.25 birds/Hectare); big sagebrush - 0.87 birds/acre (2.15 birds/Hectare); mountain mahogany - 0.36 birds/acre (0.90 birds/Hectare); and Juniper - 1.60 birds/acre (3.95 birds/Hectare).

Based on average densities, direct habitat loss by inundation will eliminate habitat supporting species numbers shown in Table 16.

The numbers presented are considered a minimum since some species may not be included in density calculations, many birds are not counted in censuses, and due to recruitment of young, bird populations in late summer are considerably higher than in the spring when censuses were conducted.

Table 16. Minimum number of birds which will be lost by inundation of the habitats listed.

HABITAT TYPE	ACREAGE LOST	DENSITY-BIRDS/ACRE	MINIMUM NUMBER OF BIRDS LOST
Riparian cottonwood	106	2.53	268
Boxelder maple	44	2.37	104
Big sagebrush	516	0.87	449
Mountain mahogany	21	0.36	8
Juniper	80	1.60	128
Grassland	357	0.50[1]	179
Rabbitbrush	36	1.00[1]	36
	1,160		1,172

[1] Estimated density

Raptors are of high interest to the U.S. Fish and Wildlife Service and Game and Fish Department, so a raptor nest survey was conducted on the project are in May, 1984. The results of the survey are presented in Table 17.

Table 17. Raptor nests and nest territories on the proposed reservoir site in May, 1984.

SPECIES	NESTING HABITAT	NEST STATUS[1]
Golden Eagle	Cliff	O
Unknown Raptor*	Cliff	UO
American Kestrel	Cliff	O
Unknown Raptor*	Cliff	UO
Red-tailed Hawk	Cottonwood Tree	O
Red-tailed Hawk	Cottonwood Tree	O
American Kestrel	Cliff	O

* Evidence of recent nest effort. May have hatched before the nesting survey was conducted.

[1] O = occupied nest at time of census
UO = unoccupied nest at time of census

As shown, at least three species of raptors make use of the reservoir site and adjacent cliffs during the nesting season. Great horned owls also nest in the area and may have used the cliff nests which were unoccupied in May. The height above the river bottom was estimated for all cliff nests. Since cliffs occur only in the upper segment of the reservoir site where the water will be reasonably shallow, inundation of the nests located in 1984 would not occur. Some nests may occur lower on the cliff wall, but most of this habitat should

remain available. The red-tailed hawk nests located in cottonwood trees will be lost by removal of the trees and the hawks will be forced to nest elsewhere if suitable unoccupied nesting territory can be found.

Small Mammals - The ten (10) small nongame mammals documented on the reservoir site are shown in Table 18.

Table 18. Small nongame mammals documented on the reservoir site in 1983 and 1984.

White-tailed Jackrabbit	Gapper's Red-backed Vole
Least Chipmunk	Yellow-bellied Marmot
Wyoming Ground Squirrel	Thirteen-lined Ground Squirrel
Black-tailed Prairie Dog	Northern Grasshopper Mouse
Deer Mouse	Porcupine

Density and distribution information was not collected for small mammal species. A black-tailed prairie dog town of approximately 80 acres in the SE¼, Section 31, T43N, R83W was mapped since the potential exists for occurrence of the endangered black-footed ferret.

Endangered Species

Bald eagles inhabit the project area from November to March, utilizing cottonwood trees along the river for roosting, and the Middle Fork River and adjacent uplands for foraging habitat. The primary bald eagle roosting area is in Section 14, T42N, R84W where 5-14 eagles are counted annually; but eagles occasionally roost downriver throughout the reservoir site and possibly below it. An alternate roost site within the proposed reservoir in the SE¼, SE¼, Section 1, T42N, R84W has been reported but is unconfirmed at the time of this writing. If this roost site is confirmed, the USFWS will consider reservoir construction to have a major impact on bald eagles and formal consultation under the

Endangered Species Act will be necessary (Taylor, personal communication). Bald eagles roosting on the Middle Fork River in the vicinity of the reservoir site may also be impacted by dewatering of the river and riparian habitat degradation below the reservoir. Impacts will include loss of roosting habitat and reduction of the fish and waterfowl prey base unless adequate instream flows are maintained.

Since a black-tailed prairie dog town of approximately 80 acres occurs on the reservoir site, black-footed ferrets could potentially be present. Searches have not been conducted at the time of this writing but will be required by the USFWS prior to issuance of a federal permit to construct the reservoir.

Peregrine falcons occasionally migrate through the vicinity, but project development should not impact this species. No other endangered species are known to occur in the project area.

Summary of Game Animal Use

A summary of the use of the reservoir site by game animals with and without the proposed reservoir is shown on Table 19.

Animal days use before and after construction are not directly comparable, therefore summation of days/use is not possible. Most of the terrestrial wildlife on the reservoir site will be eliminated by the project, however, the migratory waterfowl population in Wyoming will not be increased by the project. Ducks and geese currently passing over the Middle Fork River in migration will make use of the new reservoir, but there will be no actual increase in the wildlife resources of Wyoming. Enhancement opportunities for waterfowl nesting,

which will benefit both ducks and geese and increase waterfowl numbers in the state, are discussed later on in this report.

Table 19. Current use and estimated post-construction use of the proposed reservoir site by game animals.*

SPECIES	NUMBER OF ANIMALS	DAYS OF USE/YEAR	ANIMAL DAYS USE/YEAR WITHOUT RESERVOIR	ANIMAL DAYS USE/YEAR WITH RESERVOIR
Mule Deer	50	210	10,500	0
White-tailed Deer	45	365	16,425	0
Chukar	20	30	600	600
Gray Partridge	20	180	3,600	1,300
Mourning Dove	90	135	12,150	1,215
Turkey	30	180	5,400	0
Pheasant	20	365	7,300	0
Ducks[1]	35	270	7,200	-
Ducks[2]	50,000-spring	15	-	750,000
	7,500-fall	45	-	337,500
Canada Goose[1]	0	0	0	-
Canada Goose[2]	5,000-spring	15	-	75,000
	250-fall	45	-	11,250

[1] Current Use.

[2] Estimated post-construction use (Saul, personal communication).

* Assumes no habitat development or improvement.

Public Use

Hunting

Mule deer, white-tailed deer, turkey, chukar, cottontail rabbit, pheasant, mourning dove, and ducks are hunted on and adjacent to the reservoir site. The estimated hunter days spent per year in pursuit of each species and the estimated annual harvest are shown in Table 20.

Table 20. Estimated hunter days use/year and annual harvest on the reservoir site and adjacent public lands. (Talbott, personal communication).

	GAME SPECIES	HUNTER DAYS USE/YEAR	ESTIMATED ANNUAL HARVEST*
Reservoir Site:	Mule deer	80	24
	White-tailed deer	20	3
	Pheasant	10	9
	Rabbit	20	70
	Ducks	10	18
	Mourning Dove	5	16
	Turkey	5	2
		150	
BLM Land, North of Reservoir Site:	Mule Deer	100	30
	Rabbit	10	35
		110	
BLM Land, South of Reservoir Site:	Mule Deer	20	6
	Chukar	10	12
		30	
State Section & BLM Land West of Reservoir Site:	Mule Deer	150	45
	Chukar	10	12
	Rabbit	25	88
		185	

* Based on the average harvest/hunter day in Hunt Area 33 (big game) and Management Area 37 (game birds and small game).

Trapping

Beaver, bobcat and red fox are the primary species trapped on and adjacent to the reservoir site. Mink, muskrat and coyote are taken occasionally. The estimated trapper days spent per year and estimated annual harvest are shown in Table 21.

Table 21. Estimated average trapper days use/year and annual harvest on the reservoir site and adjacent public lands (Talbott, personal communication).

	FURBEARER SPECIES	TRAPPER DAYS USE/YEAR	ESTIMATED ANNUAL HARVEST
Reservoir Site:	Beaver		50
	Mink	60	5
	Muskrat		5
Public Lands	Bobcat		10
	Red Fox	45	20
	Coyote		2
		105	

Summary of Current Public Use

Reservoir construction will eliminate habitat which annually provides approximately 150 hunter days use and 60 trapper days use. In addition, non-residents hunting mule deer on adjacent public and private lands may be limited by loss of access to the south side of the reservoir.

Utilization of mule deer and furbearer species is currently at the optimum level; however, additional harvest potential exists for white-tailed deer, turkey, cottontail rabbit and mourning dove. The effort expended by local trappers is dependent upon fur prices and during years of high prices, the trapper days use and harvest may be much higher than the average figure shown in Table 21.

Public Use Potential

Reservoir development will not result in any appreciable increase in public hunting opportunity except in the case of waterfowl. The proposed reservoir could potentially attract several thousand ducks and Canada geese, which would

draw hunters into the area. Reservoir fluctuation rate and water level management will affect the number of ducks and Canada geese which use the reservoir, and therefore the amount of hunting which takes place. With adequate water levels between October 1 and January 15, an estimated 600 hunter days for ducks and 300 hunters days for Canada geese could be realized (Saul, personal communication.)

Potential Impact on Terrestrial Resources

Mule Deer

Reservoir construction will eliminate approximately 543 acres of mule deer summer range which supports an estimated 50 deer. These deer will be displaced when the reservoir is flooded, and since adjacent habitat is already used to capacity mule deer numbers will be reduced and public hunting opportunity will be diminished.

Relocation of the county road as shown in Figure 6 will result in loss of at least 70 acres of mule deer winter range, and this coupled with disturbance of deer in this currently inaccessible area will impact an estimated 100 mule deer. This winter range is important to deer summering along the Middle Fork River and Red Fork and will compound losses created by reservoir construction.

White-tailed Deer

Reservoir construction will eliminate approximately 440 acres of habitat utilized yearlong by white-tailed deer. Riparian vegetation, including cottonwood and boxelder maple stands and bottomland grasslands near the Middle Fork

River, is the only habitat used by white-tailed deer. An estimated 45 white-tails will be permanently displaced by flooding, and adjacent suitable habitat cannot sustain additional deer use under current ranch management systems, so total numbers will decline. Public hunting opportunity will be diminished by an estimated 20 hunter days/year.

Game Birds

Reservoir construction will not impact the small chukar and Hungarian partridge populations on the reservoir site since these birds use the site only occasionally. Current heavy livestock grazing on the project area does not favor pheasant habitat maintenance, so the pheasant population is small and scattered, and although the project will eliminate all pheasant habitat on the reservoir site, the loss will not be great. Public hunting opportunity will be diminished by an estimated 10 hunter days per year.

Project development will eliminate approximately 1,160 acres of habitat used by mourning doves, since they use all habitats on the project area to some extent. Riparian cottonwood and boxelder zones are especially important for nesting, and an estimated 90+ resident doves and an unknown number of seasonal migrants will be displaced by inundation. The mourning dove population in the management area will be reduced and public hunting opportunity diminished by an estimated 5 hunter days/year.

Construction of the reservoir will eliminate approximately 150 acres of riparian cottonwood habitat used at least occasionally by turkeys, and will disrupt seasonal movements up and down the Middle Fork River between summer use areas and winter concentration areas. Turkeys which winter on the Harlan Ranch

below the reservoir site and range upriver to the mouth of the canyon during the summer will be displaced by inundation and probably forced into habitat downriver from the reservoir. Since all available habitat is now occupied by turkeys, some loss of turkeys will probably occur and public hunting opportunity will be diminished by an estimated 5 hunter days/year.

Waterfowl use of the Middle Fork River and Beaver Creek in the project area is very light. Project construction will remove the riverine habitat currently used by waterfowl, and public hunting opportunity will be diminished by an estimated 10 hunter days per year. The new reservoir could more than offset this loss.

Furbearers and Small Game

Most aquatic furbearers which currently use the reservoir site will be eliminated by project development since a widely fluctuating reservoir is of marginal value. All upland furbearers and cottontail rabbits will be displaced and although some individuals may be absorbed into existing populations, at least some population reduction will take place. Public recreation in the form of hunting and trapping will be reduced by an estimated 80 hunter days/year.

Nongame

All habitat on the reservoir site is occupied by both nongame birds and mammals. Some habitat types support greater animal densities than others, but all 1,160 acres which will be inundated have some value. Riparian habitat, which supports the highest density of nongame birds of all the habitat types on the reservoir site, is also the rarest in the project area and in Johnson

County. Approximately 150 acres of this habitat will be eliminated by inundation. Reservoir construction will reduce the bird population in the area since adjacent habitats are already occupied and cannot absorb new immigrants.

Red-tailed hawks, American kestrels and possibly other raptor species which nest in cottonwood trees on the reservoir site will be forced elsewhere by the project, and may not find suitable nesting territories because of competition. The golden eagle nest on the east face of Castle Rock should not be directly impacted by construction of the 50,000 acre foot reservoir which is proposed. However, the eagles probably hunt on the reservoir site and if construction activity or public use takes place within ½ mile of the nest between February 15 and July 15, abandonment is possible.

Endangered Species

The bald eagle winter roost upriver from the reservoir site will not be directly impacted by construction. However, removal of cottonwood trees at the alternate roost site in Section 1 and in the upper end of the reservoir site will reduce available roosting habitat significantly and make the remaining habitat between the upper end of the reservoir and the mouth of the Middle Fork Canyon very important. Any human activity above the current level in this area between November 15 and March 1 may disturb bald eagles and cause them to move to less desirable wintering areas, possibly resulting in mortality.

Bald eagles forage on the Middle Fork River below the proposed reservoir and at least one roost may be present. Severe dewatering of the river, lowering of the ground water level and channel deterioration may impact eagles by causing long-term riparian habitat degradation and reduction of the fish and waterfowl population, which serves as part of the prey base.

The prairie dog town which will be inundated could provide habitat for the black-footed ferret. The town will be monitored for ferret sign during the winter of 1984.

Other Impacts

Reservoir construction may have significant effects on downstream riparian vegetation at least as far as the confluence with the Red Fork. According to U.S. Fish and Wildlife hydrology studies, reservoir construction will result in a deeper, narrower channel and lowered ground water table between the reservoir and the Red Fork, a distance of approximately 4 miles. This will result in a narrow, less diverse riparian zone and reduce the use of this stretch of the river by waterfowl, fish, aquatic furbearers, and nongame birds and mammals. The reservoir will also limit periodic high water flows which scour the channel and carry nutrients and sediment which nourish the riparian zone and contribute to tree and shrub regeneration. Degradation of the riparian zone will impact wildlife significantly, and greatly magnify the overall impact of the project.

The indirect impact of project development due to use of the water may also have significant effects on wildlife resources. An increase in the amount of agricultural water may increase cropland acreage or change cropping patterns and the type of crops grown. Depredation on croplands by big game could become a factor. Industrial development in the future is assumed, but the potential impacts cannot be assessed at this time.

GENERAL RECOMMENDATIONS/DISCUSSION

Fisheries

This proposed reservoir would store up to 50,000 acre-feet of water from the Middle Fork Powder River for both agricultural and future industrial use. At the maximum higher water line, the reservoir would flood 1,276 acres of land and almost 8.5 miles of stream. The fishery in over four miles of stream between the dam site and the Red Fork would be directly affected by releases. Fishery impacts below the mouth of Red Fork are expected to be minimal as trout habitat rapidly deteriorates downstream from this point.

The stream segments upstream from the dam range from relatively low to relatively high value fisheries. For example, Beaver Creek and portions of the Middle Fork near the proposed dam site presently support 15 to 20 pounds/acre of trout whereas the Middle Fork near the maximum high water line was found to contain over 125 pounds/acre of trout which ranks among the highest densities of trout in the state.

Although a potentially significant reservoir fishery is expected to develop after the reservoir is filled, this aquatic resource cannot be used to mitigate the stream fishery resource that will be flooded. Management objectives established by the WGF and USFWS mitigation policy recommend replacing unavoidable losses of high value resources with similar or "in-kind" resource values. The stream fishery value in the Middle Fork downstream from the proposed reservoir is presently low; however, the potential exists to mitigate portions of upstream fishery losses by increasing the stream fishery value below the dam. The extent of this mitigation will depend upon the quantity and timing

of releases from the dam, channel stability, and the distance below the dam that releases remain in the stream. To facilitate fishery mitigation recommendations made in the following section, we recommend that all releases from the reservoir be made directly into the existing stream channel at the base of the dam and not be diverted before reaching the mouth of the Red Fork 4.0 miles below the dam.

A direct benefit of this project will be the potential development of a relatively good quality reservoir fishery. Analyses show that this reservoir could support a relatively high fish standing crop compared to other, similar-sized reservoirs in Wyoming. Present estimates show that the reservoir may receive up to 7,260 fisherman days of use after fish populations stabilize. Certain criteria must be met, however, to achieve these associated benefits.

We recommend a minimum pool of at least 12,900 acre-feet (25.8% of capacity and 491 surface acres) to protect the fishery. Regular, prolonged periods with lower pools could reduce the density of fish by increasing crowding, elevating water temperatures, and increasing the possibility of disease among the subsequently stressed fish.

It may be periodically desirable to draw the reservoir down to a very low level in order to rehabilitate the fishery. Nongame fish are abundant at and upstream from the proposed reservoir and, over a period of years, they may become more abundant than trout in the reservoir. When this occurs it may be necessary to chemically treat the reservoir to remove most of the nongame fish and improve the quality of the fishery. The frequency of this management activity cannot be predicted, but, the outlet structure of the dam should be built so that, when it is mutually desirable to the sponsor and WGF, the reservoir can be almost totally dewatered.

We recommend that the public be allowed guaranteed access to all parts of the reservoir within the take line except where public safety precludes use such as around the dam and outlet structure. Access should also include at least one developed boat ramp and two-wheel drive vehicle access to the boat ramp and at least two other sites with parking areas along the north and west shores.

Potentially flooded portions of the stream presently contain large numbers of nongame fish which would expand their numbers rapidly after the reservoir is filled. These species compete directly with trout and would significantly limit the density of trout that would be found in the reservoir. This conflict can be minimized by removing nongame fish from flooded portions of the stream immediately prior to closure of the dam. This program will cost approximately $5,000.00 (1984 dollars). We recommend that the cost be borne by the project sponsor.

At present, few nongame fish species are found in Beaver Creek upstream from the falls located about one-half mile above the stream's mouth. When full, the reservoir will cover this fish barrier and eventually allow nongame fish to move into upstream portions of Beaver Creek where they presently do not occur. Competition with these species could subsequently reduce trout densities in this stream. To prevent this from happening, we recommend that an artificial barrier be constructed above the MHWL on Beaver Creek and be paid for by the project sponsor. This structure should be built to allow for at least a four foot vertical drop during a 100-year flood flow. An energy dissipation device should be installed to reduce downstream erosion and prevent development of a plunge-pool below the barrier.

Insufficient evidence is presently available to determine the specific impact(s) of this project on sturgeon chubs, shovelnose sturgeon, or goldeye. Goldeye and sturgeon chubs are known to occur as far upstream in the Powder River as the mouth of Salt Creek near Kaycee. Both of these species are tolerant of relatively turbid waters and Stewart (1981) felt that turbidity was an environmental variable that may be an essential component of the sturgeon chub's requirements. If turbidity levels are not significantly decreased in the Powder River downstream from the mouth of Salt Creek, impacts to sturgeon chubs will probably be minimal (George Baxter, University of Wyoming, personal communication). Sufficient information is not available to draw a similar conclusion regarding goldeye.

Although shovelnose sturgeon have only been captured in the vicinity of the Powder Rivers' confluence with Crazy Woman and Clear Creeks, it is not possible to predict the potential impact of this project (or other previously proposed Powder River projects) on shovelnose sturgeon. A great deal of information must still be obtained before conclusions can be drawn including a better definition of their present distribution and abundance in the Powder River system and an analysis of sturgeon movement patterns and habitat requirements.

Based on information collected during the past two field seasons, it appears that sturgeon seek out relatively small tributaries to the Powder River between late May and early July to spawn. Clear Creek and Crazy Woman Creeks are the only such streams where sturgeon have been captured only because they are the only streams where studies have been studied. Sturgeon may similarly ascend portions of the Middle Fork as 1) portions of the Middle Fork appear to consist of habitat similar to Crazy Woman and Clear Creeks and 2) anglers have reported

capturing sturgeon on hook and line in the Powder River upstream from the I-90 bridge in 1983 and 1984. At other times of year, it is not known if sturgeon return to and reside in the Powder River in Wyoming or if the specimens we have captured have migrated from Montana to spawn and return to the portions of the Powder in Montana after spawning.

Based on a valuation system presented by the American Fisheries Society (Anonymous 1982), the shovelnose sturgeon which were captured in 1984 alone represent a monetarily significant resource. In assessing the importance of this species, other valuation systems should also be acknowledged including their recreational and aesthetic values. In addition, the specimens which have been captured in the past two years may be a part of a spawning movement of sturgeon which reside in Montana during the remainder of the year. Water development projects which would reduce or eliminate this run of fish could create a potential conflict between Wyoming and Montana.

In order to improve our ability to analyze potential impacts of this and other potential Powder River projects on shovelnose sturgeon and provide recommendations to minimize impacts, we recommend that WDC provide funding in the amount of $40,000 to WGF to conduct a two to four year study of the shovelnose sturgeon's habitat requirements and distribution in Wyoming.

Terrestrial

1. Any powerlines constructed as part of the project should be built according to Raptor Research Foundation guidelines to prevent electrocution of eagles and hawks. Powerlines should not cross or closely parallel the Middle Fork River since bald eagles frequently fly up and down the river during the

winter and could collide with powerlines built near flight paths.

2. The black-tailed prairie dog town on the reservoir site should be searched for black-footed ferrets by qualified personnel within one year prior to construction according to USFWS guidelines. If ferrets are located, project development should be coordinated with the Wyoming Game and Fish Department and U.S. Fish and Wildlife Service.

3. Project development may result in an increase in the amount of irrigated cropland near Sussex, or at least a change in the kinds of crops grown on lands currently irrigated. This may increase the potential for damage to crops by big game animals. Project sponsors may wish to consider game proof fences for certain irrigated fields.

4. Any stock fence built as part of the project and not associated with wildlife damage control should be constructed to Wyoming Game and Fish Department specifications which recommend wire spacings that will contain livestock but allow passage of resident big game animals.

5. Reservoir construction and closing of the currently used county road may eliminate public access to BLM and state lands south of the reservoir site. Public vehicular access to this area by primitive road should be retained.

6. Relocation of the county road to the location which has been proposed would compound the impact of the project on mule deer and would not contribute to public access to the reservoir shoreline. The new road should be relocated as shown in Figure 7. This alternative will result in a similar habitat loss but disturbance of mule deer, in what is currently an area with very little access, will be avoided and the public will be provided with direct access to the shoreline for fishing, boating, and waterfowl hunting.

7. Reclamation of areas above the high water line which are disturbed during

construction should be done within one year of construction and include a plant and shrub mixture recommended by the Game and Fish Department as one which is valuable to resident wildlife.

8. Cottonwood trees below the average high water line in the upper end of the reservoir should be left standing if they are in less than 10 feet of water more than 50% of the time. The trees will provide winter bald eagle roosts and yearlong habitat for several wildlife species for a number of years.

MITIGATION RECOMMENDATIONS/DISCUSSION

Fisheries

Projected reservoir release information indicates that substantial amounts of water will be released during portions of the year (May through September). We anticipate that the quality of these releases will be greatly improved for trout over existing flows and will be potentially capable of supporting greater numbers of trout than are now found in the stream segment below the dam. However, to maintain a trout fishery in any stream requires a continuous flow during the entire year that meets or exceeds minimal trout habitat requirements. These minimal habitat requirements include enough flow to 1) allow fish to move between different habitat types and 2) allow adequate trout food production in the stream. This flow is referred to as a maintenance flow. The maintenance flow is applicable specifically to that period of the year when other flows for critical parts of a trout's life cycle (such as spawning and late summer habitat) are not required. However, this flow is also a lower limit at any time of year, especially when other models may indicate that low flow for a particular life stage is adequate. This apparent discrepancy occurs due to the fact that

each model provides information relative only to one part of a trout's habitat needs. This requires using the results of more than one model in combination with each other to determine appropriate instream flow needs.

Maintenance flow needs for the segment of the Middle Fork between the proposed dam site and the Red Fork were determined to be 33 cfs. Information provided by WDC indicates that, when fully used, industrial diversions will be a continuous 33.5 cfs throughout the year. Present WDC plans call for transferring this water to industrial sites via a pipeline originating at the dam. Conveying this amount of water in the existing stream channel to the mouth of the Red Fork would meet maintenance flow needs at all times of the year. Results from other instream flow analyses show that conveying this water in the stream channel in combination with agricultural releases (which would produce flows greater than 75 cfs) would generate less than the maximum amount of fishery benefits. At these times water for industrial use could be diverted in a pipeline from the dam if it were done in such a manner that flow in the stream were reduced to 75 cfs.

Conveying industrial flows in a pipeline originating at the dam would eliminate the already marginal trout fishery in this stream segment if this resulted in releases less than 33 cfs. This would magnify the overall negative stream fishery impacts of the project. In order to mitigate stream fishery losses associated with this project, we recommend that releases specified in the following paragraphs be made directly into the existing stream channel. We recommend that these releases not be removed before they reach the mouth of the Red Fork.

The Middle Fork between the proposed dam site and the Red Fork will be managed primarily for rainbow trout after completion of the reservoir. Management activities will include occasional plants of hatchery fish; however, much of the recruitment to fish stocks is expected to be from natural reproduction in the stream. Spawning success in this stream segment at present is severely limited by the large amount of fine sediment that occurs both in the stream gravels and in suspension. Releases from the dam will be of essentially clear, "sediment-hungry" water which would improve spawning habitat significantly within a few years after storage begins by carrying much of the fine sediments out of spawning gravels. These waters will also tend to destabilize the stream banks beyond their already highly eroded condition. Without remedial actions, this process would change the physical habitat in the stream within a relatively short period after closure of the dam and cause degradation of trout habitat.

Results from the computer model used to estimate the amount of spawning and incubation habitat over a range of flows showed that optimum habitat conditions exist at 100 cfs. Relatively small reductions in habitat would occur at both higher and lower flows. While results from this model indicate that releases less than 30 cfs may provide adequate spawning habitat (Figure 3), it should be noted that this model analyzes only spawning habitat and not whether fish would be able to reach spawning areas or have adequate food produced in the streams for fry after they hatch. As a consequence, we recommend that spawning flow releases exceed 33 cfs. Adequate rainbow trout recruitment may also occur at flows up to 160 cfs. Because of the susceptibility of the stream banks to erosion and the impact that increased erosion could have on stream habitat, we

prefer that flows be equal to or less than 100 cfs between April 1 and June 30 as much as water supply and demand conditions permit.

The period of the year that generally most limits the density of trout in western streams occurs between July 1 and September 30. This time of year is when trout potentially exhibit the greatest growth rates as a function of cover, water temperature, and stream productivity. Populations can be strictly limited if flows are low enough to reduce cover and result in water temperatures that are unfavorable for trout. Two models were used to evaluate the impact of various flows on trout.

The IFG-4 model was used to determine a range of adequate instream flows in terms of physical habitat (useable area) for life stages of rainbow trout that will reside in this stream segment during late summer after the reservoir is built. Results apply only indirectly to productivity and habitat units. The maximum useable area, according to this model, will result when releases equal 30 cfs. Again, it is necessary to note that this model does not include an analysis of fish passage or aquatic insect production needs. As previously noted, a flow of 33 cfs is necessary to meet these basic habitat requirements. The majority of the stream habitat throughout this segment is composed of relatively deep pools which the model properly interprets as good trout habitat. Because it is only a physical model and not an ecological model, it tends to overlook passage and productivity needs.

The results in Figure 4 show that physical habitat decreases at a relatively rapid rate at higher flows, though it appears that adequate habitat will probably exist up to 160 cfs. For mitigation purposes, however, the HQI model indicates that flows of this magnitude will reduce fishery benefits.

The HQI is an ecological model designed to measure the existing and potential productivity of streams. Results of the model are in habitat units which approximate pounds per acre of trout and are consequently used to determine the actual extent of fishery gains and losses. This project would directly affect four distinct stream segments. To accurately assess fishery impacts in the Middle Fork, the stream was divided into three segments: 1) from the Red Fork to the proposed dam site, 2) from the dam site to Beaver Creek, and 3) from Beaver Creek to the MHWL. A portion of Beaver Creek would also be affected. Analyses showed that these segments combined contain 1,625 HU's. If the reservoir is constructed and operated according to the information provided by WDC, total HU's will be reduced by over 95%. Though portions of this fishery are of relatively low value, a significant portion is a high quality fishery resource. A loss of the magnitude mentioned above would be counter to both WGF management objectives and USFWS mitigation policy which call for maintenance of existing stream sport fishing opportunity and no net loss of "in-kind" habitat value.

The HQI shows that the stream fishery losses which will occur upstream from the proposed dam site would be partially mitigated with a mean monthly release of 75 cfs between July 1 and September 30. Higher and lower releases would result in greater negative fishery impacts. We recommend a mean monthly flow between July 1 and September 30 of 75 cfs.

One variable that would limit productivity is stream bank stability. Nearly 60% of the stream banks in this stream segment are presently eroding and information contained in Appendix B suggests that releases from the dam will increase the rate of down-cutting in the channel and stream bank erosion. This could significantly alter existing trout habitat and invalidate the instream flow

recommendations in this report. Controlling this process would insure the accuracy of the instream flow recommendations presented in this report. To prevent this potential increased erosion, we recommend that the project sponsor implement a bank stabilization/fisheries habitat improvement program on the 4.0 miles of stream immediately below the proposed dam site. This program should include planting trees along portions of the stream, reshaping and seeding some stream banks, and placement of habitat improvement structures in appropriate places. More specific bank stabilization techniques should be developed in consultation with WGF habitat specialists. While our instream flow calculations reveal the potential for mitigating stream fishery resource losses, benefits will not be realized without releasing the recommended flows for all parts of the year.

Even if our recommended flows are released, the stream HU gains below the reservoir will still result in a 25 percent reduction in total existing stream HU's. In order to more fully mitigate these losses, we recommend that one of the following two mitigation alternatives be implemented.

Approximately 60 percent of the stream banks between the proposed dam site and the Red Fork are presently eroding. By improving streambank stability so that less than 50 percent are eroding and releasing recommended instream flows, up to 1,600 HU's could be obtained in this stream segment. This would almost totally mitigate stream HU losses associated with this project.

Should this alternative prove infeasible, we recommend that a habitat improvement program be implemented on a trout stream within a 100 mile radius of the project area. The location of habitat improvement measures should be made

following detailed evaluation of alternatives by WGF biologists. It would be necessary that this project a) generate over 400 HU's and b) include guaranteed access to the public.

The landowner immediately downstream from the proposed dam has expressed concerns that seepage around the dam could increase salinity concentrations in the river, especially at times of year when releases from the dam are low. Using this water for irrigation could reduce the productivity of his farm land. If this situation develops, higher releases may be recommended. We expect the recommended MF release to minimize this potential problem.

Terrestrial

1. An estimated 486 acres of bottomland adjacent to Beaver Creek and the Middle Fork River, including riparian cottonwood, boxelder maple, greasewood/rabbitbrush and moist meadow grasslands will permanently lose their value to terrestrial wildlife when the reservoir is built; and riparian habitat below the reservoir for several miles will be degraded in diversity and quality. To compensate for this loss, the following options are suggested (in order of preference):

   Option #1

   a) Permanent protection of approximately 3 miles (500 acres) of cottonwood riparian habitat and adjacent meadows between the upper end of the reservoir and the mouth of the Middle Fork Canyon by conservation easement. The easement would be designed to protect riparian habitat values and prevent development above the current level.

-and-

b) Acquisition of approximately 486 contiguous acres of bottomland on the Middle Fork immediately downstream from the reservoir. This land should contain habitat similar to that lost by inundation and have wildlife habitat management potential. It is assumed that with proper management the wildlife carrying capacity can be increased to partially mitigate losses on the reservoir site.

Option #2

a) Permanent protection by easement by approximately 3 miles (500 acres) of bottomland (as described in Option #1).

-and-

b) Acquisition of 486 contiguous acres of bottomland anywhere on the Middle Fork River system below the reservoir site and management of this land for wildlife habitat.

Option #3

a) Permanent protection by easement of approximately 3 miles (500 acres) of bottomland (as described in Option #1).

-and-

b) Acquisition of 486 contiguous acres of bottomland on the Powder River system which contains habitat similar to that lost on the reservoir site, and which can be managed for wildlife habitat.

2. An estimated 684 acres of upland habitat including juniper, mountain mahogany, grassland and sagebrush/grassland will permanently lose their value to terrestrial wildlife when the reservoir is constructed. An additional 70 acres will be lost by road construction, and the dam and emergency spillway will take an estimated 200 acres; making the total loss of upland habitat about 954 acres not including borrow areas and other disturbed lands which can be reclaimed. To compensate for this loss, the following options are suggested (in order of preference):

Option #1

a) Purchase all of section 31, T43N, R83W (an additional 200 acres above that currently within the reservoir take line) and management of this land for wildlife habitat.

-and-

b) Protection of the shoreline of the reservoir and adjacent uplands from livestock grazing and management of this land for wildlife habitat. With the cooperation of the Bureau of Land Management which man-ages part of the land adjacent to the reservoir, shoreline protection and enhancement of approximately 1,000 acres of land within the takeline above the normal high waterline, and approximately 1,840 acres of BLM land can be accomplished (Figure 6). Utilization of the BLM land which has some existing fences which could be used, will allow protection and management of this habitat with construction of less fence than Option #2.

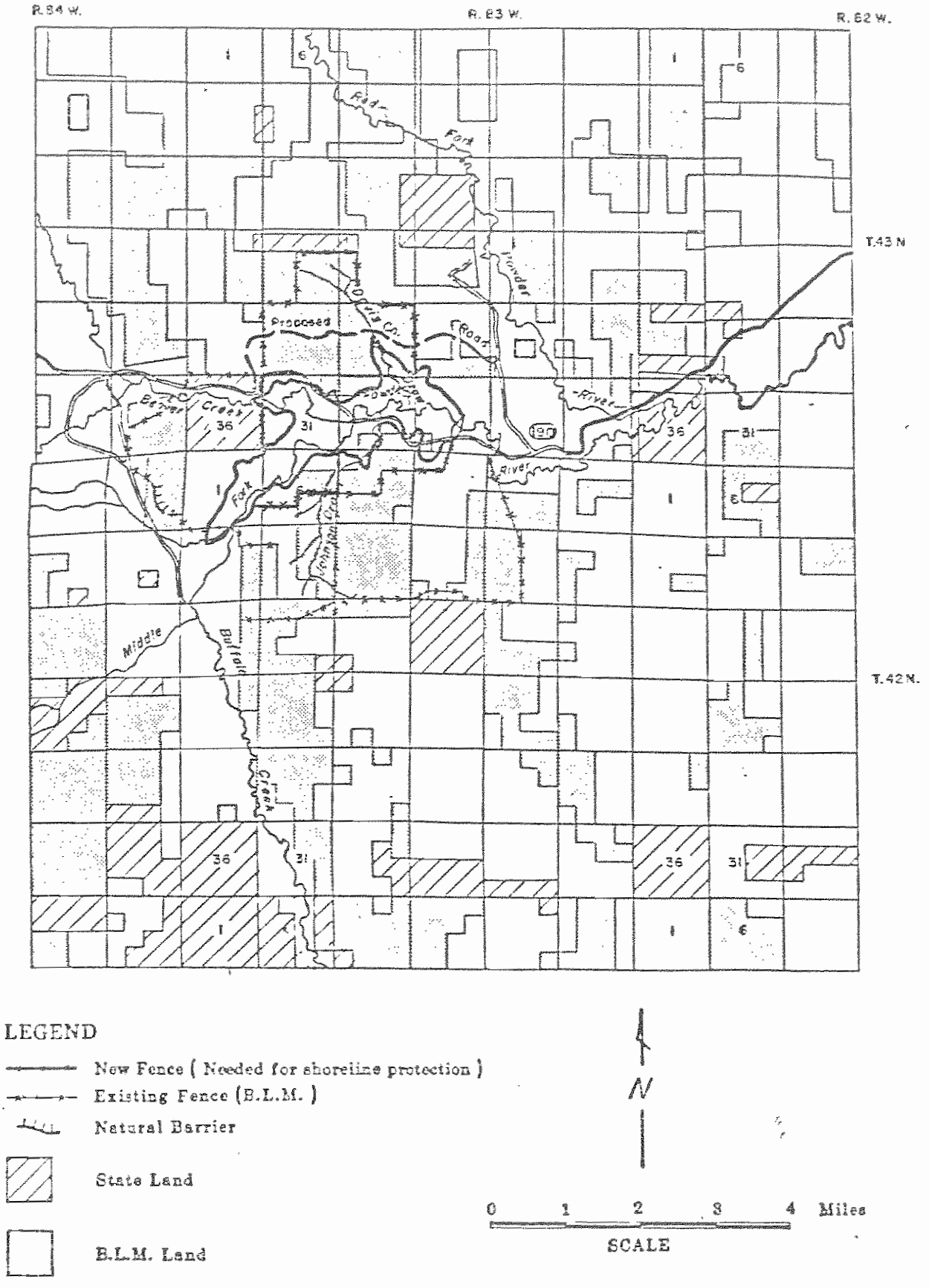

Figure 6. Existing fences and new fence needed for shoreline protection on the proposed Middle Fork Preservation [illegible]

Option #2

a) Purchase all of Section 31 as described in Option #1 (200 acres).

-and-

b) Protection of the shoreline as described in Option #1, but without inclusion of BLM land. This will result in protection of approximately 1,000 acres of land (Figure 7).

3. Development of a recreational plan for the reservoir which takes into account all potential recreational uses will help provide management direction and prevent conflicts between users. Zoning should be implemented in important areas to protect wildlife values. Areas which should be zoned include:

   a. The upper end of the reservoir (above the range line between R83W and 84W), which is bordered by steep canyon walls, should be zoned to prohibit public access, including boats, during the raptor and golden eagle and waterfowl nesting and brood rearing period - March 1 to July 15 and the season of use by bald eagles - November 15 to March 1.

   b. Bays containing waterfowl nesting islands should be zoned to prohibit boating and other disturbances during the waterfowl and shorebird nesting period - March 1 to June 30.

4. Nesting islands for ducks, Canada geese and shorebirds should be built in bays on the Forbes acquisition and in Davis Draw. Depending upon final reservoir size, configuration and rate of fluctuation, 15-20 islands are

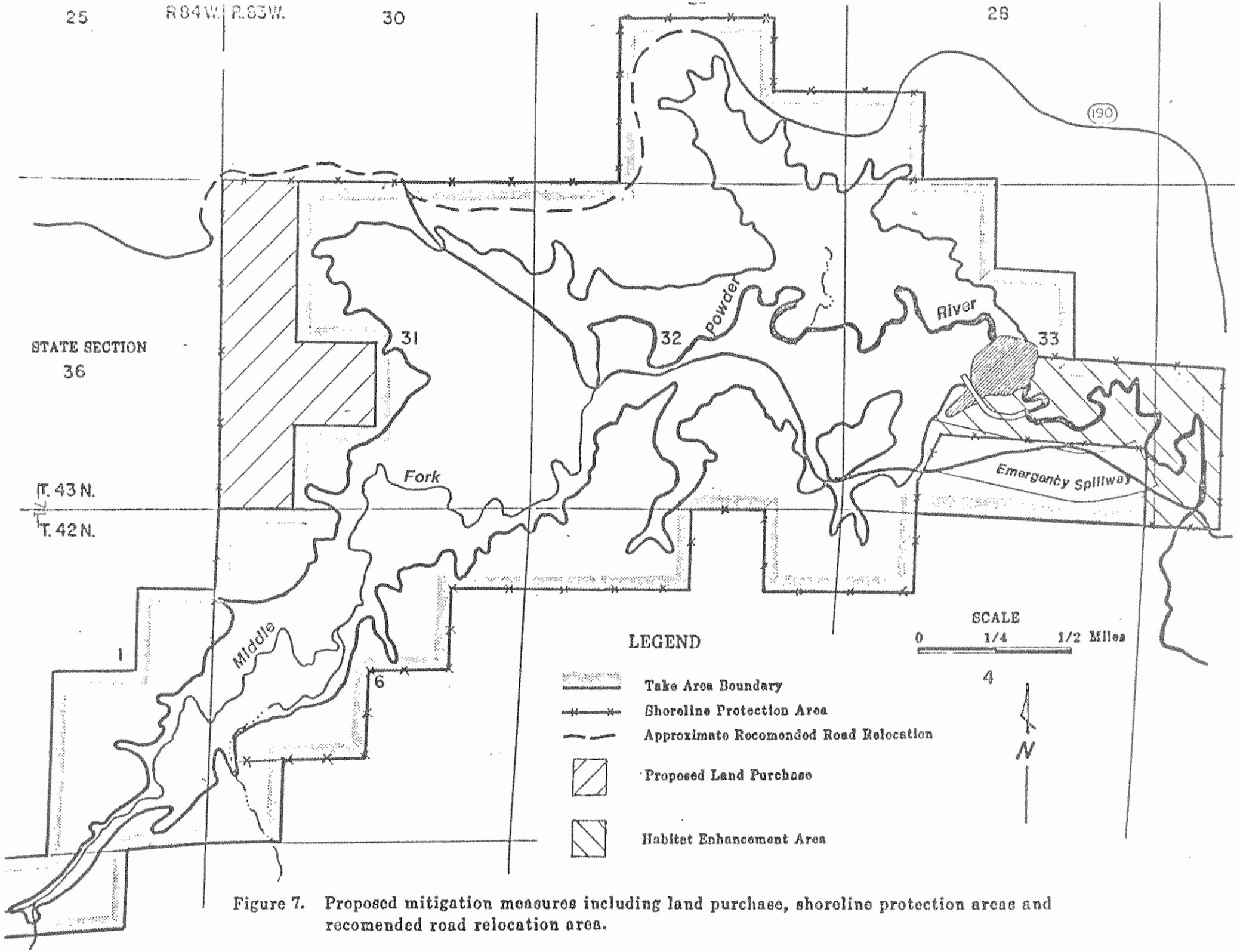

Figure 7. Proposed mitigation measures including land purchase, shoreline protection areas and recomended road relocation area.

recommended. Islands should be placed at the correct elevation to have at least 2 foot of freeboard at high water and still retain at least 2 foot of water around the base of the island on June 30. Current information on the reservoir fluctuation rate indicates a drop of approximately 20 vertical feet during the nesting season - March 1 to June 30. This would necessitate construction of islands in about 24 feet of water. Previous experience indicates islands of this size including riprap will cost approximately $4,000/island. Therefore, we recommend appropriation of $75,000 for construction of nesting islands. Each island can be expected to raise an average of 5 goslings, 10 ducklings and 5-10 shorebirds per year for the life of the island which should be at least 20 years if constructed properly. Without islands the reservoir will have very limited capability for waterfowl production.

5. When the reservoir is filled, a large peninsula, mostly in the SW¼ of section 33 near the dam will be created. The small neck of land which remains should be removed with heavy equipment in order to create an island of approximately 25 acres which can be managed for waterfowl nesting habitat. Other places where "cut-off" islands can be created will be identified before construction commences and these should also be separated from the mainland by heavy equipment and be managed for waterfowl nesting habitat.
6. According to current information, the reservoir will be at its lowest level during the fall of the year due to drawdown for irrigation. Waterfowl hunting opportunities near the reservoir which were described previously in this report will be severely reduced by this reservoir operation scheme. Five to ten dugout-type retention dams of approximately 1-5 acres in size

should be built to retain water during the summer and fall. Suggested locations are Davis Draw, the Forbes Tract and the upper end of the reservoir in the N½ of Section 6. These small, shallow ponds will provide duck habitat and dust abatement when the reservoir is low. Planting the dikes with cattail and bulrush should be done to reduce sloughing and improve the ponds for waterfowl habitat.

7. Approximately 150 acres of land along the Middle Fork River below the proposed reservoir currently supports boxelder and willow trees as well as bottomland grassland. This area is within the take line for the reservoir as shown in Figure 7. Although the wildlife value of this area may be reduced by habitat disturbance during construction and post-construction fishing use, the tract should be fenced to control grazing and managed for its wildlife and public recreational value.
8. Protection of the reservoir shoreline from livestock grazing will eventually result in development of a band of cottonwood and willow trees in the wet soil zone along the high water line. However, the wildlife value and aesthetic quality of the reservoir will be greatly improved by planting cottonwood and/or willow trees in suitable locations along the protected shoreline instead of waiting 3-5 years for this to occur by natural succession. We recommend appropriation of $25,000 to plant trees and maintain the plantings until they are established.

ENHANCEMENT RECOMMENDATIONS/DISCUSSION

Fisheries

By releasing recommended instream flows and stabilizing stream banks below the proposed reservoir, additional HU's could be generated above the number

necessary to mitigate upstream HU losses. At present about 60 percent of the stream banks between the Red Fork and the proposed dam site are eroding. Calculations show that stabilizing stream banks so that less than 25 percent are eroding would generate up to 1,700 HU's and may result in a net gain of 100 HU's. Further bank stabilization would provide even more HU's. In light of the potential accelerated erosion forecast by the USFWS which would reduce our present HU estimates, we recommend that the project sponsor implement a streambank stabilization program in consultation with WGF habitat specialists before the dam is completed.

Significant public benefits can be realized by obtaining public access to this fishery. We recommend that the project sponsor provide public access to this fishery in the form of a 100 foot wide pedestrain easement along both sides of the Middle Fork from the base of the dam to the Middle Fork's confluence with the Red Fork. In addition, we recommend that the sponsor provide adequate parking facilities both near the base of the dam, near the mouth of the Red Fork, and at one point in between. We recommend that the easement be fenced to keep cattle away from the stream banks except for developed livestock waters areas on the stream. Fencing this 4 mile long easement would enclose slightly less than 100 acres. A portion of the cost of this enhancement could possibly be obtained from the U.S. Soil Conservation Service.

Terrestrial

As agreements are signed by the Water Development Commission for purchase of the land needed to build the reservoir, seller resistance or other factors may necessitate purchase of a larger acreage than currently anticipated. If this occurs, the additional acquisition should be worked into the mitigation plan.

When private land within the reservoir site is purchased, the lease on the land in section 36, T43N, R84W may be relinquished (Figure 6). If this land is not used in mitigation for habitat loss, it would be desirable to include section 36 along with the management of the recreational complex. This could be accomplished by allowing the Game and Fish Department to assume the lease, if it is available.

SUMMARY

Fisheries

1. The proposed Middle Fork Reservoir will have a direct impact on over 12.5 stream miles and 1,625 stream habitat units. It will also create a potentially high quality reservoir fishery.
2. Based on WGF management objectives and USFWS mitigation policy reservoir fishery gains cannot be used to replace stream fishery losses as the replacement is not with an "in-kind" resource.
3. We recommend a minimum pool of at least 12,900 acre-feet. The proposed reservoir will support over 88 pounds/acre of trout and provide up to 7,260 fisherman days of use per year if an adequate minimum pool and public access are included. Periodic dewatering of the reservoir may occasionally be desirable for managing the reservoir fishery. Dewatering should occur only when mutually agreed upon by the project sponsor and WGF.
4. We recommend that the project sponsor develop a permanent boat ramp on the reservoir's north shore and provide two-wheel drive vehicle access to the boat ramp at least two other points with parking areas on the north and west sides of the reservoir. We also recommend that the public have unrestricted

walking access to all parts of the reservoir within the take line except areas where public safety is a concern.

5. Maximum trout production in the reservoir will be achieved by chemically treating flooded portions of the streams to remove nongame fish. The estimated cost of this activity is about $5,000.00. We recommend that this cost be borne by the project sponsor.

6. When the reservoir is filled, it will cover a natural barrier to fish movement in Beaver Creek. Relatively few nongame fish species are currently found above this barrier. To prevent other species from moving into upstream portions of this stream, we recommend that the project sponsor install an artificial barrier to upstream fish movements, above the maximum high water line of the reservoir.

7. Filling the reservoir will result in the unavoidable loss 1,497 stream habitat units in the Middle Fork and Beaver Creek upstream from the proposed dam. This loss in combination with projected reservoir release information from the project sponsor shows that the project would cause a total net loss of over 95% of the stream habitat units that presently exist in the potential impact area. These losses can be at least partially mitigated by implementing items 8 and 9 below.

8. We recommend release of 75 cfs from July 1 to September 30, 33 cfs from October 1 to March 31, and between 33 and 100 cfs from April 1 to June 30 directly into the existing channel to minimize stream habitat unit losses. We recommend that any diversions for industrial use be made downstream from the mouth of Red Fork and not at the dam site.

9. Streambank erosion between the proposed dam site and the Red Fork is one of the most important environmental factors which will limit the number of

stream HU's that can be achieved below the dam. A USFWS study shows that erosion may increase and changes in the stream channel morphology may occur after the dam is built if remedial measures are not take. To realize the projected number of HU's for recommended instream flows, we recommend that a bank stabilization program be implemented in consultation with WGF habitat specialists on this stream segment. We recommend that the easement in item 11 be fenced to keep cattle away from the streambanks except for developed watering areas on the stream.

10. Implementing the recommendations in 8 and 9 above will mitigate only 75 percent of the lost stream HU's. To more fully mitigate stream habitat losses, we recommend that the project sponsor either a) stabilize stream banks throughout the 4 mile reach below the dam so that less than 50% are eroding or b) implement a habitat improvement project on another, as yet unidentified, stream within a 100 mile radius of the project. Habitat improvement should generate at least 400 HU's and be done on a stream with guaranteed public access. More extensive bank stabilization would more nearly mitigate stream HU losses and the potential also exists to generate more HU's than the project eliminates. Bank stabilization should begin before the dam is completed.

11. We recommend that the project sponsor obtain an easement for public walking access to a 100 foot wide strip of land on both sides of the river between the base of the dam and the Red Fork. We also recommend that the project sponsor develop parking areas near the base of the dam, near the mouth of the Red Fork, and at one point in between.

12. If turbidity levels are not significantly reduced in the Powder River downstream from the mouth of Salt Creek, sturgeon chub populations will

probably not be affected by this project. Similar conclusions cannot be drawn for goldeye or shovelnose sturgeon without further study.

SUMMARY

Terrestrial

13. The proposed Middle Fork Reservoir will inundante approximately 1,160 acres of land including several important wildlife habitats.
14. An estimated fifty (50) mule deer and forty-five (45) white-tailed deer; chukar, gray partridge, mourning dove, turkey, pheasants, cottontail rabbits, several furbearers and several nongame birds and mammls will be displaced and eventually lost when their habitat is eliminated.
15. Raptors which will be impacted by the project include golden eagle, American kestrel, and red-tailed hawk. Habitat loss and potential human disturbance during nesting are the anticipated impacts.
16. The endangered bald eagle winters on the reservoir site and the communal roost which occurs just up river from the proposed reservoir should be protected. The presence of a black-tailed prairie dog town on the reservoir site provides potential habitat for the endangered black-footed ferret.
17. The estimated current public recreational use on the reservoir site is 150 hunter days and 60 trapper days. The potential exists for up to 900 waterfowl hunter days on the reservoir.
18. Reservoir construction will have significant effects on downstream riparian vegetation. It will result in a deeper, more narrow channel and lower ground water table which will narrow and degrade the riparian habitat zone. Impacts will occur on all wildlife species which use riparian habitats.

19. We recommend proper powerline construction to minimize raptor electrocution, stock fence built to allow passage of big game, retention of access to BLM lands, and proper reclamation of borrow areas. The county road should be relocated next to the north shoreline of the reservoir. Cottonwood trees should be left in the upper end of the reservoir to provide wildlife habitat.
20. We recommend mitigation for the riparian habitats which will be lost by inundation and degraded in quality and quantity by dewatering below the reservoir. Mitigation will consist of an easement to protect the riparian zone between the upper end of the reservoir and public land up river (approximately 3 miles), and acquisition of approximately 486 contiguous acres of riparian bottomland which can be managed for wildlife habitat.
21. We recommend mitigation for the upland habitat which will be lost by inundation, road building, etc. Mitigation will consist of purchase of 200 acres of private land adjacent to the reservoir and protection of all of the reservoir shoreline (approximately 1,000 acres) within the takeline. Inclusion of Bureau of Land Management lands by cooperative agreement could add approximately 1,840 acres to the mitigation lands and require less fencing than following the takeline. Twenty-five thousand dollars ($25,000.00) should be set aside for tree planting and maintenance.
22. We recommend construction of 15-20 waterfowl and shorebird nesting islands at an approximate cost of $75,000, several cut-off nesting islands and 5-10 dugout ponds to maximize waterfowl benefits.
23. The 150 acre tract below the reservoir should be fenced and managed for wildlife habitat and public recreational use.

CONTINUING STUDY NEEDS

Terrestrial

Additional data collection is needed to supplement some of the information presented in this report. Areas where more data are needed include:

1. Mule deer population and winter distribution on the reservoir site and winter range north of the proposed reservoir.
2. Bald eagle winter distribution and roosting areas on the Middle Fork River below the proposed reservoir.
3. Bald eagle winter use of the Bar C roost site and the alternate roost site on the Taylor Ranch.
4. Nongame bird use and distribution on the reservoir site during the winter.
5. The prairie dog town on the reservoir site should be searched for the presence of black-footed ferret sign in the winter of 1984-85.

Fisheries

6. In order to improve our ability to analyze potential impacts of this and other potential Powder River projects on shovelnose sturgeon and provide recommendations to minimize impacts, we recommend that WDC provide funding in the amount of $40,000 to WGF to conduct a two to four year study of the shovelnose sturgeon's habitat requirements and distribution in Wyoming.

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Appendix A

Table 1. Powder River flow conditions* without reservoir.

	Average Monthly Discharge		"Worst Year (1960)" Monthly Discharge	
	Acre-Feet	CFS	Acre-Feet	CFS
October	2,650	43.1	2,620	42.6
November	2,680	45.0	2,670	44.9
December	2,620	42.6	2,670	43.4
January	2,470	40.2	2,330	37.9
February	2,610	46.6	1,980	35.3
March	2,830	46.0	3,030	49.3
April	4,670	78.5	5,590	93.9
May	14,790	240.5	5,970	97.1
June	10,730	180.3	2,510	42.2
July	3,530	57.4	1,530	24.9
August	2,080	33.8	1,430	23.3
September	2,230	37.5	1,600	26.9
Annual	53,890	74.4	33,930	46.8

*At USGS gage 6309500

Table 2. Powder River flow conditions* with reservoir.

	Average Monthly Discharge		"Worst Year (1950)" Monthly Discharge	
	Acre-Feet	CFS	Acre-Feet	CFS
October	320	5.2	300	4.9
November	302	5.1	300	5.0
December	303	4.9	300	4.9
January	300	4.9	300	4.9
February	300	5.4	300	5.4
March	300	4.9	300	4.9
April	376	6.3	300	5.0
May	6,020	97.9	2,960	43.8
June	10,620	178.0	4,730	79.5
July	6,080	98.9	6,020	97.9
August	5,490	89.3	1,830	29.8
September	2,720	45.7	1,570	26.4
Annual	33,130	45.7	18,910	26.1

*At USGS gage 6309500

Appendix B

POTENTIAL CHANNEL CHANGES RESULTING FROM CONSTRUCTION OF MIDDLE FORK POWDER RIVER RESERVOIR

Project

The Wyoming Water Development Commission has proposed constructing a reservoir on the Middle Fork Powder River near Kaycee, Wyoming (Figure 1). Release flows below the reservoir have been computed from historical gage records by the sponsor's consultant (Tables 1 and 2). This analysis describes the potential for alteration of downstream channel conditions resulting from dam construction.

Channel Response

Schumm (1971, 1972) described several relationships which indicate channel responses to changes in water discharge:

$$Q_w = \frac{b,d}{s}$$

where:

Q_w	mean annual discharge
b	channel width
d	channel depth
s	channel gradient

A decrease in Q_w results in decreased channel width and decreased channel depth. Channel gradient increases under conditions of decreased Q_w.

Reservoirs release essentially sediment-free water. Commonly, this results in channel degradation (downcutting) immediately downstream of the dam until sediment transport capacity of the release flow is satisfied or an armored channel bed is formed. Lane (1955) related adjustments in the fluvial system to a balance of conditions:

$$Q_s \; d_{50} \propto Q_w \; S$$

where
- Q_s sediment discharge
- d_{50} median particle size
- Q_w water discharge
- S bed slope

The potential for degradation is indicated by rewritting Lane's relationship for clear water reservoir release conditions:

$$Q_s^{-} \; d_{50}^{0} \propto Q_w^{0} \; S^{-}$$

The decrease in Q_s term is balanced by a decrease in bed slope for the given conditions of sediment particle size and water discharge.

Downstream tributary junctions are often points of aggradation following regulation of the mainstem river. With reduced flows under reservoir operations, sediment transport capacity decreases. Again, the potential for aggradation can be illustrated by rewriting Lane's relationship for these conditions:

$$Q_s^{0} \; d_{50}^{0} \propto Q_w^{-} \; S^{+}$$

The decrease in the Q_w term is balanced by an increase in bed slope for unchanged conditions of sediment particle size and sediment discharge. Channel pattern changes often occur with channel bed slope adjustments.

Potential Channel Changes in Middle Fork Powder River

Leopold and Wolman (1957) developed a relationship showing a distinction between meandering and braided channels:

$$S = 317\ Pb^{-0.44}$$

where

S channel gradient (feet per mile)
Pb bankfull flow (cubic feet per second)

For the Middle Fork Powder River, Pb was approximated by the geometric mean of the annual peak flows, 728 cfs, for the USGS gage 6309500 (Table 3). Channel gradient, measured from the 4800 feet contour to the 4880 feet contour (Figure 1), averaged 13 feet per mile. For the above relationship, Pb of 728 cfs equates to a channel gradient of 17 feet per mile. As defined by Leopold and Wolman, a channel with a slope less than that predicted by this formula is considered a meandering channel. Generally, a meandering channel is considered to be stable and in equlibrium with its discharge and sediment load. Thus, alterations in discharge and sediment loads will require changes in the channel conditions of the Middle Fork.

Channel response relationships described earlier indicate the potential for either increased channel gradient, as a result of decreased water discharge or decreased channel gradient, resulting from decreased sediment discharge. The dominant factor is likely to be the decreased sediment discharge for this situation. Immediately below the Middle Fork reservoir, downcutting and associated decreased channel slope is anticipated because of the sediment-free reservoir releases and erodible channel bed materials. Channel width will decrease below the dam due to the

decrease in mean annual discharge (Tables 1 and 2). Local water table elevation will decrease as a result of the lower bed elevation of the channel if the water table is directly connected to the channel. Channel length will decrease as bank erosion is initiated by the downcutting channel. At the confluence of the Middle Fork and Red Fork, localized aggradation is expected with a braided channel pattern or meander cutoffs developing as stream bed slope increases. Here, shallower low flow channels may result. Further downstream on the Middle Fork, channel changes and alterations in sediment load will probably be minor.

Recommendations

This assessment of potential channel response to construction of the Middle Fork reservoir is based upon general relationships developed from several case histories. A more quantitative analysis is recommended for the Middle Fork Basin. This assessment should include field surveys of the existing channel slope and sediment source areas and descriptions of sediment transport capacity and tributary inflows. At a minimum, the Middle Fork Powder River from the damsite to its junction with the Red Fork should be studied under the current regulation and diversion proposal. Additional studies of Beaver Creek, Red Draw, the Red Fork and the Middle Fork channel downstream of the Red Fork confluence will be necessary to evaluate potential impacts to these channels if the diversion of the Red Fork into the Middle Fork Basin above the reservoir is considered. Also, the studies of the Middle Fork should be designed to address incremental levels of diversion and release flows at the dam.

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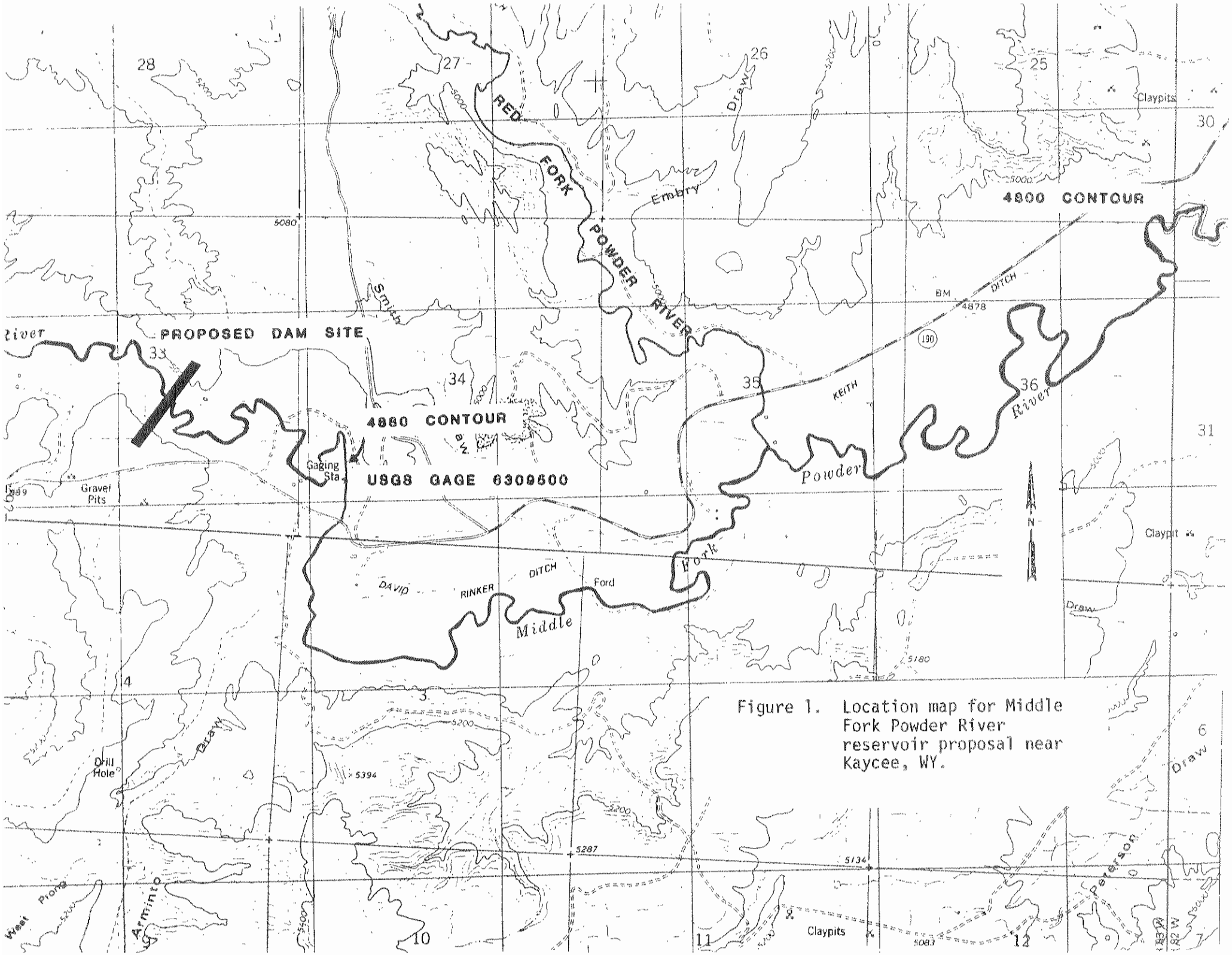

Figure 1. Location map for Middle Fork Powder River reservoir proposal near Kaycee, WY.

Table 1. POWDER RIVER FLOW CONDITIONS*
WITHOUT RESERVOIR

	Average Monthly Discharge		"Worst year (1960)" Monthly Discharge	
Month	Acre-Feet	CFS	Acre-Feet	CFS
October	2,650	43.1	2,620	42.6
November	2,680	45.0	2,670	44.9
December	2,620	42.6	2,670	43.4
January	2,470	40.2	2,330	37.9
February	2,610	46.6	1,980	35.3
March	2,830	46.0	3,030	49.3
April	4,670	78.5	5,590	93.9
May	14,790	240.5	5,970	97.1
June	10,730	180.3	2,510	42.2
July	3,530	57.4	1,530	24.9
August	2,080	33.8	1,430	23.3
September	2,230	37.5	1,600	26.9
Annual	53,890	74.4	33,930	46.8

* at USGS gage 6309500

Table 2. POWDER RIVER FLOW CONDITIONS*
WITH RESERVOIR

	Average Monthly Discharge		"Worst year (1950)" Discharge	
Month	Acre-Feet	CFS	Acre-Feet	CFS
October	320	5.2	300	4.9
November	302	5.1	300	5.0
December	303	4.9	300	4.9
January	300	4.9	300	4.9
February	300	5.4	300	5.4
March	300	4.9	300	4.9
April	376	6.3	300	5.0
May	6,020	97.9	2,960	43.8
June	10,620	178.0	4,730	79.5
July	6,080	98.9	6,020	97.9
August	5,490	89.3	1,830	29.8
September	2,720	45.7	1,570	26.4
Annual	33,130	45.7	18,910	26.1

* at USGS gage 6309500

Table 3. MIDDLE FORK POWDER RIVER ABOVE KAYCEE, WY.

Year	Peak	Date
1949	586	06/09
1950	1,020	05/18
1951	487	09/06
1952	566	04/29
1953	437	05/29
1954	287	05/13
1955	792	06/14
1956	367	05/27
1957	860	06/30
1958	933	05/13
1959	672	08/12
1960	370	06/10
1961	755	05/23
1962	932	06/15
1963	1,610	06/15
1964	1,240	06/22
1965	637	05/20
1966	660	05/07
1967	951	06/13
1968	1,750	06/08
1969	619	04/24
1970	1,260	05/26

Pgm = 728 cfs

Appendix C

Appendix C

Middle Fork Bird Species List

Brewer's Blackbird
House Wren
Yellow Warbler
Black-headed Grosbeak
American Robin
Northern Oriole
Gray Catbird
Yellow-rumped Warbler
Eastern Kingbird
Brown Thrasher
Killdeer
Mourning Dove
American Goldfinch
Clay-colored Sparrow
Western Meadowlark
Lark Sparrow
Vesper Sparrow
Western Wood Pewee
Western Tanager
Pinon Jay
Violet-green Swallow
Great Horned Owl
Prairie Falcon
Red-tailed Hawk
Belted Kingfisher
Great Blue Heron
Common Crow
Dusky Flycatcher
Barn Swallow
Loggerhead Shrike
Green-tailed Towhee
Lark Bunting
Brewer's Sparrow
Poorwill
Downy Woodpecker
Veery
Yellow-billed Cuckoo
Hermit Thrush
Tree Swallow
Bald Eagle
Clark's Nutcracker
Cedar Waxwing
Solitary Vireo
MacGillivray's Warbler
Hairy Woodpecker
Western Flycatcher
Dipper
Black-capped Chickadee
Common Yellowthroat
Yellow-bellied Sapsucker
Red-winged Blackbird
Common Grackle
Wild Turkey
Ring-necked Pheasant
Rufous-sided Towhee
Cliff Swallow
Common Flicker
Black-billed Magpie
Spotted Sandpiper
Mallard
Starling
Common Merganser
Turkey Vulture
Rock Wren
Says Phoebe
Golden Eagle
American Kestral
Mountain Bluebird
Grasshopper Sparrow
Lazuli Bunting
Song Sparrow
Common Nighthawk
Brown-headed Cowbird
Yellow-breasted Chat
Common Snipe
Savannah Sparrow
Dark-eyed Junco
Chipping Sparrow
House Sparrow
Rough-legged Hawk
Townsend Solitaire
Pine Siskin

Appendix C

Middle Fork Bird Species List

Brewer's Blackbird
House Wren
Yellow Warbler
Black-headed Grosbeak
American Robin
Northern Oriole
Gray Catbird
Yellow-rumped Warbler
Eastern Kingbird
Brown Thrasher
Killdeer
Mourning Dove
American Goldfinch
Clay-colored Sparrow
Western Meadowlark
Lark Sparrow
Vesper Sparrow
Western Wood Pewee
Western Tanager
Pinon Jay
Violet-green Swallow
Great Horned Owl
Prairie Falcon
Red-tailed Hawk
Belted Kingfisher
Great Blue Heron
Common Crow
Dusky Flycatcher
Barn Swallow
Loggerhead Shrike
Green-tailed Towhee
Lark Bunting
Brewer's Sparrow
Poorwill
Downy Woodpecker
Veery
Yellow-billed Cuckoo
Hermit Thrush
Tree Swallow
Bald Eagle
Clark's Nutcracker
Cedar Waxwing
Solitary Vireo
MacGillivray's Warbler
Hairy Woodpecker
Western Flycatcher
Dipper
Black-capped Chickadee
Common Yellowthroat
Yellow-bellied Sapsucker
Red-winged Blackbird
Common Grackle
Wild Turkey
Ring-necked Pheasant
Rufous-sided Towhee
Cliff Swallow
Common Flicker
Black-billed Magpie
Spotted Sandpiper
Mallard
Starling
Common Merganser
Turkey Vulture
Rock Wren
Says Phoebe
Golden Eagle
American Kestral
Mountain Bluebird
Grasshopper Sparrow
Lazuli Bunting
Song Sparrow
Common Nighthawk
Brown-headed Cowbird
Yellow-breasted Chat
Common Snipe
Savannah Sparrow
Dark-eyed Junco
Chipping Sparrow
House Sparrow
Rough-legged Hawk
Townsend Solitaire
Pine Siskin

Appendix D

APPENDIX D

Breeding bird species observed during censuses in the habitats listed in 1983 and 1984.*

SPECIES	BOXELDER MAPLE	% OF TOTAL	RIPARIAN COTTONWOOD	% OF TOTAL	BIG SAGEBRUSH	% OF TOTAL	MOUNTAIN MAHOGANY	% OF TOTAL	JUNIPER	% OF TOTAL
Brewer's Blackbird	16	14	24	19	1	2	2	11	1	1
House Wren	5	4	16	13					3	4
Yellow Warbler	28	24	24	19						
Black-headed Grosbeak	5	4								
American Robin	5	4	6	5	3	7			6	8
Northern Oriole	6	5	1				1	6		
Gray Catbird	8	7								
Yellow-rumped Warbler	1								4	5
Eastern Kingbird	2	2	3	2						
Brown Thrasher	7	6	1							
Killdeer	1									
Mourning Dove	8	7	2	2					19	24
American Goldfinch	6	5							6	8
Cliff Swallow			17	14	4	9	4	22		
Hermit Thrust			3	2						
Lark Sparrow	4	3			3	7	2	11		
Common Crow			4	3						
Grasshopper Sparrow	2	2			1	2	1	6		
Common Flicker	3	3	3	2	1	2			2	3
Lazuli Bunting	2	2								
Song Sparrow	1									
Say's Phoebe	2	2	6	5					1	1
Brown-headed Cowbird	1				1	2				
Yellow-breasted Chat	1									
Black-billed Magpie	3	3								
Mallard			1							
Starling			6	5					1	1
Yellow-billed Cuckoo			1							
Tree Swallow			1							
Rufous-sided Towhee			1						1	1
Yellow-bellied Sapsucker			3	2						
Downy Woodpecker			2	2						
Western Meadowlark					10	23	4	22		
Common Nighthawk					1	2	1	6		

APPENDIX D Continued.

SPECIES	BOXELDER MAPLE	% OF TOTAL	RIPARIAN COTTONWOOD	% OF TOTAL	BIG SAGEBRUSH	% OF TOTAL	MOUNTAIN MAHOGANY	% OF TOTAL	JUNIPER	% OF TOTAL
Barn Swallow					2	5				
Vesper Sparrow					11	26				
Brewer's Sparrow					2	5				
Lark Bunting					3	7	1	6		
Chipping Sparrow									10	13
Mountain Bluebird									11	14
Violet-green Swallow									4	5
Red-tailed Hawk									2	3
Black-capped Chickadee									3	4
Rock Wren							1	6	2	3
Loggerhead Shrike							1	6		
TOTAL BIRDS	117		125		43		18		79	
TOTAL SPECIES	22		20		13		10		16	

* based on two censuses in June