

ENVIRONMENTAL ASSESSMENT 1/
FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF HYDROPOWER LICENSING, DIVISION OF PROJECT REVIEW

Morris Sheppard Dam Water Power Project

FERC Project No. 1490-003--Texas
December 22, 1988

I. APPLICATION

On May 13, 1985, the Brazos River Authority (BRA) filed an application for a new license for the Morris Sheppard Dam Water Power Project (Morris Sheppard Project), an existing major project greater than 5 megawatts (MW). The BRA supplemented its application on October 31, 1985, March 24, 1986, February 24, 1987, February 26, 1987, May 29, 1987, June 22, 1987, January 4, 1988, January 21, 1988, February 12, 1988, March 15, 1988, and July 19, 1988.

The project is located on the Brazos River in Palo Pinto, Young, and Stephens Counties, 18 miles west of Mineral Wells in north-central Texas (figure 1). ^{1/} The project was constructed in 1941. The BRA presently operates the project under an annual license, having held a 50-year license issued by the Federal Power Commission on May 25, 1938.

II. RESOURCE DEVELOPMENT

A. Purpose

The proposed project would provide 37,641,000 kilowatthours of electric energy per year to the Brazos Electric Power Cooperative, Inc. (BEPC).

B. Need for Power

The primary project purpose is to provide a dependable water supply for municipal, industrial, and irrigation purposes. Hydroelectric generation, flood control, and recreational activities are secondary benefits derived from the project. The applicant has no electric facilities, generation or distribution, other than those (generation only) of the Morris Sheppard Project. The project has a rated capacity of 22.5 MW and an annual energy output of 37.6 gigawatthours (GWh). Only about 0.3 percent of the project output is needed for station service. The entire net project output is sold to the BEPC at the powerhouse bus.

^{1/} Due to reproduction requirements referenced figures have been omitted.

The BEPC has the exclusive right to use (dispatch) the hydroelectric generating facilities at the dam in, essentially, any manner consistent with the BEPC's power system needs. Typically, the facilities are used to provide peaking power, to provide replacement power during a limited down-time of a BEPC steam unit, to provide capacitive reactive kilovoltamperes, to provide spinning reserve capacity, and to off-load more costly thermal generation whenever excess flows permit.

The real need for the power produced by the Morris Sheppard Project is a current and future need of the BEPC for peaking capacity and the associated peak-load energy. Currently, the only peaking capacity available to the BEPC is the total capacity of the Morris Sheppard Project (22.5 MW) and 30 MW that is being purchased from the Southwestern Power Authority (SWPA) and produced at SWPA's Whitney Dam Hydroelectric Project. The BEPC currently needs peaking capacity, in addition to the total 52.5 MW currently being obtained from Morris Sheppard dam and Whitney dam. The BEPC has informed the staff that by 1990 additional base-load and peaking capacity, to meet forecasted load growth, would be needed in addition to the current need for peaking capacity and peak-load energy.

The BEPC informed the staff that the continued availability of peaking power from the Morris Sheppard Project has unique extra value to them since this project is located on the same river as the Whitney Dam Project. The operation of the two projects can be coordinated to maximize power production during periods of high peak demand.

To summarize, the applicant does not use the project power. Rather, the total power output is sold to a single wholesale purchaser, the BEPC, which has been using the project power over its 47 years of continuous operation. As stated earlier, the primary purpose of the Morris Sheppard Project is to provide a reliable and dependable water supply for the project area.

III. PROPOSED PROJECT AND ALTERNATIVES

A. Proposed Project

1. Project Description

The existing Morris Sheppard Project, located within the 20,000-acre project boundary, consists of the following major components: (1) a buttress-type concrete dam approximately 2,747 feet long with a maximum height of 155 feet; (2) the Possum Kingdom Lake (project reservoir), which at a normal maximum operating elevation of 1,000 feet mean sea level (msl), has a water surface area of 17,600 acres, a storage of 570,200 acre-feet, and a length of 24 river miles; (3) an intake structure;

(4) a powerhouse that is integral with the dam and that contains two 11.25-MW generators with an installed capacity of 22.5 MW; (5) a tailrace channel; and (6) appurtenant facilities (figure 2). The project does not include any transmission or distribution facilities because the BEPC takes the power directly from the powerhouse on BEPC-owned and operated transmission and distribution facilities.

The Morris Sheppard Project is operated as a peaking facility, generating to meet system power demands or when releases are required from the project to meet downstream water supply requirements.

2. Proposed Mitigative Measures

Originally, the BRA proposed no construction of new facilities and no changes to the operation of the existing project. More recently, in response to minimum flow proposals from the Department of the Interior (Interior), the Texas Parks and Wildlife Department (TPWD), and the Commission staff (memorandum of May 25, 1988), the BRA proposed to release a minimum instream flow for the protection and enhancement of fish, wildlife, recreation, and aesthetic resources in the downstream Brazos River. The proposal includes a drought contingency plan designed to reduce effects on reservoir recreation and water supply during dry years.

B. Alternative Modes of Project Operation

To protect and enhance fish, wildlife, recreation, and aesthetic resources in the Brazos River below the Morris Sheppard dam, Interior, the TPWD, the staff, and the BRA have proposed various minimum flow release regimes. Each entity recommends releasing the same amount of water; but each differs on when the minimum flow should be reduced or suspended to conserve reservoir storage and protect reservoir recreation. A description of each minimum flow proposal follows.

1. Agencies Proposal

Interior and the TPWD recommend a seasonally adjusted continuous minimum flow release of:

March through June	-	100 cfs;
July through September	-	75 cfs;
October through February	-	50 cfs.

These agencies state that during periods of below average inflow, the minimum flow requirements may need to be suspended to conserve reservoir storage. Neither of these resource agencies, however, provides a specific recommendation on when minimum flows should be suspended.

2. BRA Proposal

The BRA recommends a minimum flow release similar to that of the agencies with the addition of a drought contingency plan to protect reservoir recreation and water supply during dry years. BRA proposes the following minimum flow releases.

above reservoir elev. 997.0 ft.	- agency proposal
between elevs. 997.0 and 995.0 ft.	- 1/2 agency proposal
below reservoir elev. 995.0 ft.	- no release

The BRA also recommends that at no time would the required releases exceed the inflow to Possum Kingdom reservoir.

3. Staff Proposal

The staff recommends a minimum flow release similar to that of the agencies with the addition of a drought contingency plan that differs from that of the BRA. The staff recommends the following minimum flow releases.

above reservoir elev. 994.5 ft.	- agency proposal
between elevs. 994.5 and 990.0 ft.	- 1/2 of agency proposal
below reservoir elev. 990.0 ft.	- no release

The staff also recommends that at no time would the required releases exceed the inflow to Possum Kingdom reservoir.

C. Alternatives to Relicensing the Proposed Project

1. Issuance of An Annual License

Section 15(a) of the Federal Power Act (Act), 16 U.S.C. §808(a), provides for the issuance of annual licenses to the prior licensee if the license expires pending the relicensing determination. Under this alternative, an annual license would continue to be issued to the applicant. The annual license contains the same terms as the expired license, thereby maintaining the status quo.

2. Issuance of Nonpower License

Section 15(b) of the Act, 16 U.S.C. §808(b), authorizes the Commission to issue a license for nonpower use when the Commission "finds that in conformity with a comprehensive plan for improving or developing a waterway or waterways for beneficial public uses all or part of any licensed project should no longer be used or adapted for use for power purposes." A license that is granted by the Commission for nonpower use is temporary. When the Commission finds that a state, municipality, interstate agency, or another federal agency is authorized and willing to assume regulatory supervision of the lands and

facilities included under the nonpower license and does so, the Commission would terminate the nonpower license.

3. Denial of License Application

Denial of the license application could lead to removal of the power facilities or removal of all project works.

D. Alternative of No Action

No action on the application for a new license would result in the continued operation of the project under the annual license described above.

E. Summary of Alternative Actions

None of the three alternatives to relicensing the project is a recommended course of action. The issuance of an annual license would result in the continued operation of the existing facilities as they have operated for 50 years. This would maintain the status quo and negate the purpose of the relicensing process which is to reevaluate the project according to today's standards and procedures. If a nonpower license is issued or a new license denied, the BEPC would be forced to find a source of replacement peaking power over the short- and long-term. Over the short-term, BEPC would purchase its requirements from Texas sources, such as the City of Austin Electric Department. Over the long-term, BEPC would consider the installation of gas-fired combustion turbines and the purchase of power produced by independent power producer facilities. The use of nonrenewable, fossil-fueled generation would be more costly than the continued use of the existing project power. Therefore, these three alternatives to relicensing the proposed project are not recommended and are not evaluated further.

Implementing the no-action alternative (issuance of an annual license) would result in the continued operation of the existing facilities as they have operated for 50 years. Because this alternative would not provide for the reevaluation of the project according to today's standards and procedures, it is not recommended and not evaluated further.

Relicensing the project under one of the alternative modes of project operation is recommended and is evaluated further under Resource Analysis. Each alternative mode of operation is discussed individually under the pertinent environmental and developmental resource area, and then the alternatives are compared and one alternative is recommended.

IV. CONSULTATION AND COMPLIANCE

A. Agency Consultation

The Commission's regulations require prospective applicants to consult with the appropriate resource agencies before filing a license application. Prefiling consultation initiates compliance with the National Environmental Policy Act, Fish and Wildlife Coordination Act, Endangered Species Act, National Historic Preservation Act, and other federal statutes. Prefiling consultation must be complete and documented for the application to be accepted. After acceptance, the Commission issues a public notice and seeks formal comments in accordance with these federal statutes. All comments become part of the record and are considered during the staff's analysis of the proposed project.

The following entities commented on the application subsequent to the public notice, which was issued on March 31, 1986.

<u>Commenting entity</u>	<u>Date of letter</u>
Department of the Army, Fort Worth District Corps of Engineers	May 15, 1986
Texas Parks and Wildlife Department	May 28, 1986
	March 4, 1987
State of Texas, Office of the Governor	June 6, 1986
Department of the Interior	July 15, 1986
	August 11, 1986
Mineral Wells Chamber of Commerce	October 9, 1986
City of Breckenridge	November 4, 1986
Palo Pinto County	November 17, 1986
National Marine Fisheries Service	March 4, 1987
City of Graham	December 30, 1986

In addition to the aforementioned agencies, numerous local citizens, businesses, special interest groups, Congressmen, and Senators filed letters of comment and letters of protest subsequent to the public notice.

In addition to providing comments, organizations and individuals may petition to intervene and become a party to any subsequent proceedings. The following entities filed a motion to intervene in the proceedings.

<u>Interveners</u>	<u>Date of motion to intervene</u>
Texas Parks and Wildlife Department	May 27, 1986
Department of the Interior	August 11, 1986
P.K. Association	October 16, 1986
Texas Water Commission	February 4, 1987
State of Texas	June 27, 1988

BRA responded to interventions in supplemental filings dated June 11, 1986, July 14, 1986, August 26, 1986, and March 15, 1988.

Environmental Issues Raised by the Interveners

Texas Parks and Wildlife Department

For the protection and enhancement of fish, wildlife, recreation, and aesthetic resources, the TPWD recommends a seasonally adjusted continuous minimum flow be maintained in the Brazos River below the Morris Sheppard dam. The TPWD recommends the following minimum flows: 100 cubic feet per second (cfs) from March through June; 75 cfs from July through September; and 50 cfs from October through February.

Department of the Interior

Interior recommends that the license contain the following condition.

"The licensee shall discharge from the Morris Sheppard Dam Hydroelectric Project a continuous, minimum flow of 50 cubic feet per second from October 1 to February 28, 75 cubic feet per second from July 1 to September 30, and 100 cubic feet per second from March 1 to June 30 for the protection and enhancement of fish, wildlife, recreation, and aesthetic resources of the Brazos River. This flow may be temporarily modified, if required by operating emergencies beyond the control of the licensee, and for short periods upon mutual agreement among the licensee, the Texas Parks and Wildlife Department, and the Fish and Wildlife Service."

P.K. Association

The PKA, an unincorporated group whose members own or lease shoreline property on the reservoir, oppose any minimum flow requirement from the project reservoir. The PKA states that a minimum flow could reduce the water level in the lake, thereby reducing shoreline property values and the quality of recreation. The PKA states that these factors could cause adverse economic damage to its members, as well as the surrounding communities of Mineral Wells, Jacksboro, Graham, and Breckenridge.

Texas Water Commission and State of Texas

The Texas Water Commission and the State of Texas do not address environmental issues in their requests for intervention, but raise legal concerns regarding jurisdiction and state's rights.

B. Water Quality Certification

On October 8, 1984, the BRA requested certification of the Morris Sheppard Project under section 401 of the Clean Water Act. The Texas Department of Water Resources issued a waiver of certification on November 8, 1984.

V. RESOURCE ANALYSIS

A. General Description of the Locale

1. Brazos River Basin

The Brazos River Basin rises in eastern New Mexico and extends in a southeasterly direction across Texas to the Gulf of Mexico (figure 3). The basin has an overall length of 640 miles and a maximum width of 120 miles. The drainage area is approximately 45,662 square miles. The main tributaries of the Brazos River proceeding from the headwaters are the Double Mountain Fork, Salt Fork, Clear Fork, Paluxy River, Aquilla Creek, North Bosque River, Leon River, Little Fork, Yegua Creek, and the Navasota River.

The basin has three distinct areas--the Great Plains, the Central Lowland, and the Coastal Plain. Elevations vary from sea level to 500 feet msl in the Coastal Plain, 1,800 to 3,000 feet msl in the Central Lowland, and 500 to 4,500 feet msl in the Great Plains.

Average annual precipitation in the basin varies from 17 inches in the extreme headwater to 46 inches near the Gulf of Mexico with about 75 percent occurring during the growing season. Average annual lake surface evaporation varies from 15 inches near the coast to over 65 inches inland. Runoff over the basin varies from a trace in the extreme headwaters to about 10 inches per year near the river's mouth.

Agriculture is the principal industry in the basin with farms and ranches comprising 24,872,000 acres, or 84 percent of the area. Oil production, mining, and brick manufacturing are other industries.

The project is located in the Central Lowland area of the Brazos River Basin. The climate is subtropical with mild winters and hot summers. The average annual temperature is 64 degrees Fahrenheit (°F) with temperatures typically ranging between 10 and 110 °F. Average yearly precipitation is 28 inches; however, rainfall varies significantly both seasonally and annually.

The project area is characterized by gently rolling plains incised by the river to expose limestone bluffs. The river in the vicinity of the dam is confined by steep limestone bluffs that border the reservoir and downstream Brazos River. Upstream, the slope of the shoreline diminishes and the reservoir opens to a broad rolling prairie. Downstream, the river is confined between the bluffs for several miles before changing to rolling prairie.

Possum Kingdom reservoir is a major recreational center for northern Texas. Land use around the reservoir includes recreation, residential development, commercial establishments, agriculture, and woodland. The Brazos River below the Morris Sheppard dam is one of north-central Texas' outstanding scenic and recreational rivers. Land use along the river includes crop/pastureland, rangeland, and woodland.

2. Existing and Proposed Hydroelectric Development

There are three existing hydroelectric projects in the Brazos River Basin. The Belton Project is located on the Leon River and the Whitney Project is located 260 miles downstream of the Morris Sheppard Project on the Brazos River. The Belton and Whitney Projects were constructed by the Department of the Army, Corps of Engineers. As of July 1988, the Morris Sheppard Project is the only pending application in the basin. Because the projects are distant from each other, no resources would be affected in a cumulative manner by the existing and proposed hydroelectric development in the Brazos River Basin.

B. Environmental Resources

Because no new construction or other land disturbances are proposed, issuance of a new license for the project would have no direct or indirect adverse environmental effects on geological resources. No geological issues were raised by agencies or individuals. Therefore, geological resources are not discussed below.

1. Water Resources

Affected Environment:

a. Water Use

The Brazos River is used primarily for water supply for downstream municipal, industrial, and agricultural uses. Secondary water uses include hydropower generation and recreation. The project reservoir is part of the BRA's basinwide water supply system. Water is released to meet downstream water needs on the basis of contractual agreements and water availability.

BRA is obligated under the existing power sales contract to try to maintain the reservoir pool level above elevation 970.0 feet msl in order to maximize hydropower production. Because of the agreement in the power sales contract to try to maintain the reservoir elevation above elevation 970.0 feet msl, BRA does not include 220,000 acre-feet of reservoir storage below elevation 970.0 feet msl in the calculation of the reservoir's firm yield (Brazos River Authority, 1985). Normal project operation uses the 350,000 acre-feet of reservoir storage between elevations 995.5 and 970.0 feet msl. The total reservoir storage is 570,000 acre-feet.

The operating rule curve for the reservoir provides for the following reservoir releases: hydropower and spillway releases when the reservoir elevation is in excess of 995.5 feet msl; releases through the hydropower facility to meet power or downstream water supply needs when the reservoir elevation is between 995.5 and 970.0; and conservation of reservoir storage for water supply, with hydropower production a secondary beneficial use when the reservoir elevation is below elevation 970.0 feet msl.

The reservoir has been operated historically at a higher elevation than would be expected by the operating rule curve. BRA's efforts to conserve reservoir storage is apparent in the historical reservoir pool levels, which are typically maintained above elevation 995.0 feet msl. The median reservoir elevation is 994.5 feet msl. Since 1950, the reservoir surface elevation has dropped below elevation 985 feet msl on only three occasions. Based on the operating rule curve, reservoir elevations would be expected to drop to near elevation 970 seasonally.

b. Project Operation

The Morris Sheppard Project is operated in a peaking mode. Project releases are made from two turbines that have a total hydraulic capacity of 3,200 cfs. Releases are irregular and are made on an on-call basis to meet the power demands of the BEPC. When releases are not being made for hydropower or other project purposes, leakage from the dam of approximately 25 cfs maintains flows in the downstream Brazos River.

Flows in the Brazos River below the Morris Sheppard dam are extremely variable, ranging from a low of 0 cfs to a high of 81,700 cfs, as measured at the Geological Survey (USGS) gage near Palo Pinto. This gage has recorded flow in the Brazos River since 1925. Mean flow for the period of 1925 through 1984 is 1,010 cfs. Median flow for this period is 150 cfs. Irregular high flow events interspersed between long periods of low- or no-flow events account for the wide variation between the mean and median flows.

Construction of the Morris Sheppard dam has significantly modified the flow regime in the downstream Brazos River. The 25-cfs leakage flow provides a stable base flow. Since the construction of the dam, flows of at least 5 cfs have been recorded in the Brazos River near Palo Pinto. This is in contrast to pre-project conditions during which prolonged periods of no flow were typical on an annual basis.

Project operation rapidly modifies the quantity of flow in the downstream Brazos River. Project operation increases flows in the river from 25 to 3,200 cfs over a 20-minute period. As project operation is curtailed, flows drop abruptly for several hours or several days until hydropower operation is again resumed.

c. Water quality

The Possum Kingdom reservoir is an elongated, serpentine reservoir with many bays and inlets. From the headwaters to the dam, the reservoir is 60 miles long with 310 miles of shoreline. At the normal maximum operating elevation of 1,000 feet msl, the reservoir has a surface area of 17,600 acres and a maximum depth of 100 feet. Annual lake evaporation averages 62 inches (Farnsworth, 1982).

Inflows to the reservoir contain high levels of sodium chloride derived from natural mineral deposits in the upper Brazos River Basin. The saline inflow to the reservoir results in a chemical gradient in the reservoir with the denser, more saline water on the bottom and the less dense, fresher water, on the surface. Elevated fecal coliform bacteria and pH levels have also been observed in the tributaries to Possum Kingdom reservoir.

In addition to the chemical stratification, the reservoir is also thermally stratified from February through September (Hysmith et al., 1983). During the period of thermal stratification, the dissolved oxygen (DO) levels in the deeper portion of the reservoir are typically below 1 milligram per liter (mg/l).

Nutrient concentrations are high throughout the reservoir and account for the high primary productivity in the headwaters of the reservoir and isolated inlets. Wastewater discharge from the City of Pock Creek into the Brazos River 12 miles upstream of the reservoir contributes a small, although constant, source of nutrients to the reservoir.

The water quality of the reservoir releases is seasonally more uniform than the inflows to the reservoir. Salinity levels in the Brazos River below the dam reflect the seasonal average

inflow to the reservoir. The velocity of the discharge during peaking operation breaks down the salinity gradient in the vicinity of the intake and mixes the water throughout the water column. The mixing of water in the reservoir protects reservoir water quality by preventing the accumulation of salts in the reservoir.

State water quality standards for the Brazos River below the Morris Sheppard dam require that DO levels be at least 6.0 mg/l over a 24-hour average and at no time less than 5.0 mg/l during the spring and no less than 4.0 mg/l during the remainder of the year. DO levels in the reservoir releases are consistently below state water quality standards during periods of reservoir stratification. Releases made during the summer contain approximately 1.0 mg/l of DO. Observations indicate that DO levels increase slowly below the dam through natural aeration processes, but do not rise to the 6.0 mg/l level required by state water quality standards until about 25 miles downstream (Brazos River Authority, 1987). With the exception of DO, the releases from the Morris Sheppard dam generally comply with state water quality standards.

Environmental Impacts and Recommendations:

a. Minimum flow

The project is operated in a peaking mode of operation resulting in widely fluctuating flows in the downstream Brazos River. Variable flows alter water quality, fish habitat, and recreation resources in this downstream area (fishery and recreation resources are discussed in sections 2 and 7, respectively).

To stabilize water quality and aquatic habitat in the downstream Brazos River, the resource agencies, the BRA, and the staff recommend the following minimum flows.

March through June	-	100 cfs
July through September	-	75 cfs
October through February	-	50 cfs

The resource agencies, the BRA, and the staff do not agree, however, on when the minimum flow requirements should be suspended to conserve reservoir storage. Interior and the TPWD state that during periods of below average inflow, the minimum flow requirements may have to be suspended to conserve reservoir storage. However, neither of these resource agencies provides specific recommendations on when minimum flows should be suspended.

The BRA and the staff propose to reduce and suspend minimum

flow releases when the reservoir elevation falls to specific levels. The BRA proposes the following.

above reservoir elev. 997.0 ft. - agency proposal
 between elevs. 997.0 and 995.0 ft. - 1/2 agency proposal
 below reservoir elev. 995.0 ft. - no release

The staff proposes the following.

above reservoir elev. 994.5 ft. - agency proposal
 between elevs. 994.5 and 990.0 ft. - 1/2 agency proposal
 below reservoir elev. 990.0 ft. - no release

Both the BRA and the staff recommend that minimum flow releases not exceed reservoir inflow.

The irregular pattern of precipitation in the Brazos River Basin increases the value of reservoir storage for water supply and increases the difficulty in managing this resource. Any use of reservoir storage may reduce the available storage during periods of drought. Hydropower operation, as well as minimum flow releases, may reduce water storage or may use flows which could otherwise be used to replenish storage.

Flows released as minimum flows can typically be recaptured in BRA's downstream reservoirs. If, however, downstream storage is not available to recapture the minimum flows, they would be lost from the system. These minimum flows could, however, be withdrawn from the Brazos River by other water users prior to reaching downstream reservoirs.

During periods of low inflow, the proposed minimum flows could adversely affect water storage in the reservoir. The recommended minimum flows with provisions to protect reservoir storage during periods of below average inflow should be adopted. The BRA has operated the reservoir conservatively for the protection of reservoir storage. Based on this record of historical operation, the reservoir pool level is an appropriate indicator to determine when minimum flows should be suspended to conserve reservoir storage.

During periods of below normal precipitation, reservoir storage may also be protected by limiting the quantity of the required minimum flow so that it does not exceed the inflow to the reservoir. Leakage flows of approximately 25 cfs would maintain a constant base flow in the downstream Brazos River even when project inflows drop below 25 cfs. To protect storage in the Possum Kingdom reservoir, the minimum flow released from the Morris Sheppard dam should not exceed the inflow to the project reservoir.

With BRA's proposal, some minimum flow, above leakage, would be provided approximately 28 percent of the time based on historical operation. While this would be an improvement over the existing conditions, it would do little to improve the downstream resources. Water quality and aquatic habitat would be improved when the minimum flow is being released; but during the 72 percent of the time when no flow is being released, there would be no improvement. BRA's proposal would have little effect on the reservoir elevation. Based on a 40 year-period of record (1945-1985), BRA's proposal would reduce the reservoir elevation by 0.2 foot (see table below).

In contrast to the BRA's proposal, the staff's proposal would provide a minimum flow 74 percent of the time and would reduce the reservoir stage level by 0.4 foot. This amount of reservoir drawdown would not significantly affect the reservoir resources and would provide for significant enhancement and protection of the downstream water quality and aquatic resources by increasing and stabilizing the wetted area.

The resource agencies' proposal does not contain a specific drought contingency proposal. With no drought contingency relief, the proposal may significantly reduce the reservoir storage and would also reduce the reservoir pool level by an average of 1.5 feet. While this proposal would provide a minimum flow at all times, it would have severe adverse impacts to the reservoir water resources.

The effects of the various minimum flow proposals are described below.

Table 1. Effect of proposed minimum flow releases on Possum Kingdom Reservoir compared to historical conditions. ^{1/}

	Agencies	BRA	Staff
Change in yield (AF)	-33,700	-2,000	-3,600
Change in average stage (feet)	-1.5	-0.2	-0.4
Change in average surface area (acres)	-500	-100	-200
Percent of time some minimum flow provided	100	28	74

^{1/} Letter to Carson Hoge from Freese and Nichols, Inc., Consulting Engineers, Fort Worth, Texas, July 26, 1988.

The staff recommends that the BRA install a minimum flow outlet at the unused turbine bay and release the following minimum flows or inflow, whichever is less, from the Morris Sheppard dam: 100 cfs from March 1 through June 30; 75 cfs from July 1 through September 30; and 50 cfs from October 1 through February 28.

The minimum flow may be reduced to one-half the above value or project inflow, whichever is less, when the reservoir surface level is between elevations 994.5 and 990.0 feet msl to protect the water resources in Possum Kingdom reservoir. Leakage from the project reservoir may contribute to the required minimum flows. No minimum flow should be required when the reservoir surface level is below elevation 990.0 feet msl.

The staff recommends that the BRA develop a plan to install pool level gages in the Possum Kingdom reservoir and streamflow gages in the Brazos River downstream of the project to monitor compliance with the above minimum flow requirements.

b. Rule curve

The provision to reduce and suspend the minimum flow requirements is made because water supply is the resource of primary importance (Brazos River Authority, 1985). The existing reservoir rule curve provides for equal priority for hydropower and water supply down to reservoir elevation 970.0 feet msl. If this rationale is applied to other resource uses, the above minimum flow should also remain in effect until the reservoir elevation falls below elevation 970.0 feet msl.

Because the reservoir rule curve for the Morris Sheppard Project does not reflect the resource use priority or historical project operation, the licensee should modify the reservoir rule curve so that the reservoir storage below elevation 990.0 feet msl is reserved for water supply. Power generation should be permitted only if downstream water supply requirements are sufficient to allow hydropower as a secondary benefit. This change in the rule curve would require only minor changes in project operation and would ensure that the rule curve reflects the existing mode of operation and priority of resource use stated by BRA.

The above modification of the reservoir rule curve may require modification of the power sales contract. The modified rule curve would change how the firm yield is calculated. The entire reservoir volume would be available during periods of drought, and the reservoir firm yield would thereby increase by 220,000 acre-feet.

c. Dissolved oxygen

Water quality in the Brazos River below the Morris Sheppard dam is severely degraded by project operation. The BRA filed information in 1987 that shows that during periods of thermal stratification of the reservoir, primarily February through September, project operation releases water with DO levels less than 1 mg/l. The effects of this low DO have been observed up to 25 miles downstream. Low DO levels may severely degrade downstream water quality, aquatic habitat, and downstream aquatic biota (Environmental Protection Agency, 1986). The release of water with DO levels of 1 mg/l is lethal to all but the most tolerant aquatic species. Periodic releases of large quantities of low DO water throughout the summer have resulted in all but the most tolerant species being eliminated from the downstream pool. As DO levels in the downstream Brazos River increase, the diversity of species increases. This recovery is not complete until 25 miles downstream where DO levels reach 5.0 mg/l. Neither the BRA nor the resource agencies provided comments or recommendations on the DO levels in the releases.

The BRA and the TPWD, in consultation with the Environmental Protection Agency, are conducting a study to determine if project releases can feasibly meet state water quality standards. Based on the results of this study, the water quality standards for the Brazos River below the Morris Sheppard dam may be modified (personal communication, Steven Twidwell, Texas Water Commission, Austin, Texas, March 8, 1988).

To attempt to meet state standards, the staff recommends that the BRA take the following measures to increase DO levels in the project releases: (1) install a Howell-Bunger valve on the minimum flow outlet and adjust the valve so that water released through this valve is saturated with DO; (2) install a turbine aeration system to incorporate air into the water released through the turbines; (3) install an air diffuser system in the stilling basin to raise the DO level of the 25-cfs leakage flows to 6.0 mg/l. These measures have been found to be effective in increasing the DO levels in water releases at similar projects (Wilhelms et al., 1985; Raney, 1975; and Bohac et al., 1983).

The minimum flows recommended in the above section are integral to mitigating the project's impacts on water quality. The minimum flows released through the Howell-Bunger valve would provide a more consistent source of aerated water, than currently exists, to the large pool located immediately below the dam. In addition, the minimum flow would carry this aerated water downstream to more rapidly replenish the diminished DO levels after project operation.

These methods may not be effective at increasing the DO level in the project releases during peaking operation to the 6.0 mg/l level required by state standards. These methods are, however, expected to consistently raise the DO levels in the project releases to about 5.0 mg/l or higher. This would be a significant improvement over existing DO conditions and would substantially improve downstream aquatic resources.

Alternative measures to consistently raise the DO levels to that required by state standards are not applicable or feasible at this site because of their effects on other resources. Suspension of project operation or spilling water from the dam during project operation would be an effective means of ensuring adherence to state water quality standards. The importance of water supply and peaking power precludes these alternatives. Localized reservoir destratification (Dortch, 1979) would also be effective at raising downstream DO levels; however, this would also increase the temperature of the project releases, adversely affecting both the downstream biota and the downstream recreational resources. While the staff's recommended measures may not be effective at achieving state water quality standards at all times, the proposed mitigative measures would significantly improve the downstream DO levels and would reduce the areal extent of the depressed DO in the downstream Brazos River.

The DO levels in the project releases should be continuously monitored during project operation to determine the effectiveness of the mitigative measures. The licensee, after consultation with the TWC, should install DO and temperature monitoring devices in the Brazos River immediately below the project releases.

Unavoidable Adverse Impacts: Project operation would result in the continued release of water containing DO levels that are below state standards during periods when the reservoir is stratified. Mitigative measures would maintain higher DO levels in the project releases and would reduce the areal extent of the project's impact on DO levels in the downstream Brazos River.

2. Fishery Resources

Affected Environment: A variety of fish species inhabit the Possum Kingdom Lake and the Brazos River (Hysmith et al., 1983; Brazos River Authority, 1985; Hysmith et al., 1985). Important game fish include largemouth bass (Micropterus salmoides), spotted bass (M. punctulatus), smallmouth bass (M. dolomieu), white bass (Morone chrysops), striped bass (M. saxatilis), white bass X striped bass hybrid, yellow bass M. mississippiensis), bluegill (Lepomis macrochirus), warmouth (L. gulosus), green sunfish (L. cyanellus), bantam sunfish (L. symmetricus), redear sunfish (L. microlophus), orangespotted sunfish (L. humilis),

redbreast sunfish (L. auritus), longear sunfish (L. megalotis), spotted sunfish (L. punctatus), black crappie (Pomoxis nigromaculatus), white crappie (P. annularis), flathead catfish (Phylodictis olivaris), channel catfish (Ictalurus punctatus), and blue catfish (I. furcatus). In addition, many species of rough and forage fish, such as spotted gar (Lepisosteus oculatus), longnose gar (L. osseus), gizzard shad (Dorosoma cepedianum), threadfin shad (D. petenense), central stoneroller (Campostoma anomalum), common carp (Cyprinus carpio), Mississippi silvery minnow (Hybognathus nuchalis), plains minnow (H. placitus), speckled chub (Hybopsis aestivalis), silver chub (H. storeriana), golden shiner (Notemigonus crysoleucas), emerald shiner (Notropis atherinoides), blackspot shiner (N. atrocaudalis), pugnose minnow (N. emiliae), red shiner (N. lutrensis), sharpnose shiner (N. oxyrhynchus), silverband shiner (N. shumardi), blacktail shiner (N. venustus), mimic shiner (N. volucellus), bullhead minnow (Pimephales vigilax), river carpsucker (Carpiodes carpio), smallmouth buffalo (Ictiobus bubalus), golden redhorse (Moxostoma erythrurum), black bullhead (Ictalurus melas), yellow bullhead (I. natalis), gulf topminnow (Fundulus grandis), blackstripe killifish (F. notatus), mosquitofish (Gambusia affinis), inland silverside (Menidia beryllina), slough darter (Ethostoma gracile), orangethroat darter (E. spectabile), logperch (Percina caprodes), big scale logperch (P. macrolepida), dusky darter (P. sciera), and freshwater drum (Aplodinotus grunniens), have been collected from the Brazos River system. Both the lake and river fishery provide a valuable recreational resource for northern Texas.

Construction of the Morris Sheppard dam transformed approximately 65 miles of free-flowing riverine habitat into a lentic or lake-like system. Operation of the reservoir for water storage and hydroelectric peaking purposes changed both the seasonal and daily flow patterns, as well as water quality, in the Brazos River below the dam. When hydropower peaking operations begin, downstream flows and water levels change rapidly resulting in unstable habitat areas. As power generation ceases, many aquatic organisms can become stranded by receding waters and may succumb to desiccation or predation (Rochester et al., 1984; Nestler et al., 1986). This variation in river flows affects the habitat characteristics and the dependent fishery within the Brazos River downstream of the Morris Sheppard dam.

Many of downstream fishery habitats, particularly of shoal and riffle areas, are dependent on whether or not power generation is occurring. Because generation flows are intermittently released, the amount of continuously available habitat is limited to the amount maintained when the project is not generating and only leakage flows are provided. Such periods when only leakage flows are provided vary considerably. For example, the average monthly number of days with no turbine releases ranged from 8.7 to 20.5 days during January 1979 through

September 1984 (Brazos River Authority, 1985a). During these non-generation periods, the dependable habitat is maintained by leakage flows of 0.42 to 0.56 cubic meters per second (cms) [about 15 to 20 cfs] even though generating flows may increase river flows up to 75.5 cms [approximately 2,666 cfs] (Anderson et al., 1983).

Reservoir release patterns not only create fluctuating flow conditions but can greatly influence downstream water quality. Since Possum Kingdom Lake stratifies, releases of water withdrawn from the deep strata (hypolimnion) may have very low levels of DO. Forshage (1972) reported that, under a generating discharge of about 12,800 cfs, DO levels at the Highway 16 bridge [approximately 2 miles below the dam] were only 2.6 mg/l. Forshage's study found that DO concentrations did not rise above 6 mg/l until just upstream of the Highway 4 bridge [about 20 miles downstream]. Such water quality conditions directly impact fish growth and survival (Davis, 1987) and sometimes can become problematic. To illustrate, low DO levels were suspected to have caused a fish kill in the project tailrace on August 30, 1982 (Texas Parks and Wildlife Department, 1983); an estimated 3,064 dead fish valued at \$23,887.29 were reported.

In addition to the low DO content, water withdrawn from the hypolimnion may be substantially colder than the receiving river waters. Zimmerman et al. (1980) reported that project releases, especially during the summer months, influence water temperatures as far as 57 kilometers (km) [about 34 miles] below the dam. This study found water temperatures 1 km (about 0.6 mile) below the dam were greatly influenced by the hypolimnetic leakage flows exhibiting a maximum temperature drop of 4 degrees Celsius ($^{\circ}\text{C}$) as power generation began. The greatest temperature change occurred 30 kilometers downstream (approximately 18.63 miles) where the water temperatures dropped 7 $^{\circ}\text{C}$ over a 1-hour period. Such temperature changes can result in thermal shock and stress to aquatic organisms (Davis, 1987).

To take advantage of the cold temperatures in the tailwater, the TPWD studied a 20-mile segment of the Brazos River downstream of the project dam for its suitability as a trout fishery (Forshage, 1972). During August 1972, under a 17-cfs leakage flow, this study reported that water temperatures 6 miles downstream of the dam rose to 82 $^{\circ}\text{F}$. Although this temperature was deemed too high for trout, the study suggested that the first 4 miles of the Brazos River below the dam may contain water temperatures suitable for trout. In February 1973, the TPWD began stocking catchable-sized (minimum length approximately 8 inches) rainbow trout (*Salmo gairdneri*) in the tailwater of the Morris Sheppard dam. Stocking continued periodically throughout 1973; however, stockings during August met with limited success as water temperatures approached the trout's lethal tolerance levels (Forshage, 1975).

Presently, the trout fishery is maintained from November through April by the stocking efforts of the TPWD. Rainbow trout are planted on a put-and-take basis, concentrating most of the trout fishing effort in the 4-mile reach below the Morris Sheppard dam. In addition to the successful season trout fishery, the TPWD has periodically experimented with a variety of stocking programs within Possum Kingdom Lake. Species stocked have included the northern and Florida strains of largemouth bass, smallmouth bass, walleye (Stizostedion vitreum), striped bass, white crappie, channel catfish, warmouth and several sunfish species (Brazos River Authority, 1985a).

Environmental Impacts and Recommendations: Continued operation of the Morris Sheppard Project as a peaking facility would have adverse effects on the downstream fishery. Artificially restricted flows during periods of nongeneration reduce habitat for many fish species. Drastically fluctuating flows, which occur when project operation begins and ends, result in unstable aquatic habitat, and water temperature and DO fluctuations. These factors stress fish downstream of the reservoir, thus limiting the sport fish production and the resulting sportfishing opportunities.

The maintenance of suitable aquatic habitat for tailwater organisms, through the provision of adequate minimum flows, can substantially reduce the adverse impacts to the aquatic habitats associated with hydroelectric peaking activities (Rochester, et al., 1984; Nestler et al., 1986). During the relicensing process, an instream flow study was undertaken to evaluate the flow needs of the fishery resources downstream of the Morris Sheppard dam (Brazos River Authority, 1985a). Two study sites, located near the Highway 16 and the Highway 4 bridge crossings (sites 1 and 2, respectively), were chosen for investigation; site 1 was indicative of a riffle area whereas, site 2 typified a pool.

A computer program called HABTAT was used to model the amount of available habitat for several representative fish species under varying flow regimes. Because the model used species' habitat preference curves which were not specifically derived for the Brazos River, the BRA and Interior suggested that the model predictions of available habitat were probably underestimated. However, the model results did indicate that the habitat for many of the studied fish species showed a positive relationship to increasing flows above the amount currently provided by leakage. Tables 2 and 3 show predicted amounts of fish habitats for the two study reaches at various flows.

Table 2. Weighted usable area in feet²/1000 feet of stream at IFIM study reach 1 (Highway 16). 1/

Life Stage & Evaluation Species	Discharge (cfs)			
	20	50	80	100
Spawning:				
Spotted bass	14,280	23,443	31,423	36,061
Channel catfish	173	548	832	1,008
Gizzard shad	13,274	21,449	27,642	31,226
White bass	4,839	9,156	12,005	14,116
Fry:				
Spotted bass	2,511	4,497	5,798	6,504
Channel catfish	75,482	104,596	118,842	125,424
Gizzard shad	13,701	17,482	17,953	17,256
White bass	12,729	19,685	24,402	26,602
Juveniles:				
Spotted bass	3,220	5,193	6,322	6,828
Channel catfish	356	624	928	1,199
Gizzard shad	95	517	975	1,228
White bass	3,703	7,402	10,111	11,835
Adults:				
Spotted bass	0	91	249	366
Channel catfish	565	1,047	1,498	1,762
Gizzard shad	95	517	975	1,228
White bass	0	0	0	43

1/ Brazos River Authority, 1986.

Table 3. Weighted Usable area in feet²/1000 feet of stream at IFIM study site 2 (Highway 4). 1/

Life Stage & Evaluation Species	Discharge (cfs)			
	20	50	80	100
Spawning:				
Spotted bass	17,733	26,116	31,541	34,696
Channel catfish	0	101	221	272
Gizzard shad	16,871	26,220	31,835	34,706
White bass	6,955	13,625	18,347	20,563
Fry:				
Spotted bass	3,196	5,147	6,252	6,580
Channel catfish	79,786	93,591	99,177	101,449
Gizzard shad	4,075	3,470	3,000	2,800
White bass	17,765	25,739	29,258	30,734
Juveniles:				
Spotted bass	4,126	5,249	5,570	5,684
Channel catfish	411	729	982	1,138
Gizzard shad	0	16	239	386
White bass	3,857	7,895	10,641	12,241
Adults:				
Spotted bass	0	0	0	0
Channel catfish	386	870	1,188	1,343
Gizzard shad	0	16	239	386
White bass	0	0	0	0

1/ Brazos River Authority, 1986.

In addition to the use of the HABTAT models, the resource agencies suggested that the amount of aquatic habitat with water depths greater than one half of a foot should be studied because such areas would be suitable for the production of fish, algae, aquatic insects, and other invertebrates. Based on a seasonal evaluation of fishery flow needs, the resource agencies proposed, and the BRA agreed to the following minimum flow releases.

March through June	--	100 cfs
July through September	--	75 cfs
October through February	--	50 cfs

The proposed minimum flow regime considers the typical seasonal flow patterns as they relate to the life history stages of the resident riverine fish. For example, increased flow rates during the spring coincide with fish spawning activities. By increasing minimum flows from leakage to 100 cfs during the spring and early summer (March through June), the amount of dependable wetted stream habitat having a depth of at least 0.5 of a foot would significantly increase. Such flow releases would

double this type of habitat at study site 1 and would increase by 44 percent at study site 2 (figure 3). Therefore, providing 100 cfs should increase the amount of shallow water spawning areas in the Brazos River and should enhance reproductive conditions for the fish.

As the season progresses into the summer and early fall (July through September), records for the Brazos River indicate that streamflows decrease. Therefore, after spawning activities are completed, reducing minimum flows during the summer and early fall would mirror naturally occurring conditions. Providing a minimum flow of 75 cfs at this time would increase the amount of continuously maintained fry and juvenile habitat and may subsequently improve recruitment of these smaller fishes into the adult stage. During the remainder of the year (October through February), as water temperatures decrease with the approach of winter, the metabolism and activity level of many warmwater fishes also decreases. Subsequently, lowering the minimum streamflow down to 50 cfs during October through February would provide an adequate amount of over-wintering habitat.

The minimum flows recommended by the resource agencies and agreed to by the BRA would enhance downstream fishery habitat. As the project goes on and off-line, providing increased minimum flows could help moderate river level fluctuations resulting in a smaller change in wetted perimeter than that which occurs under the existing conditions. Under drought conditions these minimum flows would be reduced (the percentage of time in which the recommended minimum flows would be maintained is discussed in Section 1 - Water Resources). In addition to increasing the physical amount of habitat, the measures recommended in the previous section to improve the DO concentrations of the discharged waters would substantially enhance the downstream fishery by reducing stress and mortality related to low DO situations. Increased DO levels may result in better fish growth and survival (Davis, 1987).

Unavoidable Adverse Impacts: Water levels downstream of the dam would still fluctuate greatly between periods of operation and non-generation; however, provision of the recommended minimum flows would maintain a greater wetted perimeter reducing the amount of area likely to strand aquatic organisms. Despite the fact that fishes of temperate rivers and streams can endure a fairly wide range of temperatures (Hynes, 1970), some thermal stress may still occur due to rapid changes in river water temperatures during the summer.

3. Vegetation Resources

Affected Environment: The project area is within the Cross Timbers and Prairies Vegetational Area of north central Texas, which is characterized by rolling to hilly topography, oak

woodlands, and prairie. The major vegetative cover types in the project area include upland woodlands, riparian woodlands, gravel bars, savannah, pasture and cropland, and emergent wetlands.

Upland woodlands are dominated by post oak (Quercus stellata), cedar elm (Ulmus crassifolia), Texas ash (Fraxinus texensis), honey mesquite (Prosopis glandulosa) and plateau oak (Q. fusiformis). Understory species include elbow bush (Forestiera pubescens), greenbrier (Smilax sp.), pencil cactus (Opuntia leptocaulis), and grasses, including little bluestem (Schizachyrium scoparium), sideoats grama (Bouteloua curtipendula), and threeawn (Aristida spp.)

Riparian woodlands occur on moist soil along the margins of the reservoir and on the Brazos River and its tributaries. Dominant species include pecan (Carya illinoensis), cedar elm, Texas sugarberry (Celtis laevigata), black willow (Salix nigra), cottonwood (Populus deltoides), and honey mesquite. Understory species include Mexican plum (Prunus mexicana), saltcedar (Tamarix sp.), and buttonbush (Cephalanthus occidentalis). Common herbaceous species include switchgrass (Panicum virgatum), rushes (Juncus sp.), and marshelder (Iva annua).

Gravel bars generally contain the same species as riparian woodlands, but are without a developed overstory due to the flushing effect of high-water storm events. Common species include black willow, cottonwood, buttonbush, and saltcedar.

Savannahs occur in upland areas and are dominated by grasses with an open crown cover of scattered trees. Grasses include little bluestem, sideoats grama, and coastal bermudagrass (Cynodon dactylon). Trees include ashe juniper (Juniperus ashei), honey mesquite, post oak, and cedar elm.

Pasture and cropland occur on the major bends in the river both upstream and downstream of the reservoir. Native pastures are dominated by prairie grasses, such as little bluestem and sideoats grama. Cultivated pastures are usually dominated by coastal bermudagrass. Row crops grown in the study area commonly include wheat, oats, barley, and peanuts.

Emergent wetland vegetation is limited along the reservoir because the shoreline is steep and rocky. Common forms include cattail (Typha sp.), rushes, sedges (Carex spp.), and spikerush (Eleocharis sp.).

Environmental Impacts and Recommendations: The existing project originally displaced riparian habitat, pastureland, cropland, gravel bars, emergent wetlands, and limited amounts of savannah and upland woodland through inundation by the project reservoir. Over time, riparian species and emergent wetland species colonized the shoreline. Saltcedar, and to a lesser

extent, honey mesquite and cottonwood became established in the upper reaches of the reservoir where the water table remains high.

None of the three alternative modes of project operation would have an appreciable beneficial-or adverse effect on the existing plant communities because, under both the current and the proposed operating regime, the riparian communities would be limited by the high flows not the low flows.

Unavoidable Adverse Impacts: None.

4. Wildlife Resources

Affected Environment: Species of mammals associated with the project area include white-tailed deer (Odocoileus virginiana), gray fox (Urocyon cinereoargenteus), bobcat (Felis rufus), nine-banded armadillo (Dasypus novemcinctus), raccoon (Procyon lotor), striped skunk (Mephitis), black-tailed prairie dog (Cynomys ludovicianus), eastern cottontail (Sylvilagus floridanus), black-tailed jack rabbit (Lepus californicus), and opossum (Didelphis virginianus).

Avian species in the study area include mourning dove (Zenaida macroura), bobwhite quail (Colinus virginianus), wild turkey (Meleagris gallopavo), red-tailed hawk (Buteo jamaicensis), turkey vulture (Cathartes aura), great blue heron (Ardea herodias), belted kingfisher (Megaceryle alcyon), red-winged blackbird (Agelaius phoeniceus), Carolina chickadee (Parus carolinensis), and song sparrow (Melospiza melodia). Waterfowl that potentially nest within the project area include blue-winged teal (Anas discors), mallard (A. platyrhynchos), and wood duck (Aix sponsa). The reservoir serves as a resting area for migratory waterfowl.

Common reptiles in the project area include ornate box turtle (Terapene ornata), Texas greater earless lizard (Cophosaurus texana), Texas spiny lizard (Sceloporus olivaceus), diamondbacked rattlesnake (Crotalus atrox), Texas rat snake (Elaphe obsoleta), diamondback water snake (Nerodia rhombifera), and blotched water snake (N. erythrogaster).

Environmental Impacts and Recommendations: Any benefit to the aquatic community would benefit the wildlife community, especially fish-eating birds like herons and kingfishers. Any one of the three proposed alternatives would be preferable to the existing operating regime. Differences in the three alternatives would be insignificant.

Unavoidable Adverse Impacts: None.

5. Threatened and Endangered Species

Affected Environment: The project is within the range of six federally listed endangered species: the bald eagle (Haliaeetus leucocephalus), peregrine falcon (Falco peregrinus), whooping crane (Grus americana), interior least tern (Sterna albifrons), black-capped vireo (Vireo atricapilla), and black-footed ferret (Mustela nigripes). Bald eagles are known to winter in the project area; however, no recent nest sightings have been confirmed. The peregrine falcon and whooping crane are potential migrants through the project area. Occurrence of the black-footed ferret in the project area is unlikely (telephone conversation with Tom Cloud, Biologist, U.S. Fish and Wildlife Service, Fort Worth, Texas, May 24, 1988).

The project area provides potential habitat for the interior least tern and the black-capped vireo. No sightings at the project have been recorded; however, the black-capped vireo has been observed in nearby Taylor County. The interior least tern is known to inhabit reservoirs and sandbar areas and the black-capped vireo characteristically inhabits ash and juniper woodlands. These habitat types occur throughout the project area (telephone conversation with Tom Cloud, Biologist, U.S. Fish and Wildlife Service, Fort Worth, Texas, May 24, 1988).

Environmental Impacts and Recommendations: The continued operation of the project, with the addition of a proposed minimum flow release regime, would not affect any of these federally listed species. Future development, road construction, or other land-disturbing or shoreline-disturbing activities could potentially affect federally listed species; most notably the bald eagle, black-capped vireo, and interior least tern. The staff recommends that, prior to any future project construction or land-disturbing activities within the project boundary, the BRA consult with the U.S. Fish and Wildlife Service (FWS) regarding potential impacts to federally listed threatened or endangered species that may exist at the time.

Unavoidable Adverse Impacts: None.

6. Cultural Resources

Affected Environment: The applicant has provided data concerning prehistoric and historic resources in the Morris Sheppard Project area, based on available academic literature and a review of the National Register of Historic Places, records of the Texas Historical Commission, and records of the Texas Archeological Research Laboratory, Balcones Research Center.

The study boundaries included a 1,000-foot area beyond the reservoir level (1,000-foot contour) and the recreational areas

associated with the reservoir. The study area included portions of Palo Pinto and Young Counties.

Records show 102 cultural properties within the study boundaries, 85 in Palo Pinto County, and 17 in Young County. Since most of these properties were recorded prior to the establishment of the National Register, the records do not address the issue of eligibility. Complete site data needed to determine eligibility were not available for all of the sites identified within the study boundaries. Further study by the applicant to determine eligibility has not been deemed necessary. The issue is rendered moot by the fact that none of the properties would be impacted by continued use of the dam and hydroelectrical facilities (letter from LaVerne Herrington, Ph.D., Deputy State Historic Preservation Officer, Texas Historical Commission, Austin, Texas, January 28, 1985).

Environmental Impacts and Recommendations: The project is unlikely to impact National Register or eligible properties. However, the possibility that there could be significant undiscovered properties in the project area cannot be completely ruled out. If there are, they could be exposed to an adverse impact potential resulting from the project operation or modification. Therefore, if the licensee discovers such properties during the course of project operation or modification, the licensee should halt land-clearing and land-disturbing activities in the vicinity of the properties; consult with the SHPO; prepare a plan, based on consultation with the SHPO, describing the appropriate course of action, and a schedule for implementing this course of action; file the plan for Commission approval; and take the necessary steps to protect the discovered properties from further impact until notified by the Commission that all of these requirements have been satisfied.

These impact determinations are based on the project design and location, as reported in the application and in the applicant's subsequent filings. If the design or the location is altered after a license has been issued, regardless of the reason, these alterations in the project design or location would invalidate all cultural resource determinations concerning the project. Therefore, before implementing any changes to the project that would involve land-clearing or land-disturbing activities within the project area that have not already been anticipated, that have not been analyzed by the staff as to their environmental impact potential, and that have not been commented on by the SHPO, the licensee should consult with SHPO; prepare a plan, based on consultation with the SHPO, describing the appropriate course of action and a schedule for carrying it out; file the plan for Commission approval; and take no further actions that could affect National Register or eligible properties until notified by the Commission that all of these requirements have been satisfied.

Unavoidable Adverse Impacts: The proposed project has no known potential for adversely impacting properties listed on or eligible for listing on the National Register of Historic Places.

7. Recreation and Other Land and Water Uses

Affected Environment: Recreation at the Morris Sheppard Project occurs in two distinct locations: the Possum Kingdom reservoir and the Brazos River downstream of Morris Sheppard dam.

a. Possum Kingdom Reservoir

The reservoir covers 20,000 acres, has about 310 miles of scenic shoreline, and is a major recreational center for northern Texas. Recreational activities at the reservoir include boating, swimming, water skiing, fishing, camping, sightseeing, and scuba diving. In 1984, an estimated 3 million persons visited the reservoir. Of the total, approximately two-thirds were day visitors and one-third were overnight visitors. Greatest visitation occurred from May to September.

Existing recreation facilities at Possum Kingdom reservoir include 22 public use areas, 16 of which are operated totally or in part by concessionaires. The BRA provides, free of charge to the public, a scenic overlook and 6 public use areas covering 192 acres with the following facilities: 6 boat launching ramps, 3 swimming areas, 17 picnic tables, 143 designated campsites, approximately 250 informal campsites, and associated parking and restroom facilities. Over the past several years, the BRA has expanded and modernized the restroom facilities at the public use areas, added a courtesy dock for boaters, and provided controlled access on a first come, first served basis at two popular camping areas. Facilities provided by concessionaires on project lands include rental cabins, boat rentals, boat launching facilities, marinas, camping facilities, swimming areas, supply stores, restaurants, and mobile home parks. The TPWD operates and maintains the Possum Kingdom State Recreation Area, a 1,724-acre park located adjacent to the project reservoir. Recreational facilities at the park include picnic sites, a swimming area, a boat ramp, a fishing pier, and overnight camping and cabin facilities. In addition to the above public use areas, the BRA leases the following special use areas: (1) a 22-acre site operated by and for U.S. Army personnel; (2) a 150-acre site operated by the Dallas YMCA; and (3) extensive land around the periphery of the reservoir where private cottages have been developed.

Further, the BRA has reserved approximately 1,000 acres at 10 sites for future recreational development. These areas are currently used for informal, boat-in camping and picnicking. To protect the scenic, recreational, and environmental values at the

project reservoir, the BRA maintains a 25-foot-wide (measured horizontally from elevation 1,000 feet msl) buffer strip along the shoreline at developed cottage site areas and a 50-foot-wide buffer strip along the undeveloped shoreline that is reserved for future cottage site development.

To ensure public safety in its use of project lands and waters, the BRA maintains the Possum Kingdom Lake Patrol office staffed by the lake supervisor and 4 lake rangers. The BRA also provides brochures on lake regulations and a buoy and numbering system on the reservoir. To warn persons downstream of the dam and powerhouse of water releases, the BRA provides signs, fences, and a siren system.

b. Brazos River

The Brazos River below Morris Sheppard dam is considered one of the outstanding scenic and recreational rivers in north-central Texas (Texas Parks and Wildlife Department, 1974). The primary recreational activities in the 40-mile-long stretch of the Brazos River from the Morris Sheppard dam downstream to highway 180 are fishing and canoeing, with some swimming and camping. In 1984, annual visitation was estimated to be about 28,000 persons. Fishermen, taking advantage of the TPWD put-and-take trout program, are the primary users from November through April, and canoeists are the primary users during the summer.

The BRA provides parking and restroom facilities and allows public access for fishing in the tailwater area below the dam. The Texas Highway Department maintains a gravel boat ramp and a small parking area at the highway 16 bridge crossing, 2 miles downstream of the dam. With the exception of the project land immediately below the dam, all shoreline is privately owned. Public access is thus limited to the tailwater area and highway rights-of-way at the highway 16, 4, and 180 bridges. There are 2 commercial campgrounds, 1 canoe rental company, and a boy scout camp located along this portion of the river.

A 120-mile-long stretch of the Brazos River from the Possum Kingdom dam downstream to the headwaters of Lake Granbury is listed on the Nationwide Rivers Inventory for outstanding scenic, recreational, wildlife, and vegetation values. This stretch of river has been recommended for inclusion in the Texas Natural Rivers System.

Other than recreation, the primary uses of project land are hydropower generation, agriculture, woodland, and residential development. The primary use of project water is for water supply for downstream municipal, industrial, and agricultural use. Secondary water uses include hydropower generation and recreation.

Environmental Impacts and Recommendations:a. Recreation facilities

Relicensing offers the opportunity to reevaluate recreational demands in the project area and to determine if additional measures are needed to satisfy these demands. The BRA concludes, based on projections of visitation to BRA public use areas and recreational facilities requirements, that adequate project land has been reserved for future recreation development and that the existing recreation facilities at the public use areas are adequate to serve the needs of the public for the term of any new license (Brazos River Authority, 1985b). The BRA agrees to provide additional recreation facilities at the project when a need arises, but does not propose any specific measures or facilities for the enhancement of recreational opportunities at the Morris Sheppard Project at this time.

Based on the Texas Outdoor Recreation Plan (TORP), which indicates significant existing and future needs for recreation facilities in the project vicinity, Interior recommends that the BRA provide additional recreation facilities at the project at this time (letter from Bruce Blanchard, Director, Environmental Project Review, Department of the Interior, Washington, D.C., July 15, 1986).

The staff has reviewed three studies that evaluate existing and projected recreational needs in the project area. First, the TORP indicates that Region 4, the north central region where the project is located, has a critical shortage in recreation facilities and areas for all activities, except lake acreage and motorcycle trails, and that the shortage of boat ramps, campsites, fishing access, picnic tables, and swimming areas will increase over the next 10 years (Texas Parks and Wildlife Commission, 1981). Second, the BRA's biannual Licensed Hydropower Development Recreation Report filing for 1982 shows that boat ramps, picnic areas, and camping areas within the project boundary are used to 80 percent of capacity on weekends and that swimming areas are used to 90 percent of capacity (Federal Energy Regulatory Commission, 1982). Because visitation is expected to increase, use at the existing facilities would be expected to approach capacity. Third, a BRA study indicates that a total of 3 boat ramps, 57 picnic sites, and 194 campsites are needed in 1988, and that 7 boat ramps, 135 picnic sites, 459 campsites, and associated parking and restroom facilities are needed by year 2018, the term of a 30-year license (Brazos River Authority, 1985b). With the exception of picnic sites, existing facilities meet the projections for 1988, but do not meet the projections for the year 2018.

Based on these studies, the staff concludes that there is a need for additional recreation facilities at the Morris Sheppard

Project during the term of any new license. Specifically, picnic sites are needed now, and additional picnic sites, boat ramps, swimming areas, and campsites will be needed in the future. Picnic tables and fire pits or grills should be provided at the existing public use areas at the reservoir, as well as at the downstream fishing access area. A schedule should be developed for providing additional recreation facilities at the areas reserved for future recreational development.

Continued operation and maintenance of the existing recreation facilities and lands reserved for future recreational development, the provision of public safety measures, the provision of a buffer strip along the shoreline at cottage sites, and the construction of the additional recreation facilities would serve the needs of the public in the project area. Therefore, the BRA should continue to do the following: (1) operate and maintain the existing recreation facilities and the lands reserved for future recreational development; (2) provide public safety measures; and (3) provide a buffer strip along the shoreline at cottage sites. Further, the BRA should construct 40 picnic tables and 40 fire pits or grills within 1 year of issuance of the license, and should construct additional recreation facilities for boat launching, swimming, picnicking, and camping at the reservoir during the term of the license. The licensee should consult with the FWS and the TPWD to develop a plan for construction of the aforementioned recreation facilities.

b. Effect of instream flow release on recreation

When flow releases from the Morris Sheppard dam are not being made for hydropower or other project purposes, the only downstream flow is leakage, which amounts to approximately 25 cfs. This low flow adversely affects the fishery resource (section 2 - Fishery Resources) and limits the associated fishing opportunities. The low flow also reduces boating opportunities in the Brazos River below the dam because of insufficient water depth. The three minimum flow release proposals would variously affect downstream recreational fishing and boating.

The Texas Rivers Coalition (letter from Ivan L. Calhoun, Chairman, Texas Rivers Coalition, Fort Worth, Texas, October 7, 1987), the Texas Chapter of Trout Unlimited (letter from James C. Vynalek, President, Texas Chapter, and National Director, Trout Unlimited, Pleasanton, Texas, May 11, 1987), and numerous local citizens support a minimum flow release. These entities state that the aquatic habitat and subsequent recreational use would benefit greatly from increased instream flows to the Brazos River.

Originally, the BRA, the PKA, YMCA Camp Grady Spruce (letter from John Dohm, Dohm & Wolff, Dallas, Texas, September 25, 1986),

Boy Scout Camp Constantine (letter from William C. Gamble, Scout Executive, Boy Scouts of America, Dallas, Texas, September 23, 1986), the town of Mineral Wells (letter from Harold Shields, President, Mineral Wells Chamber of Commerce, Mineral Wells, Texas, October 9, 1986) and numerous residents and businesses at the reservoir opposed any minimum flow release. These entities acknowledge that additional streamflows would improve the recreational potential of the Brazos River, but they are concerned that any release would reduce the water level in the reservoir resulting in substantial adverse impacts to reservoir recreation. They state that reduced reservoir levels could cause such problems as the inability to use existing recreation facilities, reduced aesthetic appeal, increased boating hazards, less boating surface area, and adverse economic impact on businesses and homeowners. More recently, the BRA has proposed a minimum flow release with a strict drought contingency plan to protect reservoir recreation during dry years.

The staff has previously discussed in Fishery Resources (section 2) the need to provide flow releases from the dam to protect and enhance fish resources. Enhancing fish resources would result in increased sportfishing opportunities. Because there is a shortage of river-oriented recreation facilities and opportunities in north-central Texas, the additional streamflows are particularly important. The flows would improve the recreation potential of the river and satisfy some of the demand for this type of activity in the area.

Implementation of increased and dependable downstream flows would also enhance boating opportunities. Although the TORP states that the Brazos River from the Morris Sheppard dam downstream for 176 miles is permanently floatable, the quality of the recreational boating experience in the popular 20-mile-long section of the river directly below the dam depends upon water being released from the dam. Releases occur primarily during hydropower generation. If the project is not generating, the river is relatively shallow which results in exposed gravel areas that necessitate dragging or portaging canoes (Texas Parks and Wildlife Department, 1974). Interior, by letter of April 23, 1979, states that the desired minimum flow for recreational boating in the project area is 250 cfs and that the absolute minimum flow for boating is estimated at 50 cfs. The proposed minimum flows would improve the float trip by providing an additional 6 inches of water depth over many of the gravel areas.

Besides protecting and enhancing the downstream fishing and recreational boating resources, the minimum flow release would also provide an economic benefit. Based on a review of recent studies on instream flow values in the southwest (Colby, 1988), the staff determined that the recreation value of instream flow releases from the Morris Sheppard dam during low flow periods would equal approximately \$668,196.00 with the agencies proposal,

\$36,882.00 with the BRA's proposal, and \$408,078.00 with staff's proposal. This value is calculated by multiplying the acre-feet of flow augmentation in a typical year by a recreation value of \$27.00 per acre-foot (Ward, 1987).

Ward, after examining the relationship between stream flow levels, recreation use levels, and travel costs incurred by recreationists on New Mexico's Rio Chama, inferred a value of \$16.00 to \$27.00 per acre-foot for reservoir releases in the summer recreation season. The range of values is related to the level of stream flow; the lower the stream flow, the higher the value. Because a minimum flow release at Morris Sheppard dam represents a low stream flow, it was assigned a high value.

Other studies estimated the value of additional flows during low flow periods at \$21.00 to \$80.00 per acre-foot (Colby, 1988). The key findings, however, in all of these studies is: (1) that minimum flow maintenance is of value to recreationists rather than additional increments to already adequate flows; and (2) that the dollar value of instream flows can equal the dollar value of water for offstream uses such as water supply or irrigation.

The effect of the proposed minimum flows on recreation opportunities at the reservoir must also be considered. Although the BRA, the PKA, and other entities express concern that reduced aesthetic appeal, increased boating hazards, and reduced boating surface area would adversely affect recreational use of the reservoir, this does not appear to be the case. Rangers at the state park recreation area indicate that park facilities, during the 1988-89 summer season with a lake level of approximately 987 feet msl, are filled each weekend. Thus, it appears that recreationists are using the lake despite low lake levels. There are, however, two main problems caused by reduced reservoir levels. These are the inability to use some existing recreation facilities and the adverse economic impact on businesses and homeowners. Impacts to recreation facilities are discussed below and economic impacts are discussed in the section on socioeconomic considerations.

Use of the reservoir recreation facilities is dependent on maintaining a minimum reservoir level. Most water-oriented recreation facilities are designed to remain functional at water levels between elevations 1,000.0 feet msl and 990.0 feet msl. The use of some recreation facilities becomes impaired, however, below elevation 995.0 feet msl. The BRA states that no piers, 448 boat docks, and 5 boat ramps would be unusable at elevation 995.0 feet msl; while an additional 147 piers, 354 boat docks, and 61 boat ramps would be unusable at elevation 990.0 feet msl (memo from Pete Pullen, Water Resource Division Manager, Brazos River Authority, Waco, Texas, March 2, 1988).

Because of recent reservoir drawdowns due to dam safety, many of the aforementioned facilities have been adapted for use at lower water levels. The Possum Kingdom Lake Economic Survey, which was conducted when the lake was at elevation 987.0 feet msl, shows that 80 percent of the residents surveyed do not anticipate any future costs to adjust recreation facilities to a more frequently changing lake level (Research and Planning Consultants, Inc., 1988). From observations during a site visit on June 16 and 17, 1988, recreation facilities at the BRA public use areas, with the exception of a gas dock and a fishing pier, and recreation facilities at the state recreation area have been adapted for use at lake levels of 990.0 feet msl. Recreational use of the reservoir continues at this level.

The recreation facilities that appear to be most impaired at elevation 990.0 feet msl are boat docks and piers at private homes and commercial areas located in the coves and upper reaches of the reservoir. In these areas, the shoreline gradient is mild, which results in a small change in reservoir elevation having a significant effect on the facilities. From time to time, these properties have been adversely affected during historical operation of the project (see table 4). The percent of increase in time that these facilities would be unusable is crucial in determining the level of adverse impact on reservoir recreation facilities.

Based on a 40-year period of record (1945-1985), the reservoir has fallen below the 990-foot-level approximately 23.8 percent of the time. With the flow release schedule proposed by the agencies, the reservoir level would fall below 990.0 feet msl 31.1 percent of the time, an increase of 7.3 percent over historic levels (Brazos River Authority, 1988). With the BRA's proposal, the lake would fall below 990.0 feet msl approximately 24.3 percent of the time, an increase of 0.5 percent over historic levels. With staff's proposal, the lake level would fall below 990.0 feet msl 25.4 percent of the time, an increase of 1.6 percent over historic levels (see table 4).

A comparison of the percent of time instream flows would be released, thus enhancing downstream recreation, and the percent of time the pool would fall below 990.0 feet msl, thus adversely affecting reservoir recreation, under each of the proposed minimum flow regimes, shows that the staff's minimum flow proposal would benefit downstream recreation with minimal adverse effect on reservoir recreation. The effect on recreation facilities and recreational use of the reservoir from the 1.6 percent increase, over historic levels, in the amount of time the reservoir would fall below 990.0 feet msl would be minor. The benefits to downstream recreation from instream flows being released almost 75 percent of the time would be significant. Because there is an abundance of reservoir recreation in north-central Texas and a shortage of river-oriented recreation and

because staff's proposal would enhance downstream recreational opportunities with minimal adverse impact on reservoir recreation, the staff's minimum flow proposal is recommended. This proposal would serve the needs of the recreation public in the project area.

Table 4. Effect of Proposed Minimum Flow Releases on Recreation.

	Historic	Agencies	BRA	Staff
Percent time instream flow released	0	100	28	74
Percent time pool below 990 feet <u>1/</u>	23.8	31.1	24.3	25.4
Percent time pool below 995 feet <u>1/2/</u>	51.8	59.7	53.5	56.5
Value of flow augmentation <u>3/</u>	none	\$668,196	\$36,882	\$408,078

1/ Personal communication, Thomas Gooch, Freese and Nichols, Fort Worth, Texas, December 20, 1988.

2/ Although staff believes 990.0 feet msl is the critical reservoir stage at which reservoir recreation is adversely affected, the BRA and the PKA are concerned that reservoir recreation begins to be impaired when the reservoir falls below elevation 995.0 feet msl. Because of this concern, figures on the percent of time the reservoir would fall below elevation 995.0 feet msl have been included.

3/ Ward, 1987.

c. Effect of rapid flow fluctuations on public safety

Current project operation causes rapid flow fluctuations immediately downstream of the dam. When project generation begins, the river rises 2 to 3 feet in 20 minutes. This rapid flow fluctuation creates a potentially dangerous condition for recreationists below the dam. The rapidly rising water can strand recreationists on islands in the river. The faster river currents can cause boaters to capsize or be swept into overhanging trees or bridge abutments. The BRA has provided safety measures, consisting of signs, fences, and a siren system,

to warn persons downstream of the dam and powerhouse prior to any water release.

Neither the BRA nor the agencies have provided any recommendations to reduce rapid flow fluctuations. The recommended minimum flow releases would moderate somewhat the flow fluctuations below the dam; however, flow fluctuations would continue to pose a safety hazard to recreationists below the dam. Because the project's safety record does not indicate that the flow fluctuations have caused accidents, there is no need to change project operation to reduce flow fluctuations. There is, however, evidence that occasional stranding or capsizing has resulted in rescue efforts by the lake rangers (personal communication, Weldon Newman, Manager, Possum Kingdom reservoir, Texas, June 16, 1988). To increase the public's awareness of the flow fluctuations, the staff recommends that the BRA include a phone number for public information on the water release schedule on all signs at public access points. For the safety of the public below the dam, the BRA should continue to provide signs, fences, and a siren warning system.

Unavoidable Adverse Impacts: The agencies' minimum flow release proposal would have a moderate, adverse effect on reservoir recreation facilities. The staff's minimum flow release proposal would have a minor, adverse effect on reservoir recreation facilities. Rapid flow fluctuations when project generation begins would continue to pose a minor safety hazard to recreationists below the dam.

8. Socioeconomic Considerations

Affected Environment: The populations of Palo Pinto, Young and Stephens counties are 26,000, 21,300, and 10,900, respectively. On the average, the population increased 10 percent between 1980 and 1984 (Rand McNally, 1986). Major cities in the project area include Mineral Wells with a population of 14,468, Graham with a population of 7,477, Breckenridge with a population of 6,922, and Jacksboro with a population of 4,000. The project is located 32 miles from the Dallas-Fort Worth metropolitan area with a total population of 1,289,000.

Agriculture is the principal industry in the area with farms and ranches comprising 84 percent of the surrounding area. Agriculture is diversified; major crops are cotton, grain, sorghum, rice, peanuts, forage crops, hay, pecans, and many types of vegetables. Dairying, livestock and poultry raising, and the production of wool and mohair are also important agricultural industries.

Production and processing of crude oil, including petrochemicals, comprise the major non-agricultural industry. Brick

manufacturing is a significant, though secondary non-agricultural industry.

Mineral deposits in the area consist of petroleum, natural gas, gravel, stone, sand, bromide, magnesium, chloride, salt, lime, sulphur, graphite, clays, gypsum, and shell (Federal Energy Regulatory Commission, 1980).

Environmental Impacts and Recommendations: Mitigative measures would require the installation of a new outlet for the minimum flow releases and would alter project operation. The effects of these actions are described below.

Based on comparable projects, an average of 10 construction workers would be employed at the project site to install the minimum flow outlet structure at the existing dam. Most personnel would commute daily from residences in Mineral Wells. A few workers would be nonlocals who would commute on a weekly basis, occupying a motel room or a trailer in the area during the workweek and spending weekends at their permanent residences. The earnings of local workers and the spending of all personnel at retail and service establishments in Palo Pinto county would benefit the local economy. In addition, the project contractor undoubtedly would purchase some equipment and material from local suppliers, thus providing additional, short-term economic benefits.

The PKA and numerous individuals originally stated that any minimum flow release from the dam would result in significant, adverse economic effects on property owners and businesses around Possum Kingdom reservoir. More recently, the PKA urged the adoption of the BRA minimum flow proposal stating that the lake level elevations at which the minimum flows would be reduced and suspended were acceptable. The PKA states that at a lake elevation of 995.0 feet msl, there is no substantial impairment of lake uses, and that a lake elevation of 990.0 feet msl causes severe physical and economic hardship to the public.

These comments are based on the anticipated lowering of the reservoir pool level causing lower visitation and diminished property values. Each of the three minimum flow proposals would reduce the average stage of the pool from the historical conditions. The agencies' proposal would reduce the average stage by 1.5 feet, the BRA proposal would reduce the average stage by 0.2 feet, and the staff proposal would reduce the average stage by 0.4 feet.

A reduction in the average reservoir stage by 1.5 feet, as would occur with the agencies' proposal, would cause moderate, adverse effects on the economic well-being of some homeowners and businesses. As discussed previously (section 7 - Recreation Resources), those most affected would be private homes and

commercial areas located in the coves and upper reaches of the reservoir. Although all proposed minimum flows would reduce the reservoir pool level causing adverse effects on some homeowners and businesses, a reduction of either 0.2 feet or 0.4 feet, beyond historical conditions, as would occur with either the BRA or the staff proposal would cause only minor, adverse effects. The small reduction in the reservoir surface elevation with either the BRA or staff proposal would have little effect on reservoir visitation and property values.

The PKA states that the proposed minimum flows would adversely affect the towns of Mineral Wells, Graham, Breckenridge, and Jacksboro. The towns of Jacksboro, Breckenridge, and Graham are located closer to other recreational reservoirs that more directly affect their economics than does Possum Kingdom reservoir. Mineral Wells, however, would be affected by changes in project operation. The staff's proposed minimum flow release would increase downstream recreational opportunities with little effect on reservoir recreation (section 7 - Recreation Resources). It is expected, therefore, that total visitation to the Possum Kingdom area would increase. This increase in visitation would have a positive economic benefit on the town of Mineral Wells.

Unavoidable Adverse Impacts: The agencies' proposal would have moderate, adverse effects on the economic well-being of some homeowners and businesses. Both the BRA and the staff's minimum flow release proposal would have a minor, adverse effect on the socioeconomic conditions at the reservoir.

C. Developmental Resources

1. Power Generation

Affected Environment: The main purpose of the project is to provide a source of dependable water supply. Power generation is a secondary benefit. The BRA generates power with all flows that are released from the Morris Sheppard dam to meet downstream water demand. The project generates an average of 37.6 GWh annually which is sold to the BEPC.

The BEPC has the exclusive right to use the hydroelectric generating facilities at the dam in essentially any manner consistent with the BEPC's power system needs. The facilities are used to provide peaking power, to provide replacement power during a limited down-time of a BEPC steam unit, to provide capacitive reactive kilovolt-amperes, to provide spinning reserve capacity, and to off-load more costly thermal generation whenever excess flows permit.

The BEPC states that the continued availability of peaking power from the project has a unique extra value because this

project is located on the same river as the Whitney Dam Project and the dispatch of power from the two projects can be coordinated under BEPC control, and because the BRA can, to a significant extent, schedule the release of water to conform with the BEPC peaking power requirements. During periods of high peak demand, the released water can be used twice by operating both power facilities at the same time.

Developmental Impacts and Recommendations: There are three proposals for minimum flow releases from the project for downstream enhancement: the agencies proposal, the BRA proposal, and the staff proposal (section III.B. - Alternative Modes of Project Operation). These proposals have been analyzed based on historic operational data of the reservoir for the period of July 1945 through December 1985 using a comprehensive computer program developed by the BRA. The impacts of the three proposals are summarized below in terms of loss of power generation.

Table 5. Hypothetical power losses for agencies, BRA, and staff minimum flow proposals based on years 1945-1985. 1/

Power Generation	Agencies	BRA	Staff
Amount (kWh)	845,000	243,000	443,000
Value <u>2/</u>	\$33,800	\$9,720	\$17,720
Percent <u>3/</u>	2.2	0.6	1.2

1/ Staff, from data in letter to Carson Hoge from Freese and Nichols, Inc., Consulting Engineers, Fort Worth, Texas, July 26, 1988.

2/ Purchase of replacement power from Austin Electric Department at 40 mills per kWh.

3/ Based on annual generation of 37,641,000 kWh.

The agencies' proposal would have the greatest impact on power generation, the BRA proposal would have the least impact, and the staff proposal would have a moderate impact. All proposals would, however, reduce generation by only a small percentage of the total generation (i.e. 0.6 to 2.2 percent).

The three proposals would result in less power for sale to BEPC. In the short term, the BEPC would have to replace the shortfall of power by purchasing replacement power from the city of Austin Electric Department. Over the long term, the BEPC would have to consider the installation of gas-fired combustion

turbines and the purchase of power from independent power producing facilities.

The three proposals would increase, to a varying degree, the consumption of nonrenewable fossil fuels used to generate replacement power and would increase the emission of noxious byproducts caused by the combustion of fossil fuels. The agencies' proposal would result in the additional consumption of 520 tons of coal or 8,800,000 cubic feet of natural gas annually in a fossil fuel generation system. The BRA's proposal would result in an additional consumption of about 150 tons of coal or 2,500,000 cubic feet of natural gas and the staff's proposal would result in an additional consumption of about 270 tons of coal or 4,600,000 cubic feet of natural gas in a fossil fuel generation system annually.

Staff concludes that the loss of power generation and increase in consumption of nonrenewable fossil fuels that would result from any of the proposals would be relatively insignificant.

Unavoidable Adverse Impacts: The three proposals would result, to varying degrees, in less power for sale to BEPC. Generation of replacement power would result in additional consumption of nonrenewable fossil fuels.

2. Water Supply

Affected Environment: The main purpose of the Morris Sheppard Project is to provide a source of dependable water supply. The BRA has evaluated the dependable yield from its reservoir system. BRA defines dependable yield as the amount of water which can be withdrawn from a reservoir during each year of the most severe drought of record without exhausting the supply under conditions that are expected to prevail in the year 2020. Dependable yield is not the average yield or average flow released from the project. BRA used the period October 1950 through April 1953 for the most critical period for the Possum Kingdom reservoir.

There are eleven reservoirs in BRA's system. BRA has five reservoirs (Lakes Aquilla, Granger, Proctor, Georgetown, and Limestone) that have their entire dependable yield committed for local water supply needs. The other six reservoirs (Possum Kingdom, Granbury, Belton, Stillhouse Hollow, Somerville, and Whitney) in BRA's system have a cumulative dependable yield of 456,276 acre-feet. BRA has long-term, local commitments for 193,457 acre-feet and long-term, system commitments for 256,625 acre-feet from these six reservoirs. These commitments total 450,082 acre-feet, which leaves a balance of 6,194 acre-feet of uncommitted system water from these six reservoirs.

Possum Kingdom reservoir water supply commitments range from 2 acre-feet per year to 45,000 acre-feet per year (memorandum on commitments to supply water from Possum Kingdom, Brazos River Authority, June 17, 1987). The water is used for various purposes, including domestic water supply, agricultural irrigation, mining operations, fish hatchery operations, and steam-electric power plant operations. The users include individuals, farms, ranches, municipalities, industry, electric utilities, and the TPWD's fish hatchery.

Developmental Impacts and Recommendations: As previously stated, there are three proposals for minimum flow releases from the project for downstream enhancement. These proposals have been analyzed based on historic operational data of the reservoir for the period of July 1945 through December 1985 using a comprehensive computer program developed by the BRA. The impacts of the three proposals are summarized below in terms of loss of dependable yield.

Table 6. Hypothetical water supply losses for agencies, BRA, and staff minimum flow proposals based on years 1945-1985. 1/

Water supply - Dependable yield	Agencies	BRA	Staff
Amount (AF)	33,700	2,000	3,600
Value <u>2/</u>	\$4,044,000	\$240,000	\$432,000
Percent <u>3/</u>	21.5	1.3	2.3

1/ Staff, from data in letter to Carson Hoge from Freese and Nichols, Inc., Consulting Engineers, Fort Worth, Texas, July 26, 1988.

2/ 1988 price for water sold under long-term contract at \$120 per acre-foot.

3/ Based on dependable yield of 157,100 acre-feet per year.

Because there is insufficient uncommitted system water to meet the agencies' minimum flow release proposal, the agencies proposal would reduce the long-term dependable yield of the reservoir and would result in a shortage of 27,506 AF of water needed to meet existing commitments. There is, however, currently sufficient uncommitted system water to meet the minimum flow release amounts for the BRA's and the staff's proposals. Because it is likely that the demand for water will increase in the future, however, the availability of uncommitted water may be reduced to zero.

The BRA cannot predict future rainfall and runoff. Hence, BRA must operate its reservoir system as if a new drought were to commence at the end of runoff from every rainfall. Additionally, the Brazos River basin is so large that one portion of the basin can have a surplus of surface runoff when another portion of the basin has a shortage of runoff. Such a condition would impact BRA's system reservoir operation because releases could only be made from certain reservoirs to meet downstream user needs.

The BRA's most likely alternative to replace a loss of dependable yield would be to construct a new dam and water supply reservoir for replacement water. The impacts of constructing a new dam and water supply reservoir would affect fish resources, terrestrial habitat, riparian habitat, aesthetics, recreation, water quality, cultural resources, and local economics. Additionally, there would likely be opposition to the construction of a new dam.

The staff believes the loss of dependable yield from the agencies' proposal is significant; therefore, the agencies' proposal is unacceptable. Despite the existence of sufficient quantity of currently uncommitted water to meet the BRA and the staff minimum flow proposal, there is the potential for significant impacts on dependable water supply because of future water needs. To protect future dependable water supply yield, minimum flow releases for downstream enhancement should be minimized. Because the BRA proposal minimizes the downstream flow releases, it would have the least adverse effect on water supply.

Unavoidable Adverse Impacts: The BRA would suffer, to a varying degree with the three proposals, a loss of dependable yield water supply.

D. Comprehensive Development - A Comparison of Alternative Modes of Project Operation

Section 4(e) of the Act states that in deciding whether to issue a license, the Commission, in addition to the power and development purposes of the project, shall give equal consideration to the purposes of energy conservation, of the protection, mitigation of, damage to, and enhancement of, fish and wildlife, of the protection of recreational opportunities, and of the preservation of other aspects of environmental quality. Further the Act in section 10(a) states that the project adopted shall be such that in the judgement of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water power development, for the adequate protection, utilization, and enhancement of fish and wildlife

(including related spawning grounds and habitat), and for other beneficial public uses, including irrigation, flood control, water supply, and recreational and other purposes discussed in section 4(e).

This assessment evaluates the effect of project operation on the environmental resources of the project area and provides a discussion of mitigative measures that should be implemented to protect and enhance these environmental resources. Mitigative measures include minimum flow releases below the Morris Sheppard dam, measures to raise DO levels below the dam, measures to protect endangered species and cultural resources prior to any future land-disturbing activities in the project area, and the construction of recreation facilities to meet public demand. While implementing most of the mitigative measures would protect and enhance the environmental resources of the project area without conflicting with other resources, the provision of a minimum flow release below the Morris Sheppard dam could conflict with reservoir recreation and socioeconomic conditions, power generation, and water supply.

The minimum flows required to protect and enhance the flow-dependent resources below the dam would result in reduced power production and a lowered lake level that could cause adverse effects on reservoir recreation, economic conditions of reservoir businesses and homeowners, and water supply. The beneficial effects include an increased amount and quality of downstream fishery habitat, increased fish production, and enhanced downstream recreational opportunities.

Because these beneficial effects are considered important, the agencies, the BRA, and the staff each recommended minimum flow releases. The three proposals recommend the same flow releases. The proposals differ, however, on when the minimum flows should be suspended to protect reservoir recreation and socioeconomic conditions, power production, and water supply.

To determine the best comprehensive development for the area, the amount of time minimum flows would be released, thus benefiting downstream resources, was compared to the adverse effects of the releases on reservoir recreation and socioeconomic conditions, power production, and water supply. Table 7 makes this comparison. The adverse impacts are based on a comparison with historical reservoir operation between the years 1945 and 1985.

Table 7. A comparison of the effects of the minimum flow release proposals on the Brazos River below Morris Sheppard dam and on Possum Kingdom reservoir.

Beneficial effects to downstream resources	Agencies	BRA	Staff
Percent time minimum flow released	100	28	74
Recreation value of minimum flow	\$668,196	\$36,882	\$408,078
Adverse effects to reservoir resources			
Percent increase in time pool is below 990 feet msl	7.3	0.5	1.6
Change in average stage (feet)	-1.5	-0.2	-0.4
Loss of power generation (kWh)	845,000	243,000	443,000
Value of generation loss	\$33,800	\$9,720	\$17,720
Percent of total generation	2.2	0.6	1.2
Loss of dependable yield (AF)	33,700	2,000	3,600
Value of yield loss	\$4,044,000	\$240,000	\$432,000
Percent of total yield	21.5	1.3	2.3

Because the agencies' proposal does not contain a drought contingency provision (see section III.B.), it would provide the greatest protection and enhancement of downstream resources; but, it would also result in the greatest adverse effects on reservoir resources. Because the agencies' proposal would reduce the lake level below 990 feet msl an additional 7.3 percent of the time, it would cause moderate, adverse impacts on reservoir recreation facilities, and homeowners and businesses who depend on that lake

level for use of their facilities. In addition, staff has determined that the loss of 21.5 percent of the total dependable yield water supply, which would occur with the agencies' proposal, is significant (see section V.C.2.). Although the agencies' proposal would reduce power generation by the greatest amount of any proposal, staff considers the loss of 2.2 percent of the total generation to be relatively insignificant (see section V.C.1.). Despite the increased protection and enhancement of downstream resources, the agencies proposal does not represent the most comprehensive use of the resources because of the significant adverse effects on the reservoir resources.

The BRA's proposal with its strict drought contingency provision (see section III.B.) would result in the least protection and enhancement of the downstream resources; but, it would cause the fewest adverse effects on the reservoir resources. With BRA's proposal, some minimum flow would be provided 28 percent of the time. Staff believes that this would do little to improve downstream resources (see section V.B.1). A reduction of the lake level below 990 feet msl, an additional 0.5 percent of the time, and a loss of 0.6 percent of the total power generation would cause a very minor impact on reservoir recreation, homeowners, businesses, and power production. Although staff considers any loss of dependable yield water supply to be significant, staff considers that BRA's proposal has the least adverse effect on water supply because it minimizes downstream flow releases (see section V.C.2.). Despite the very minor effects of BRA's proposal on reservoir resources, the BRA proposal does not represent the most comprehensive use of the resources because it does little to enhance the downstream resources.

The staff's proposal with its less restrictive drought contingency provision (see section III.B.) would result in a significant level of protection and enhancement of the downstream resources; and a minor impact on reservoir resources and water supply. Downstream flows would be provided 74 percent of the time, lake levels would be reduced below 990 feet msl an additional 1.6 percent of the time, power production would be reduced by 1.2 percent, and dependable yield water supply would be reduced by 2.3 percent. The staff has determined that this small reduction in lake level elevation would have little effect on reservoir recreation, homeowners, and businesses (see sections V.B.7. and V.B.8.). The staff has determined that the loss of power production would be insignificant (see section V.C.1.). Although the staff believes that the loss of dependable yield water supply is significant, the significance is based on future needs (see section V.C.2.). Because there is currently sufficient uncommitted system water to meet the minimum flow releases recommended in the staff's proposal, the staff believes the beneficial effects to the flow-dependent resources from increased flows below the Morris Sheppard dam would be of

sufficient magnitude to offset any potential future adverse effects to water supply. Therefore, the staff's minimum flow proposal represents the most comprehensive use of the resources.

E. Recommended Alternative

Issuing a new license for the existing project is the preferred alternative because electricity generated from a renewable resource would be used, thus lessening the use of existing fossil-fueled, steam-electric plants, and because the proposed mitigative measures would decrease the environmental effects of continued operation of the project.

VI. FINDING OF NO SIGNIFICANT IMPACT

Project operation would result in the continued release, during periods when the reservoir is stratified, of water containing DO levels below state standards. Mitigative measures would increase DO levels in the project releases and would reduce the areal extent of the project's impact on downstream water quality and related aquatic resources.

Water levels downstream of the dam would still fluctuate greatly; however, the recommended minimum flows would maintain a greater wetted perimeter reducing the amount of area likely to strand aquatic organisms. Some thermal stress may still occur due to rapid changes in river water temperatures during the summer.

Increasing the minimum flow below the Morris Sheppard dam would improve river recreation opportunities; however, it would have a minor, adverse impact on reservoir recreation and the economic well-being of some homeowners and businesses. Rapid flow fluctuations below the dam would continue to pose a minor potential safety hazard to recreationists.

This environmental assessment was prepared in accordance with the National Environmental Policy Act of 1969. On the basis of the record and of the staff's independent environmental analysis, issuing a new license for the Morris Sheppard Project would not constitute a major federal action significantly affecting the quality of the human environment.

VII. LITERATURE CITED

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