RECOMMENDATION TO PROHIBIT
CONSTRUCTION OF THE BIG RIVER RESERVOIR
PURSUANT TO SECTION 404(c) OF THE CLEAN WATER ACT

U.S. Environmental Protection Agency
Region I

October 1989

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I. INTRODUCTION

This decision recommends prohibiting construction of the Big River reservoir, a 3400 acre water supply impoundment, in Kent County, Rhode Island. The reservoir, which has at separate times been proposed by the U.S. Army Corps of Engineers and the State of Rhode Island would cause serious environmental damage. It would destroy 575 acres of valuable wetlands, eliminate 17 miles of streams, many containing cold water fisheries, worsen downstream water quality, and cause substantial adverse impacts to the recreational values of the site. It would also threaten the viability of an additional 700 to 800 acres of wetlands by depriving them of groundwater and surface water.

The proposed reservoir has been controversial and has generated substantial public opposition. I have carefully considered the record developed by EPA and the Corps in this case, including public comments, information presented at the public hearing, and submissions by other federal and state agencies. For the reasons described below, I have determined that the filling and inundation of wetlands and waters for the purpose of building the impoundment would be likely to have unacceptable adverse effects on wildlife habitat and recreation. Therefore, I recommend that EPA prohibit the discharge of dredged or fill material into Big River, Mishnock River, and their tributaries and adjacent wetlands for the purpose of constructing the proposed Big River reservoir and its ancillary facilities. This determination applies to the proposals of both the Corps and the State.

Construction of the project would involve the placement of soil and other fill material into Big River and its adjacent wetlands. Section 404(c) of the Clean Water Act (CWA, 33 U.S.C. § 1251 et seq.), authorizes the Administrator of the Environmental Protection Agency (EPA) to prohibit or restrict the use of any defined area as a disposal site, whenever he determines, after notice and opportunity for public hearing, that the discharge of dredged or fill materials into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds, fishery areas (including spawning and breeding areas), wildlife, or recreational areas. Before making such a determination, the Administrator must provide opportunity for consultation with the Chief of the Army Corps of Engineers, the property owner(s), and the applicant(s) in cases where there has been application for a Section 404 permit.

EPA's regulations at 40 C.F.R. Part 231 establish procedures to be followed in exercising §404(c) authority. The process consists of four steps: The Regional Administrator's notice to the Corps, the property owner, and applicant (if any); the Regional Administrator's proposed decision to prohibit or restrict the use of a site; the Regional Administrator's recommendation to prohibit or restrict use of the site; and the Administrator's final decision to affirm, modify, or rescind the regional recommendation. The

Administrator has delegated the authority to make a final decision under Section 404(c) to the Assistant Administrator for Water, EPA's national Section 404 program manager.

This document, the third step in the process, explains the basis for my recommendation. The next section describes the proposed Big River reservoir and summarizes the history of the project. Section III describes the environmental characteristics of the project area and the overall Big River watershed, and Section IV examines the impact of the proposed reservoir on the site. In keeping with the environmental attributes protected by section 404(c), the document focuses primarily on the significance of the site for fish and wildlife, and recreation, and the impacts the project would cause to those values. Section V analyzes the need for the project and the alternatives available to constructing the proposed reservoir. Section VI presents my conclusions and recommendation to prohibit construction of the project. The three appendices contain technical information in support of this recommended determination.

II. PROJECT DESCRIPTION AND HISTORY

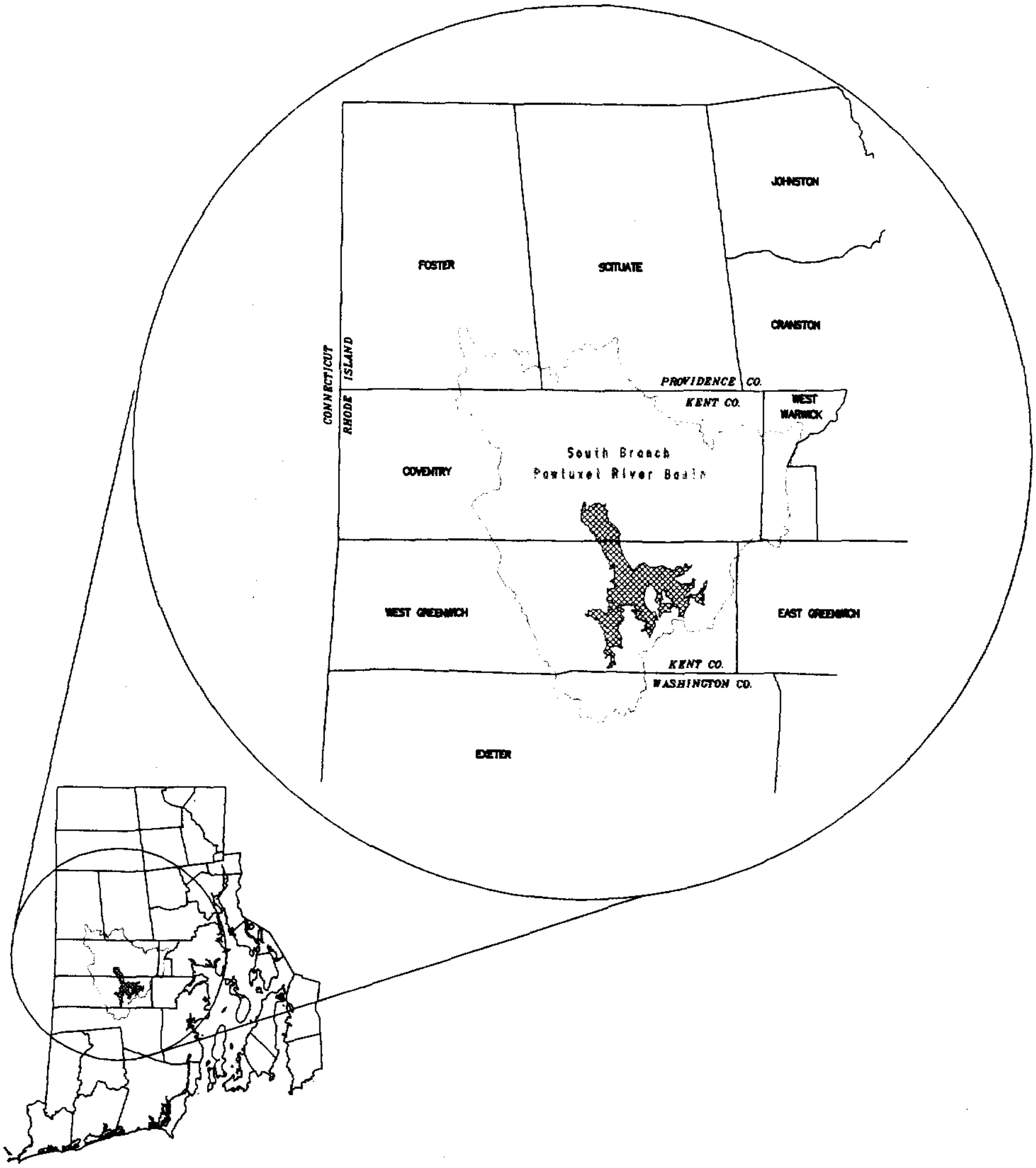
The Big River is located in south central Rhode Island. It originates in Exeter, Rhode Island and flows north to the Flat River reservoir, the site of the proposed dam, in Coventry, Rhode Island. The impoundment would be located primarily in West Greenwich, and would be crossed by Interstate 95 south of the dam. Figures 1 and 2 show the location of the proposed reservoir, and Figure 3 shows a cross section of the proposed dam.

As discussed in greater detail below, both the State and the Corps have, at different times, proposed to build a dam across Big River to create a reservoir. The proposals differ slightly, in that the State has proposed a water supply impoundment only, whereas the Corps has proposed a water supply impoundment that would also provide some flood control and recreation. The two proposals are, however, very similar in their project dimensions, site characteristics, and impacts. This recommended decision focuses on the reservoir as conceived under either proposal.

To construct the reservoir, dredged and fill material would be discharged into Big River to form a 70 foot high dam and create a 3,400 acre impoundment, with an average water depth of 25 feet. The reservoir would produce 27 or 32 million gallons a day (MGD) of potable water, as estimated by the State and the Corps, respectively. A slurry wall built down to bedrock in the northeast portion of the proposed reservoir would intercept approximately 3 MGD of groundwater that enters Mishnock Lake; the slurry wall would also block additional groundwater that now replenishes Mishnock swamp and aquifer. Mishnock aquifer and swamp, located outside of the Big River watershed approximately 1/2 mile northeast of the proposed reservoir, receive a considerable amount of water from the proposed reservoir site. A treatment plant, built adjacent to the proposed reservoir on 51 acres of land, would transport water through a 96" diameter rock tunnel approximately 6 miles to an existing distribution system.

The impoundment would inundate approximately 575 acres of wetlands and 17 miles of free flowing streams. Another 700 to 800 acres of wetlands could suffer adverse impacts due to deprivation of groundwater and the reduction of flows downstream in the South Branch of the Pawtuxet River. Site preparation and flooding would destroy more than 2,500 acres of terrestrial forest and relocate six roadways, 300 structures, numerous graveyards, and several dump sites.

According to state estimates, the project would cost at least $282 million, not including costs for operation and maintenance, a closed drainage system for I-95, environmental studies, and mitigation for wildlife impacts, downstream water quality impacts, and recreational losses. Under the Corps proposal the federal government would construct less than half of the project and fund



LOCATION OF PROPOSED BIG RIVER RESERVOIR, RHODE ISLAND

Figure 2

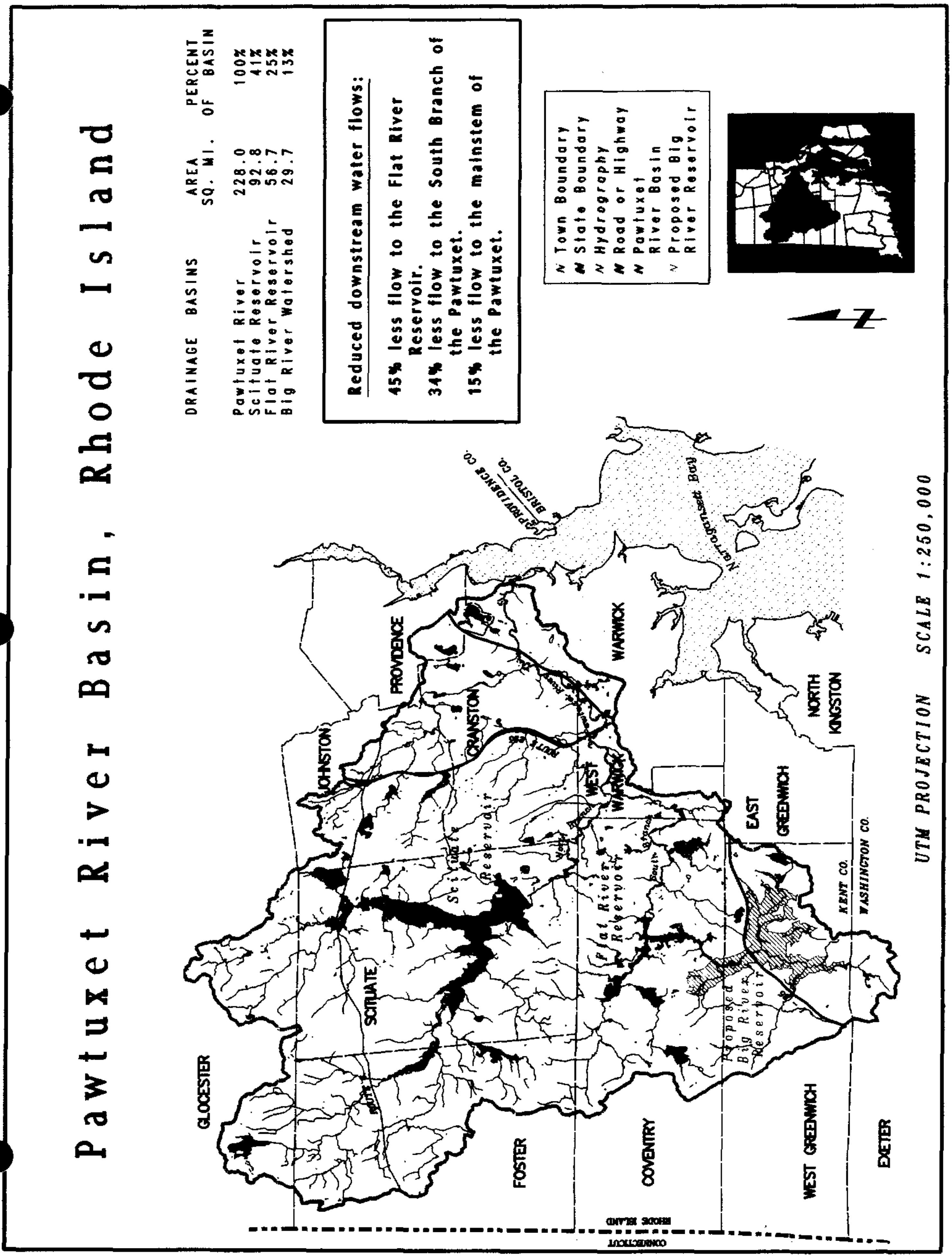
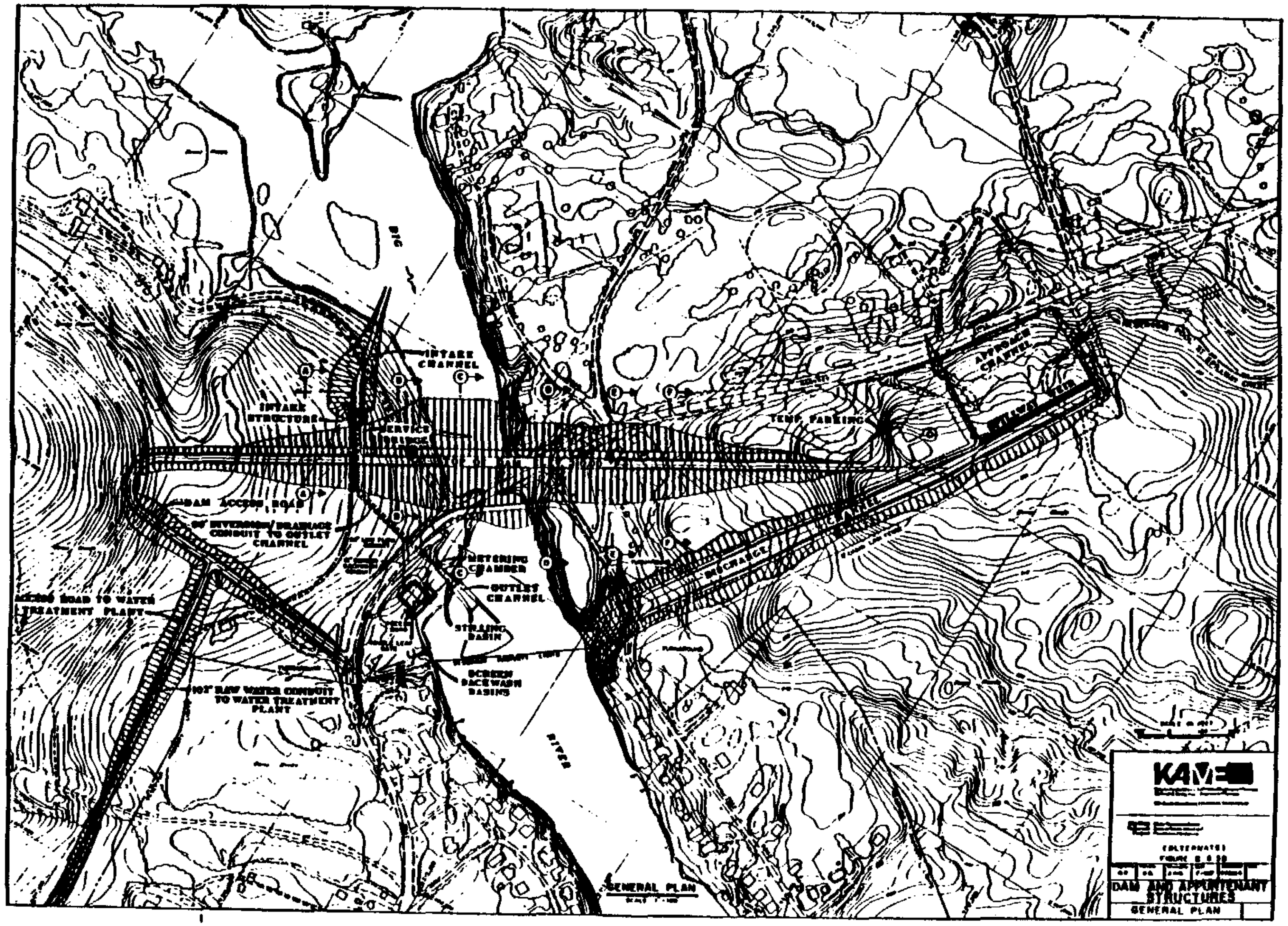

Pawtuxet River Basin, Rhode Island
DRAINAGE BASINS
AREA SQ. MI.
PERCENT OF BASIN
Pawtuxet River 228.0 100%
Scituate Reservoir 92.8 41%
Flat River Reservoir 56.7 25%
Big River Watershed 29.7 13%
Reduced downstream water flows:
45% less flow to the Flat River Reservoir.
34% less flow to the South Branch of the Pawtuxet.
15% less flow to the mainstem of the Pawtuxet.
Town Boundary
State Boundary
Hydrography
Road or Highway
Pawtuxet River Basin
Proposed Big River Reservoir
N
PROVIDENCE CO.
BRISTOL CO.
Narragansett Bay
PROVIDENCE
WARWICK
CRANSTON
JOHNSTON
WEST WARWICK
NORTH KINGSTON
EAST GREENWICH
KENT CO.
WASHINGTON CO.
Scituate Reservoir
Flat River Reservoir
Proposed Big River Reservoir
GLOCESTER
SCITUATE
FOSTER
COVENTRY
WEST GREENWICH
EXETER
RHODE ISLAND
CONNECTICUT
UTM PROJECTION SCALE 1:250,000

Figure 3: Big River Dam (Source: KAME 1984)



less than 50% of the initial cost. Most of that expenditure would be reimbursed by the State, resulting in a federal share of approximately 2% - 5%.

During the 1960's the State of Rhode Island acquired over 8,000 acres of land surrounding Big River in anticipation of building a reservoir. In 1978, having failed several times to secure funding to complete engineering studies, Rhode Island asked the Corps to consider constructing the reservoir as part of a federal flood control project. The Corps completed an Environmental Impact Statement (EIS) on the reservoir project in 1981, which concluded among other things that the project would cause a "significant disruption of the food chain and the chemical, physical, and biological integrity of the aquatic ecosystem." In 1982, EPA alerted the Corps that because of the adverse wetland impacts, the project could not comply with the §404(b)(1) Guidelines, the primary federal regulations that protect wetlands.

Congress authorized the project as part of the Omnibus Water Resources Development Act of 1986, contingent upon the completion of additional wildlife mitigation studies no later than November 17, 1987. The Corps has not done these additional studies. Later in 1986, Rhode Island decided that it again wished to pursue the reservoir as a state project and subsequently applied to the Corps for a federal §404 permit. The Corps in 1987 determined that a supplemental EIS would be required to address alternatives, mitigation, downstream water quality impacts, and a number of other unresolved issues surrounding the project.

During 1987 and 1988, EPA voiced its concerns about the adverse environmental impacts of the reservoir proposal and warned the State that the project could not comply with section 404 requirements. By December 1987 EPA identified the Big River reservoir as a candidate for a section 404(c) veto and urged the State to abandon the project. EPA also recommended that the State thoroughly analyze the need for and alternatives to the project. In a June 6, 1988 letter EPA urged the Corps to deny the permit because the project would cause significant degradation of the aquatic environment which could not be adequately mitigated. The Corps agreed and on July 1, 1988 sent a letter to Rhode Island's Governor DiPrete stating that the project as proposed would cause significant impacts to the aquatic environment, would not comply with the §404(b)(1) Guidelines, and probably could not receive a federal §404 permit. However, during an August 11, 1988 meeting, the Corps indicated to Governor DiPrete that the Big River reservoir might again become a federal project, thereby avoiding the need to acquire a permit, if the State so desired.

On August 24, 1988, EPA's Regional Administrator informed the Rhode Island Water Resources Board, the Governor, and the Corps that he intended to begin a §404(c) action because he believed that the project may have unacceptable adverse impacts to wildlife and fisheries. Pursuant to 40 C.F.R. §231.3, a 15-day opportunity for consultation ensued, which ended on September 9, 1988. Neither the State nor the Corps chose to consult with EPA. Instead, the State on September 1, 1988 officially asked the Corps to build the dam. The State withdrew its §404 permit application to the Corps on September 8, 1988.

Following the consultation period, the Regional Administrator took the next step in the §404(c) process and signed a proposed determination to prohibit the use of Big River, Mishnock River, and their tributaries and adjacent wetlands for use as disposal sites. In accordance with 40 C.F.R. § 231.3(a)(2), EPA published notice of the proposed determination in the Federal Register on February 1, 1989 (54 Fed. Reg. 5133), and published a summary of the proposed determination in the Providence Journal and the Pawtuxet Valley Times on February 3, 1989. The notice established a public comment period from February 1, 1989 through July 31, 1989 and indicated that a public hearing would be held. Notice of the public hearing was published in the Federal Register on May 2, 1989.

EPA conducted the public hearing at Coventry High School on June 8, 1989. Approximately 200 people attended the three-hour hearing. Thirty-seven people spoke at the hearing, thirty-three of whom expressed opposition to the reservoir and support for EPA's proposed prohibition. Several of these speakers urged EPA to move forward promptly to prohibit the project. Three people representing the State and one person representing Senator Claiborne Pell requested EPA to refrain from making a final §404(c) decision until after Rhode Island completes a new study of statewide water supply needs and alternatives to meet those needs.

The public comment period ended on July 31, 1989. EPA received 219 comments. An overwhelming majority (88%) of those who responded opposed the reservoir on environmental or economic grounds. Roughly 6% favored construction of the reservoir citing a belief that it would be needed at some point. The remaining 5% were undecided. The Corps did not submit a formal comment on EPA's proposed action.[1] The U.S. Fish and Wildlife Service provided detailed information about the effects the reservoir would have on fish and wildlife resources in the area, which is attached as Appendix II. A number of environmental groups also submitted comments concerning the impact of the project and provided specific information about the existence of practicable alternatives. The

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[1] The Corps did, however, inform EPA on June 30, 1989 of the conclusion reached by the Assistant Secretary of the Army for Civil Works that the Big River Reservoir is not exempt, under §404(r) of the Clean Water Act from EPA's §404(c) authority. The applicability of §404(r) to this project had previously been an issue in this case.

State did not submit additional comments after the public hearing except for the Rhode Island Department of Environmental Management, Division of Groundwater and Freshwater Wetlands, which informed EPA in writing that if the Rhode Island Water Resources Board applied for a state permit to build the dam, it would likely be denied.

During the §404(c) public comment period, Governor DiPrete formed the Rhode Island Water Resources Coordinating Council, and directed it to develop an analysis of statewide water needs and evaluate supply and demand alternatives for meeting future needs. The State initially planned to complete its analysis by the close of EPA's §404(c) comment period. On April 5, 1989, the Governor informed EPA that additional time would be needed to conduct the study. A consultant has since been retained, and the State currently expects the study to be complete in March 1990.

As noted above EPA received requests both to complete a §404(c) decision promptly and to postpone its decision until after the State completes its study. I have decided to move forward with the process for several reasons. EPA proposed to prohibit the project primarily because of the serious environmental damage it would cause; the record developed to date documents the adverse environmental impacts from the project, especially to wetlands. There is also considerable information in the record which indicates that these impacts are avoidable. Since I have concluded that the adverse impacts of the project would likely be unacceptable, nothing would be gained by delaying the §404(c) process. Moreover, before issuing a final decision, EPA headquarters will provide the State with an opportunity for further consultation. EPA supports Rhode Island's decision to conduct a comprehensive review and planning effort concerning its statewide water policies and needs. Indeed, for the past several years EPA has urged the State to abandon the Big River reservoir and instead undertake an analysis of this type. EPA Region I believes the state study, if properly conducted, will assist Rhode Island in formulating a rational and environmentally acceptable approach to water supply issues. The study should be especially useful to the State in evaluating future options if EPA headquarters affirms my recommendation, concludes that the environmental impacts of the Big River reservoir would be unacceptable, and prohibits construction of the project.

III. SITE DESCRIPTION

The Big River watershed is an outstanding natural resource. Because of its large size, abundance of habitat types, and relative lack of disturbance, the watershed supports large and diverse wildlife communities. The richest wildlife habitat is found within the area to be flooded by the reservoir. Over 100 species of breeding birds and 25 species of mammals have been observed at the site; over 30 species of reptiles and amphibians have been observed or can be reasonably expected to occur at the site.[2] Approximately 100 additional bird and some mammal species feed and rest at the site during migration and in winter. Because of continued urbanization and fragmentation of natural areas throughout southern New England, the large contiguous tracts of land in the Big River watershed provide essential and increasingly scarce habitat for many sensitive and rare species.

The proposed Big River reservoir impoundment area (3,400 acres), is part of the 29.7 square mile Big River watershed. The State owns the land in the proposed impoundment area along with an additional 4,600 acres of adjacent lands. This 8,000 acre parcel comprises the Big River management area (Figure 4). Big River watershed drains into the 228 square mile Pawtuxet River Basin which in turn empties into Narragansett Bay. The wetlands along Big River, Mishnock swamp and the South Branch of the Pawtuxet River form the largest wetland complex (over 1400 acres) in the Pawtuxet River basin and remain relatively unaltered by development or other human intrusions.

The largest wetlands in the proposed impoundment area border Big River and six tributary streams scattered throughout the site: Carr River, Bear Brook, Nooseneck Brook, Congdon River, Mud Bottom Brook, and Sweet Pond Brook. Variable topography and hydrology produce a diverse mixture of interspersed wetland and upland habitats. This allows the ecosystem to support a broad range of aquatic, semi-aquatic, and terrestrial wildlife communities. Vertical stratification of the herbaceous, shrub and tree layers in the wetland and upland communities is complex. Hence, a wide array of fish and wildlife species use the area for resting, breeding, rearing, and feeding, and as a travel corridor within the watershed and to adjacent habitat patches. The streams transport organic material from upstream areas in the watershed to the floodplain wetlands, providing food web production for on-site and

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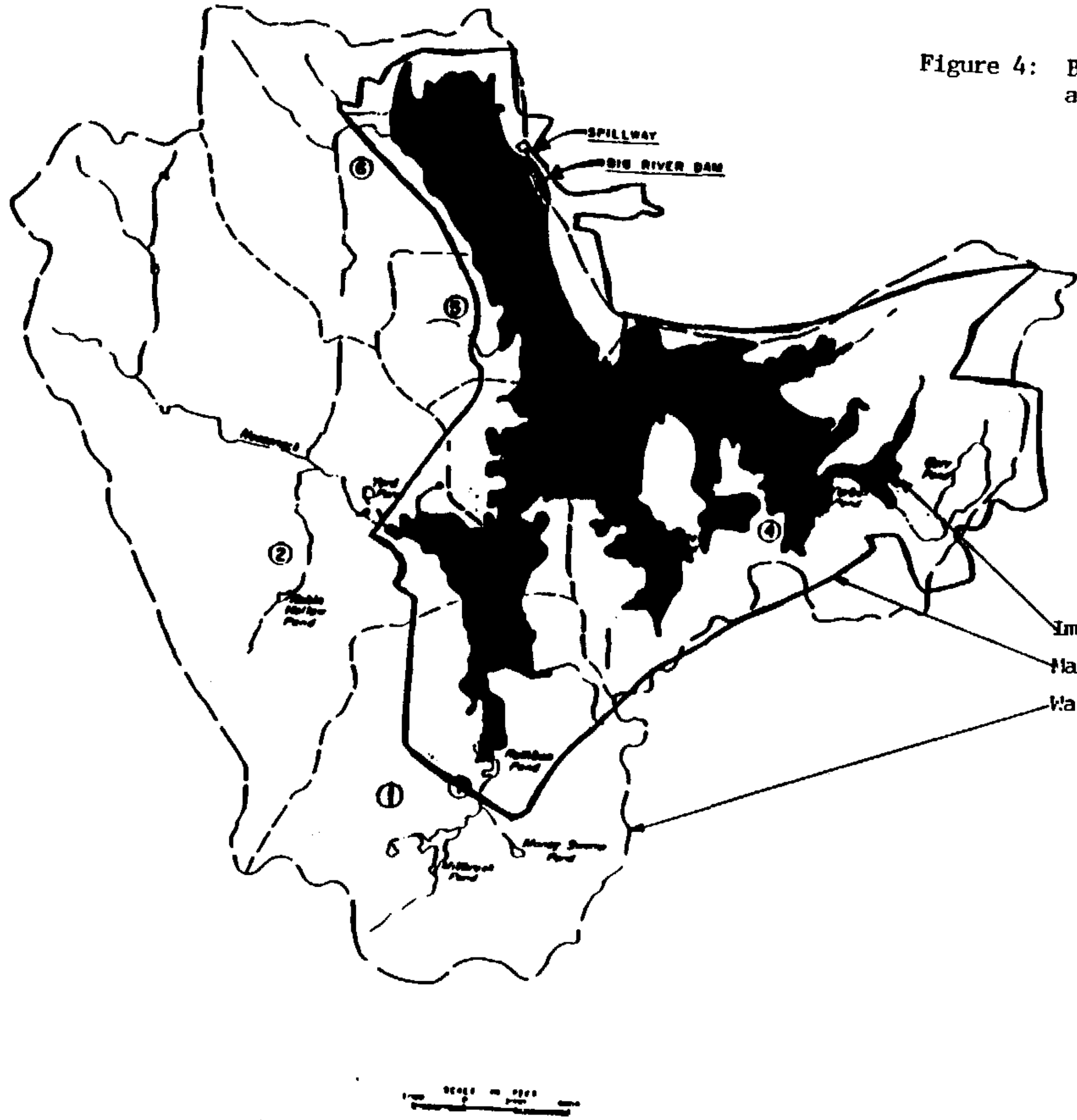
[2] Over 90% of the reported wildlife species observations occurred with in the limits of the proposed Big River impoundment area; however, occasional observations were made in parts of the management area outside of the pool area. EPA expects all species found in the management area to utilize the impoundment area, since all cover types are represented.

Figure 4: Big River Watershed, Management Area and Impoundment Area

BASIN SUB-DIVISIONS		
AREA	DESCRIPTION	DRAINAGE AREA (SQUARE MILES)
1	CONGDON RIVER	5.82
2	NOOSENECK RIVER	8.06
3	BIG RIVER BETWEEN NOOSENECK AND CARR RIVERS	1.28
4	CARRR RIVER	7.11
5	BIG RIVER BETWEEN CARR RIVER AND BEAR BROOK	1.72
6	BEAR BROOK	4.21



downstream biological communities. The riverine wetlands also assimilate nutrients and pollutants, store floodwaters, and moderate flow.

People hunt, fish and enjoy other recreational activities in the wetlands and upland habitats in the project area. The Big River site contains numerous ponds and 17 miles of streams, the majority of which support cold water fisheries. Immediately downstream, the Flat River Reservoir contains substantial warm water fisheries. As the only free flowing river remaining in the Pawtuxet River basin, Big River has the potential to provide additional recreational opportunities uncommon in Rhode Island.

A) Site Ecology[3]

Land Use. Over 15,000 acres of forest dominate the 19,000 acre Big River watershed (RI Water Res. Brd. 1986). Wetlands and deep water habitats comprise the second largest land type (1,729 acres)(URI 1984), while agricultural land (580 acres), roadways (330 acres), and residential areas (310 acres) account for the remaining land use acreage in the watershed (RI Water Res. Brd. 1986). The predominance of forest and wetland acreage and scarcity of disturbed areas within the watershed illustrate the relatively unaltered nature of the area.

The proposed impoundment area has a high percentage of wetlands. While the impoundment would occupy 17% of the land in the watershed, it would contain 33% of the total wetland area in the watershed. The diverse structure of the wetlands and deep water habitats along Big River is evidenced by the 14 different wetland vegetative subclasses and life-form characteristics present (URI 1984). The hydrologic and geographic locations of the wetlands vary as well; they cross intermittent and perennial streams, border open water habitats, occur on river floodplains and as isolated units (RI Water Res. Brd. 1986). Over three-quarters of the wetlands in the impoundment area are riparian systems, i.e., associated with riverine floodplain or streambank ecosystems (Figure 5). The highest quality wetlands in the impoundment area are listed in Table 1.

Forested and shrub wetlands are the most prevalent type of wetland in the impoundment area. Deciduous and evergreen forested wetlands comprise 56% (323 acres) of the wetland and open water habitats. The largest forested wetlands are riparian and occur in contiguous tracts. Red maple (Acer rubrum) dominates in deciduous swamps with

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[3] In the preparation of this recommended determination, EPA Region I retained the services of Dr. Curt Griffin, a professor of wildlife ecology at the University of Massachusetts. Dr. Griffin assisted in evaluating the environmental characteristics of the site and the proposed project's impacts.

Figure 5

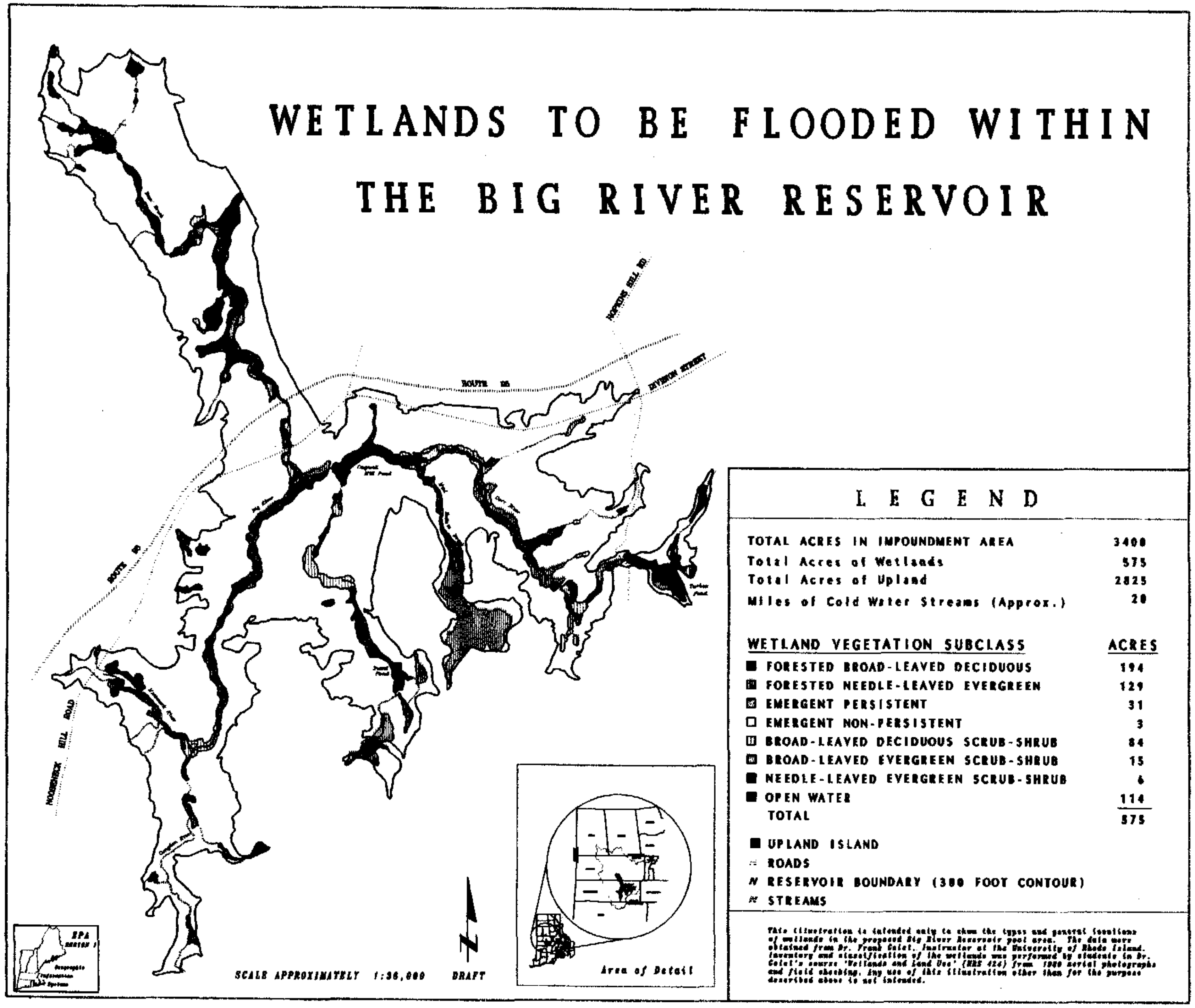
WETLANDS TO BE FLOODED WITHIN
THE BIG RIVER RESERVOIR
LEGEND
TOTAL ACRES IN IMPOUNDMENT AREA 3400
Total Acres of Wetlands 575
Total Acres of Upland 2825
Miles of Cold Water Streams (Approx.) 20
WETLAND VEGETATION SUBCLASS ACRES
FORESTED BROAD-LEAVED DECIDUOUS 194
FORESTED NEEDLE-LEAVED EVERGREEN 129
EMERGENT PERSISTENT 31
EMERGENT NON-PERSISTENT 3
BROAD-LEAVED DECIDUOUS SCRUB-SHRUB 84
BROAD-LEAVED EVERGREEN SCRUB-SHRUB 15
NEEDLE-LEAVED EVERGREEN SCRUB-SHRUB 6
OPEN WATER 114
TOTAL 575
UPLAND ISLAND
ROADS
RESERVOIR BOUNDARY (300 FOOT CONTOUR)
STREAMS
This illustration is intended only to show the types and general locations of wetlands in the proposed Big River Reservoir pool area. The data were obtained from Dr. Frank Golet, Instructor at the University of Rhode Island. Inventory and classification of the wetlands was performed by students in Dr. Golet's course 'Wetlands and Land Use' (NRS 424) from 1980 aerial photographs and field checking. Any use of this illustration other than for the purpose described above is not intended.
NOOSENECK HILL ROAD
DIVISION STREET
Area of Detail
SCALE APPROXIMATELY 1:36,000
DRAFT

Table 1: High Quality Wetlands in the Big River Impoundment Area

Wetland	Description *
Carr River Floodplain	Top scoring in watershed, 81 acres ±, diverse, class rich; good interspersion and hydrological connection, bottom streamside location classes include PSS1s, PSS4s, PSS3c, PFO1, P4O4, R2OWH, L1OWH, L2EM2b.
Mud Bottom Brook	Large, 98 acres ±, abuts Capwell Mill Pond. Classes include PSS1s/r, PFO1, PFO4c.
Unnamed, Located East of Burnt Sawmill Road	Associated with perennial stream from Sweet Pond to Capewell Mill Pond. Classes include PSS1s/r, PFO1, PFO4.
Big River Floodplains located south of route 95 and Route 3	91 acres ±, class rich, good hydrological connection bottom streamside location. Classes include PSS1s/r, PFO1, PFO4, R2OWH, POW, PSS4s.
Big River Floodplain located just north of Route 95	Second highest scoring wetland in watershed, 34 acres ±, class rich, good hydrological connection and edge, bottom streamside location. Encompasses lower two coves of Big River. Classes include R2OW, PEM1n, PFO1, PFO4.
Big River Floodplain located west side of Big River, North of Reynolds Pond	Bottom streamside location, good position to other wetlands. Marsh vegetation dominant, 7.5 acres ±, classes include PSS36, PEM1n, PFO1.
Bear Swamp Cove and Big River Floodplain	Third highest scoring wetland in watershed, bottom streamside location, good hydrological connection and cover. Class and subclass rich, forested vegetation dominant. Classes include R3OWH, PFO1, PEM1n, PEMS, PSS1s/t, PEM/ow. Possibly some evergreen bog.
Bear Brook Floodplain Wetland	Bottom streamside location 14 acres ±, linear wetland dominated by red maple. Classes include PFO1, POWH.
Nooseneck River Floodplain	Bottom streamside location, linear wetland dominated by red maple. Classes include PFO1, PSSIE

* classification symbols after Cowardin (1979)

Source: Water Resources Board (1986)

Atlantic white cedar (Chamaecyparis thyoides) dominant in evergreen wetlands. The Rhode Island Natural Heritage Program considers the riparian cedar swamp along the Carr River to be the most outstanding community of its type in the State (R. Enser, RI Natural Heritage Program, pers. comm., 1989).

Shrub wetlands comprise 105 acres of the impoundment site. Shrub species that commonly occur include highbush blueberry (Vaccinium corymbosum), speckled alder (Alnus rugosa), winterberry (Ilex verticillata), sweet pepperbush (Clethra alnifolia), leatherleaf (Chamaedaphne calyculata), and Atlantic white cedar saplings (RI Water Res. Brd. 1986). These shrub wetlands occur along rivers and streams, and along edges of ponds. Deep water lakes and open water systems at the impoundment site comprise 114 acres. These streams, lakes and ponds support considerable cold and warm water fisheries (RI Water Res. Brd. 1986).

Emergent wetlands (marshes, wet meadows, and fens) constitute 34 acres of the impoundment area which represents 62 percent of the emergent wetlands of the watershed (URI 1984). Vegetated with both persistent and non-persistent emergents, typical plants include tussock sedge (Carex stricta), bayonet rush (Juncus militaris), rice cutgrass (Leersia oryzoides), and a variety of other rushes. Emergent wetlands provide high habitat value for waterfowl and other waterbirds and are an uncommon wetland type in the State (Tiner 1989).

The Big River impoundment area also contains approximately 2,500 acres of forest, consisting of both deciduous and coniferous communities, which often appear in mixed forest stands. The evergreen forest consists of white pine (Pinus strobus) and pitch pine (Pinus rigida) as pure stands or in combination with each other. White pine is common, whereas pitch pine is considered by the Rhode Island Natural Heritage Program to be an unusual and distinct habitat type within Rhode Island. These pitch pine communities also provide important habitat for two state threatened wildlife species, the buck moth (Hemileuca maia), and the Nashville warbler (Vermivora ruficapilla) (RI Water Res. Brd. 1986). The deciduous forest stands are generally mixtures of beech (Fagus grandifolia), red maple, white oak (Quercus alba), red oak (Quercus borealis), and black oak (Quercus velutina). These species provide important wildlife habitat, especially the oaks, which provide large acorn mast for wildlife food and abundant cavities in standing dead trees.

Habitat Values. The majority of the wetlands in the impoundment area border a complex system of streams. These riparian communities combine the attributes of aquatic and terrestrial ecosystems, and provide extensive linear ecotones. Complex vegetative structure combines with the fluctuating water levels to provide essential support for abundant riparian fish and wildlife communities. These features include: (1) predominance of woody plant communities; (2) presence of surface water, wet soils and a abundance of nutrients from overbank flooding; (3) close proximity of diverse structural features (live and dead vegetation, water bodies, unvegetated substrates) resulting in extensive edge and structural heterogeneity; and (4) distribution in long corridors that provide pathways for migration and movement of animals between habitats (Brinson et al. 1981). This combination of water and varied vegetation, unique to riparian ecosystems, provide abundant food, cover, water and which support large and diverse fish and wildlife populations in the Big River impoundment area.

Woody plants are essential for almost all of the animals, except fish, at the Big River site. For example, more than half of the birds at the Big River site depend on vegetation, directly or indirectly, for food, including nuts and seeds or insects which feed on plants. Almost all birds depend on vegetation for cover, resting, or isolation during breeding season. Even water birds such as wood duck and great blue heron need vegetation cover and nesting, and primarily feed in water less than 20" deep.

Periodic flooding of riparian wetlands, in conjunction with micro-topographic changes in the landscape, cause differential hydrologic regimes which results in diverse patterns of plant communities and life forms. Thus, trees, shrubs, dead vegetation, marshes, and open waterbodies are interspersed and in close proximity to each other. Overbank flooding deposits nutrients and material carried by Big River into adjacent wetlands. The timing and duration of flooding produces a seasonal dimension to the landscape which allows a range of aquatic, semi-aquatic and terrestrial species to all utilize the site. In addition, water moving in streams and wetlands transports organic matter to the floodplain thereby promoting productivity and energy flow in the ecosystem.

The Big River management area is linked hydrologically and biologically with a much larger area. A portion of the litterfall and detritus produced within the productive riparian habitat along Big River is transported and made available to instream and downstream aquatic communities. Areas immediately downstream, including Flat River Reservoir, receive organic material from the Big River watershed. However, numerous dams limit the transport of material to Narragansett Bay. The Big River watershed supplies surface and groundwater to over 800 additional acres of wetlands, including Mishnock swamp (500 acres) and wetlands along the South Branch of the Pawtuxet River (300 acres) (RI Water Res. Brd. 1986).

The long, linear riparian habitats along the streams in the impoundment area and the undisturbed natural habitats of the watershed serve as important corridors for resident and migratory animals to move within the watershed and to nearby habitat blocks. The continuity of these habitats, especially the riparian systems, enhances the ability of the site to maintain viable wildlife populations. Genetic variation persists because genetic material is exchanged freely among animals moving within the large habitat blocks. Dispersing animals recolonize areas which have suffered from local extinctions. Carnivores such as river otter, fisher and bobcat, which require large home range sizes, freely move between habitat blocks along the extensive riparian corridors. The remainder of the watershed, encompassing nearly 30 square miles, is also relatively unfragmented by development and human disturbance, a critical factor to the many area-sensitive wildlife species which depend on large contiguous tracts. Further, recruitment and replacement individuals likely emigrate from the watershed to colonize smaller fragmented habitats nearby.

In summary, the wetland and upland communities in the Big River management area provide the full spectrum of natural resource values. The wetlands are large and varied and interspersed with extensive upland forested habitats. This interspersion of habitats, in combination with the complex vertical stratification of plant communities provide outstanding fish and wildlife habitat. The riparian wetlands also serve as important corridors for wildlife movement within and between the watershed and adjacent areas. Moreover, the wetland and upland habitats of the watershed are relatively unaltered by development and provide large contiguous natural habitats for many area-sensitive species. Both the overall diversity of the fish and wildlife communities and the presence of rare species underscore the integrity of the watershed. The actual observations of wildlife at the site, discussed below, strongly corroborate these predicted high wildlife habitat values.

B) Fish and Wildlife

Recent field surveys of birds, mammals, herptiles, fish and invertebrates in the Big River impoundment area reveal high species diversity and the occurrence of numerous rare and area-sensitive species (Appendix II). On a regional scale, few other areas in southern New England provide a comparable mosaic of habitats capable of supporting such a large and diverse wildlife community.

Birds. Field surveys have recorded at least 106 species of birds which breed in the Big River management area (Appendix I). An additional 94 species of birds are expected to use the site during spring and fall migration or during winter. Nearly 90 of the observed species of breeding birds spend some portion of their life cycle in wetland habitats. Fifty of these species strongly prefer aquatic habitats or riparian wetlands, such as American black ducks (Anas rubripes), wood ducks (Aix sponsa), red-shouldered hawks (Buteo lineatus), barred owls (Strix varia), green-backed herons (Butorides striatus), and Virginia rails (Rallus limicola).

A number of state listed species occur in the management area. Two state listed species, the acadian flycatcher, (Empidonax virescenis) and the winter wren (Troglodytes troglodytes), breed in the Big River management area according to a 1989 survey.[4] Between 1983 and 1987, the Rhode Island Breeding Bird Atlas Project recorded seven additional species listed either as state threatened or state interest as likely breeders. These include the Cooper's hawk (Accipiter cooperii), upland sandpiper (Bartramia longicauda), horned lark (Eremophilia alpestris), worm-eating warbler (Helmitheros vermivorns), cerulian warbler (Dendroica cerulea), grasshopper sparrow (Ammodramus savannarum), and white-throated sparrow (Zonotrichia albicollis). The RI Natural Heritage Program considers two additional species listed as state interest, the great blue heron (Ardea herodias) and pileated woodpecker (Dryocopus pileatus), as potential breeders within the Big River area (USFWS 1989). In addition, the bald eagle (Haliaeetus leucocephalus) and peregrine falcon (Falco peregrinus), listed as endangered under the federal Endangered Species Act, and the state listed osprey (Pandion haliaetus) either overwinter or migrate through the area (R. Enser, RI Natural Heritage Program, 1989, pers. comm.).

The avifauna of the Big River management area also include 43 area-sensitive species, including 21 forest-interior and 22 interior-edge migratory bird species which nest in the impoundment area (Appendix II). These area-sensitive species typically require extensive tracts of land for breeding and decline sharply with habitat fragmentation and reductions in forest patch sizes. The breeding birds on the Big River site most susceptible to these fragmentation effects include the black-and-white warbler (Mniotilta varia), Louisiana waterthrush (Seiurus motacilla), northern waterthrush (Seiurus aurocapillus), black-throated green warbler (Dendroica virens), Canada warbler (Wilsonia candensis), worm-eating warbler, hermit thrush (Catharus mimimus), yellow-throated vireo (Vireo flavifrons), red-shouldered hawk, Cooper's hawk, and broad-winged hawk (Buteo platypterus) (Appendix II).

Some of these forest interior species may persist in suboptimal sized forest patches if large nearby reserves supply recruitment or replacement individuals. The Big River management area is sufficiently large to function in this capacity and may play a role in replenishing the regional populations of area-sensitive birds that occur in moderate to low numbers in central Rhode Island (Appendix II). Moreover, several of these area-sensitive species are long distance or neotropical migrants, currently suffering

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[4]The RI Natural Heritage Program has several categories of "species of state interest." "State threatened" species are likely to become endangered in the state; "state interest" species are not endangered or threatened but occur in only 6 to 10 sites in the State; "species of concern" are listed due to various factors of rarity or vulnerability.

habitat destruction of both their breeding grounds in North America and their wintering grounds in Latin America. Long-term population declines have been observed in this group of birds in areas of the United States undergoing rapid urbanization, a trend of significant concern to the U.S. Fish and Wildlife Service. Thus, the large, unfragmented habitats of the Big River Watershed contribute to the conservation of both regional forest bird populations and several neotropical migrant species.

Mammals. Field tracking of large and medium size mammals and small mammal trapping indicate a large and diverse mammal community in the Big River management area (Appendix II). Twenty five species of wild mammals were recorded on the site in 1989 (Appendix I), the most common large mammals being white-tailed deer (Odocoileus virginiana), red fox (Vulpes), and raccoon (Procyon lotor). Meadow voles (Microtus pennsylvanicus), masked shrews (Sorex cinereus), woodland jumping mice (Napaeozapus insignis), and short-tailed shrews (Blarina brevicauda) were the most frequently trapped small mammal species. An additional 21 mammal species probably occur on the site. At least 30 of these 46 species actively use wetlands during some part of their life cycle. Thirteen species strongly prefer aquatic habitats, such as beaver (Castor canadensis), mink (Mustela vison), muskrat (Ondatra zibethicus), river otter (Lutra canadensis), raccoon, and water shrew (Sorex palustris). Capture of the state-listed water shrew represents only the third record of the species in Rhode Island. EPA received one report of a southern bog lemming (Synaptomys cooperi) in the area as well. Further, Audubon Society staff observed bobcat (Felis rufus) tracks in the impoundment area in 1989, and a fisher (Martes pennanti) was observed in the impoundment area in 1988 (Appendix II). Both of these carnivores are listed as state threatened species.

The Big River and its tributaries provide an important, unaltered habitat for populations of most of Rhode Island's mammal species. Larger, rarer species such as the river otter depend heavily upon large, undisturbed wetland systems with clean water and plentiful fish. The abundant small mammal populations play a key role in the biological community as the essential link in the food chain for several raptor species, such as the red-tailed hawk (Buteo jamaicensis), red-shouldered hawk, American kestrel (Falco sparverius), great horned owl (Bubo virginianus), and barred owl. Small mammals also provide a valuable food source for upper-level mammals, such as red foxes, gray foxes (Urocyon cinereoargenteus), and long-tailed weasels (Mustela frenata).

Herptiles. Herpetological surveys by the RI Division of Fish and Wildlife staff show that 7 salamander, 2 toad, 6 frog, 7 turtle, and 11 snake species (Appendix I) either occur, or can be reasonably expected to occur within the Big River Management Area (Appendix II). Seven of these species are state-listed: the marbled salamander (Ambystoma opacum), four-toed salamander

(Hemidactylium), wood turtle (Clemmys insculpta), worm snake (Carphophis amoenus), hognose snake (Heterodon platyrhinos), redbelly snake (Storeria occipitomaculata), and ribbon snake (Thamnophis sauritus). Extensive stream, river floodplain, and pond habitats support large populations of spotted turtles (Clemmys guttata), painted turtles (Chrysemys picta), American toads (Bufo americanus), green frogs (Rana clamitans), pickerel frogs (Rana palustris), and probably water snakes (Nerodia sipedon). Two-lined salamanders (Eurycea bislineata) and wood turtles occur in small stream habitats. Spotted salamanders (Ambystoma maculatum) are abundant and widespread, especially in ephemeral ponds along the floodplains of rivers and streams while dusky salamanders (Desmognathus fuscus) are uncommon and restricted to cold spring seepage areas. Most of the salamander species overwinter in upland sites, while many of the turtles need upland sites to lay eggs. Some species of snakes frequent the old field habitats.

Reptiles and amphibians favor the juxtaposition of wetland and upland habitats characteristic of the Big River area. At least 21 of these species depend on or closely associate with aquatic habitats or riparian wetlands. The seasonal flooding of these riparian zones is critical to the survival of these species. Ephemeral ponds dimple the landscape especially in overflow areas near the major waterbodies. These ponds provide rich invertebrate food sources for the abundant salamanders, frogs and turtles that occur in the area. In addition, amphibian larvae develop and adults breed in these ephemeral ponds. These herptiles also provide a vital link in the food chain. They are not only important prey for a wide variety of birds, mammals, and other reptiles and amphibians, but they also play an integral role in transferring energy from wetland to upland systems.

Fish. Approximately 17 miles of free flowing streams and 10 ponds within the proposed impoundment area support both cold and warm water fisheries. Congdon River, Nooseneck River, Bear Brook, and Big River (south of Route 3) support brook trout. The RI Division of Fish and Wildlife stocks approximately 2,000 fish a year into Big River at six locations. Warm water fish live in most of the remaining streams and ponds. Approximately 10 species of fish, including brook trout, largemouth bass, white suckers and redfin pickerel were collected in the streams (Appendix I). Pond habitats support approximately 10 species of fish, such as yellow perch, golden shiner, and banded sunfish (Appendix I). Largemouth bass and redfin pickerel spawn in the riverine wetlands. These seasonally flooded areas supply invertebrates for food and function as nursery areas (Wilkinson et al. 1987). The fish in turn provide important food for other wildlife species, such as herons, kingfishers, mink, raccoon, and river otters.

The Big River site and Flat River Reservoir are two of the best three fishing areas in the Pawtuxet Basin (Corps, EIS, 1981). Big River flows into Flat River Reservoir and supplies over half its water. The RI Division of Fish and Wildlife reports that Flat River Reservoir has the best warm water fishery in the Pawtuxet Basin, and the best largemouth bass fishery in the State. The South Branch of the Pawtuxet River and the mainstem of the Pawtuxet River contain warm water fisheries, although little recent data exists for these rivers. Two centuries ago, large runs of anadromous fish including shad, alewives, smelt, and Atlantic salmon ascended the Pawtuxet River and its tributaries to spawn. However, these species fell victim to urban pollution, numerous dams, and low flow problems, and no longer appear in the Pawtuxet River (Corps, EIS, 1981). The State hopes eventually to restore the anadromous fisheries (Corps, EIS, 1981).

Invertebrates. While little information exists on invertebrate communities, several unique or rare species occur within some of the upland and wetland habitats of the watershed. One of the largest concentrations of buck moths in Rhode Island, a state threatened species, is found in the pitch pine community (RI Water Res. Brd. 1986). Two amphipod species are also of particular interest. One amphipod, Crangonyx aberrans, is endemic only to southeastern New England. The other amphipod of interest is Synurella chamberlaini, a species in New England disjunct from its main distribution along the middle Atlantic Coastal Plain from Maryland to South Carolina (Smith 1987). Collection within the watershed represents only the third known location for this amphipod in New England (Appendix II).

Wetland invertebrate fauna nourish first order consumers and also provide organic matter available to detrital food chains. Invertebrates thrive in the seasonally flooded riparian wetlands and in the moist litter and soil. Most invertebrate production occurs in these seasonally flooded wetlands as opposed to the main stream channels. Invertebrates are the primary prey for a wide array of wildlife groups, such as forage fish, salamanders and frogs, small and medium size mammals, and many bird taxa. They play a key role in decomposing or processing the plentiful organic matter in riparian systems so that it is available to the detrital food chains.

Wildlife Habitat Assessments. Numerous independent wildlife investigations over the last 13 years reinforce the conclusion that the Big River site supports unusually valuable wildlife habitat (Appendix II). The Corps of Engineers, for example, commented that the numerous ponds, rivers, swamps, and marshes provide some of the best wildlife habitat in the State (Corps, EIS, 1981, Appendix H). Most of these investigations were based on observing animals at the site and general recognition of the mixture of vegetation communities. Three studies, however, involved more formal wildlife habitat assessments of the area.

The U.S. Fish and Wildlife Service (FWS) conducted a Habitat Evaluation Procedures (HEP) analysis of the forest and wetland habitats within the Big River management area in 1979. The evaluation used a "guild" of 26 wildlife species (11 mammals, 11 birds, 2 amphibians, and 2 reptiles). FWS concluded that the scrub/shrub and forested wetlands, the predominate wetlands in the management area, provide excellent wildlife habitat, and very few management actions could improve the wildlife use of the wetlands. They also concluded that the emergent wetlands on the site provide important habitat for waterfowl.

A 1984 University of Rhode Island study evaluated the wildlife habitat of 166 wetland units within the Big River watershed as wildlife habitat using the Golet evaluation system.[5] Almost all of the major wetlands in the proposed impoundment area are of outstanding or high value under the Rhode Island classification system (Figure 6). The majority of the high quality wetlands in the watershed, including the 3 most valuable wetlands for wildlife and 8 of the top 11 wetlands, fall within the proposed impoundment area. The impoundment area also contains 62% of the emergent wetlands in the watershed, a somewhat unusual wetland type in Rhode Island, of high value to waterfowl and other animals.

In 1986, Wetland Management Specialists, Inc., a consultant to the RI Water Resources Board, also conducted a wetlands wildlife evaluation for the larger wetlands in the proposed impoundment area. Using the Rhode Island Department of Environmental Management (DEM) Wetland Wildlife Ranking protocol (a modified Golet method), it classified 32 wetland units as having "low," "medium," "high," or "outstanding" value for wildlife. DEM considers wetlands ranked as outstanding (a score of 70.5 or above) to be unique (RI DEM, 1988). Nine wetlands, covering 63% of the total area of all the wetlands evaluated, received outstanding scores (RI Water Res. Brd., 1987, unpubl. data). In addition, 11 wetlands rated high (29% of land area) and 12 as medium value (8% of the area). No wetlands received a low score.

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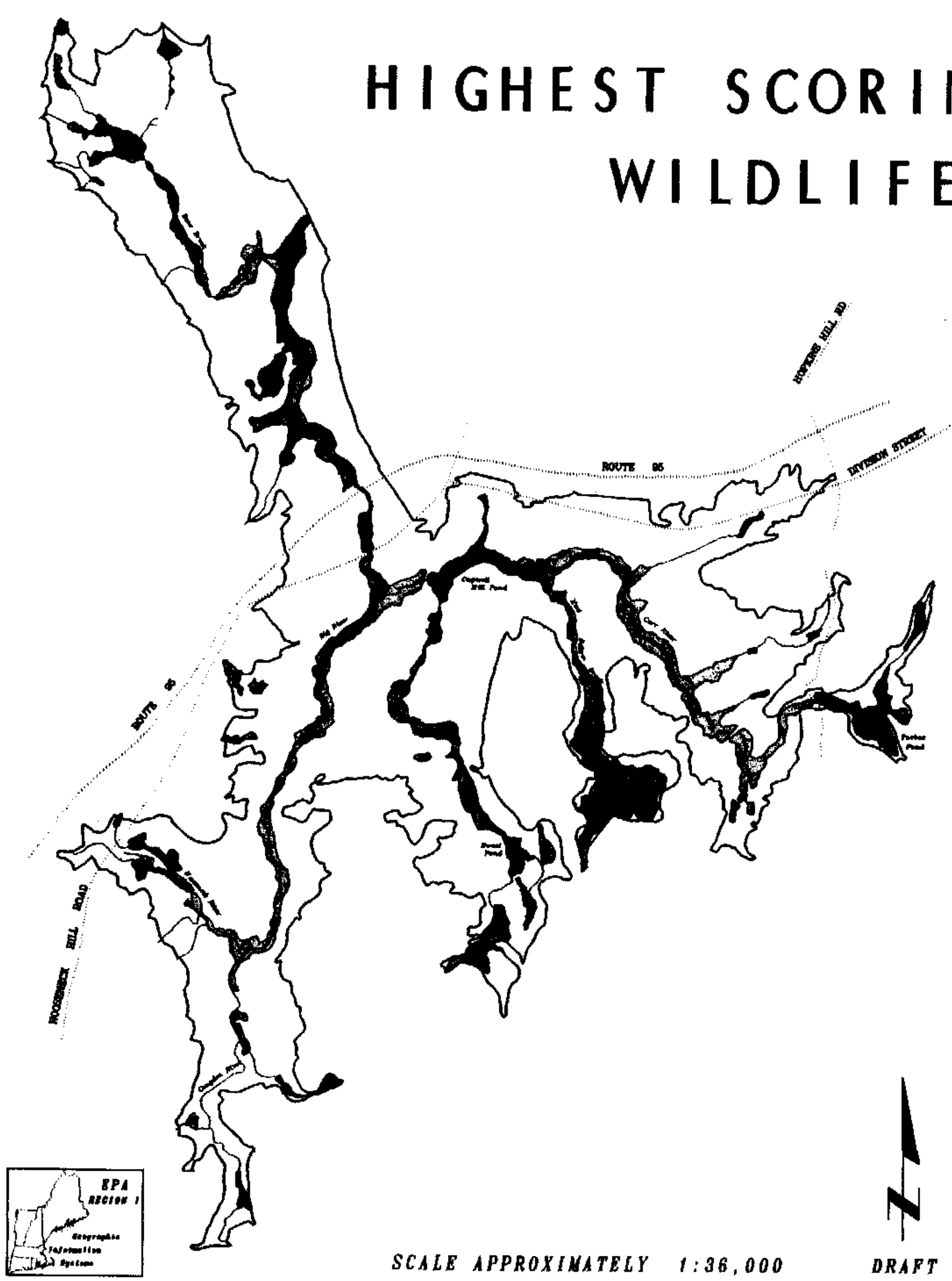
[5] A quantitative system which rates each wetland's ability to support wildlife based on 10 criteria: 1. Wetland Class Richness (the number of different classes present); 2. Dominant Wetland Class (the class that occupies the greatest area in the wetland); 3. Size (total area of the wetland, measured in hectares); 4. Subclass Richness (the number of different subclasses present); 5. Site Type (the topographic and hydrologic location); 6. Surrounding Habitat (the extent and diversity of natural habitat types compared to developed types); 7. Cover Type (the relative proportions and degree of intermixing of vegetation and open water); 8. Wetland Juxtaposition (the proximity of other wetlands and their degree of hydrologic connection); 9. Vegetative Interspersion (the degree of intermixing of various life forms of vegetation); 10. Water Chemistry (pH value). (Golet 1976).

Figure 6

HIGHEST SCORING WETLANDS FOR WILDLIFE HABITAT



Wildlife habitat value was assessed using Golet's (1976, 1979) quantitative evaluation system which rates each wetland's ability to support abundant, diverse wildlife communities.

LEGEND

- STREAMS
- ROADS
- RESERVOIR BOUNDARY (300 FT CONTOUR)
- UPLAND

WILDLIFE VALUE

- OUTSTANDING
- HIGH VALUE
- MEDIUM VALUE OR NOT EVALUATED
- OPEN WATER

This illustration is intended only to show the types and general locations of wetlands in the proposed Big River Reservoir pool area. The data were obtained from Dr. Frank Golet, Instructor at the University of Rhode Island. Inventory and classification of the wetlands was performed by students in Dr. Golet's course 'Wetlands and Land Use' (NRS 424) from 1980 aerial photographs and field checking. Any use of this illustration other than for the purpose described above is not intended.

SCALE APPROXIMATELY 1:36,000

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The Water Resources Board's consultant also examined other potential high quality wetland areas in the watershed and downstream of the proposed impoundment. The vast majority of the high value wetlands are located in the impoundment area, Mishnock swamp or the South Branch of the Pawtuxet River. An additional five wetlands classified as having high wildlife value, receiving a score of 60 or greater (RI Water Res. Brd., 1987, unpubl. data), were in areas that would be affected by highway relocations and other related activities.

C) Hydrological Values

Groundwater Recharge and Discharge. Groundwater in the aquifer associated with Big River is intimately connected with surface water in streams and floodplains. The normal gradient and direction of groundwater movement is toward these surface water features through groundwater discharge. However, during seasonal flooding, the gradient reverses and water moves from streams to the floodplain and into the aquifer. Wetlands also discharge water to streams from water upslope runoff. In addition, during drier times of the year, wetlands contribute to the basal flow of streams during low flow conditions, helping to maintain viable aquatic communities downstream.

Wetlands recharge groundwater more readily into porous soils, such as the sand and gravel soils near Capwell Mill Pond, Division Road, and Mishnock swamp to the north. As early as 1952, researchers recognized that the Carr River area recharges the groundwater which then flows north into Mishnock Lake and swamp (C.A. Maguire & Assoc., 1952). Although the quantity of flow has not been conclusively determined, one consultant measured the flow to be approximately 3 MGD near Mishnock Lake and concluded that the majority of the water budget for the lake comes from the proposed Big River impoundment area (RI Water Res. Brd., 1986). Similarly, groundwater recharge from Big River watershed may also supply the bulk of the water budget for Mishnock swamp (RI Water Res. Brd., 1986).

Flood Storage. Wetlands comprise approximately 17% of the area in the proposed impoundment, with most located along the streams and rivers. Many of these wetlands are only seasonally flooded and provide extensive storage for flood waters from neighboring streams and from upland sheet runoff. A 6" rise of water, for example, in a 10 acre wetland places more than 1.5 million gallons of water in storage (Niering, 1980). The dense vegetation of the wetlands along Big River slows the velocity of the water, lowers the peak runoff and allows greater opportunity for groundwater infiltration. Hence, the vegetation and the porous soils work in tandem to provide important flood storage and recharge benefits.

Water Quality. Wetlands alter the fate of pollutants by chemically or biologically removing contaminants from water. Therefore, most wetlands provide water quality benefits to adjacent and downstream waterbodies. For a wetland to attenuate pollutants in this fashion, the water which carries the contaminants must contact the wetland vegetation and soils. This typically occurs when streams overtop their banks and flood adjacent wetlands or when water flows into the wetland vegetation and soils by sheet runoff. Wetlands often provide natural treatment by removing as much as 80-90% of the suspended sediments in the water column which could otherwise interfere with normal plant and animal growth (Larson, 1981). High turbidity levels, for example, can restrict sunlight penetration, reduce plant growth, and clog fish gills.

A high density of wetland plants also enhances the processes of sedimentation, ion exchange, and algal and bacterial growth necessary for organic degradation of particulate matter. Wetlands reduce nutrient levels, such as nitrogen and phosphorus, which often impact downstream waterbodies. Most wetlands release some nitrogen to the air through denitrification, while others remove nutrients and toxics from the water column by storing the chemicals in sediments and peat. Wetlands also store nutrients in the wetland vegetation during the growing season, and release the nutrients later in the year when water is colder and less vulnerable to algae blooms and other forms of nutrient pollution.

EPA expects that the extensive wetlands at Big River provide similar water quality benefits for downstream aquatic communities. Interactions between water and wetland vegetation and soils clearly occur at the Big River site, given the prevalence of riverine wetlands. The thick vegetation in the wetlands at Big River retard water flow and allow materials to settle. Although the Big River watershed is largely undeveloped, there are some sources of pollution within the watershed. For example, several highways cross the watershed, including I-95, the busiest roadway in the State. Pollutants from spills and normal highway runoff likely enter the watershed and the river. The rivers and streams within the site, and downstream waters such as Flat River Reservoir, would benefit from the wetlands' ability to remove such pollutants from the water column.

D) <u>Recreation</u>

Rhode Island contains approximately 400 ponds, lakes, and impoundments, 100 of which are in the Pawtuxet River basin (USGS 1987; SCORP, 1986). Thirty-four of the ponds in the Pawtuxet River basin exceed 10 acres (Corps, EIA, 1981, Vol. IV). Big River, the only free-flowing river in the basin, is one of the few remaining streams in the State with good water quality, public access for canoeing, fishing, and swimming, and an undeveloped shoreline (RI DEM, 1987). The Big River management area accounts for about 17% of all the publicly owned open space in the State. One of the largest areas of open land in the State, it is among the last undeveloped natural areas left in Rhode Island, the second most densely populated state in the country.

Recreation use in the Big River impoundment area is moderate to heavy, even though the State does not actively manage the area for recreation, and the site is one of the most popular hunting areas in the State (Corps, EIS, 1981, Appendix H). All of the most popular game species in the State are found there, including pheasant, grouse, quail, woodcock, rabbits, and deer. People hunt and fish in the Big River area in a moderate to heavy capacity (USFWS 1978; RI Division of Fish and Wildlife, 1989). People hunt deer 1,000 user-days and small game 2,300 user-days a year at the site. Last year the Big River management area yielded approximately 20% of all the deer killed on state lands (J. Myers, RI Division of Fish and Wildlife, pers. comm., 1989). People fish for trout in streams within the proposed impoundment area 1,000 user-days, and for warm water species, 800 user-days a year. The RI Division of Fish and Wildlife stocks approximately 2,000 fish a year in Big River at six locations. People swim in several ponds and portions of Big River. Because there is no entrance gate or fee required, precise estimates of other uses including walking, nature observation, canoeing, swimming, camping, and off road vehicle use are not available. Nevertheless, a number of people commenting on EPA's proposed determination testified to their use of the area for these activities.

Big River is located approximately 15 - 20 miles from the large metropolitan region generally surrounding the city of Providence. In 1978, FWS concluded that this rare juxtaposition of a large and diverse tract of open land so close to a heavily populated area creates tremendous opportunity for recreation. The 1986 State Comprehensive Outdoor Recreation Plan 1986 - 1991 (SCORP) describes the uncommon and fragile nature of open space in Rhode Island, and indicates the importance of protecting large areas of habitat. It also points out that in many areas development surrounds open space in the State, making them less valuable for wildlife.

In addition to providing valuable wildlife habitat, the 8,000 acres of mostly forested land in the management area provide existing and potential opportunities for activities such as bicycling, walking, horseback riding, picnicking, and swimming, all activities which rank high in popularity (SCORP 1986). Also, approximately 1/3 of the people in the State now explore nature for observation and photography (SCORP 1986). As one of the last remnants of intact natural areas left in the State, better access for hiking, swimming, canoeing, and camping would encourage more people to experience the area.

The recreational use of waterbodies immediately downstream of the proposed impoundment are also extensive. Flat River Reservoir, used for boating, swimming, fishing and other forms of water recreation, provides the best largemouth bass fishery in the State and trophy size northern pike. The U.S. Fish and Wildlife Service estimates fishing use at Flat River Reservoir to be 10,000 user-days a year. It also estimates that with proper management and better access, the Flat River Reservoir could provide 25,000 user-days of fishing a year (USFWS 1978).

E) Summary

Based on the administrative record, I find that the Big River watershed, especially the proposed impoundment area, contains excellent fish and wildlife habitat. I base this conclusion on several factors including direct observations and data supplied by experts and the public, the conclusions of the 1981 EIS, and a number of habitat evaluations all of which found the area to be valuable for wildlife. I also find that the wetlands in the watershed provide other beneficial functions including flood storage, water quality maintenance and groundwater recharge and discharge. Furthermore, I conclude that the site provides valuable recreational benefits. Although not currently promoted as a recreation area, the site enjoys substantial use by the public for fishing and hunting, and provides excellent opportunities for canoeing, birdwatching, and other outdoor activities.

IV. ADVERSE ENVIRONMENTAL IMPACTS

The proposed Big River reservoir would profoundly alter the natural habitats of the site. Construction of the dam and associated facilities would inundate 575 acres of wetlands, approximately 2,500 acres of primarily forested uplands, and 17 miles of free flowing streams. It would transform a large, diverse complex of wetland and upland habitats which support a broad array of aquatic, semi-aquatic, and terrestrial wildlife communities into a shallow lake favored by only a few species. It would dramatically reduce the amount of valuable wetland habitat in the watershed. Emergent and evergreen forested wetlands, the most uncommon wetland habitats in the watershed, would be most severely impacted. Several unique or sensitive plant community types, including the riparian cedar swamp along the Carr River, and the large pitch pine communities near Division Road would be inundated by the reservoir. Each of these plant communities has been recognized by the RI Natural Heritage Program as outstanding examples of habitats uncommon in Rhode Island. Over 144 species (87%) of vertebrate wildlife (fish, birds, reptiles, amphibians, and mammals) observed at the site and an undefined number of invertebrate species would be adversely affected. Many area-sensitive species and others with specific habitat requirements, including 23 state-listed species and two federal endangered species, would be either eliminated from lands and waters occupied by the reservoir or adversely affected in areas outside of the reservoir boundaries. One of the State's few remaining cold water stream fisheries would be destroyed.

The proposed project would affect ecological processes both upstream and downstream of the dam and have both short and long term effects on wildlife habitats. It may adversely affect wildlife populations far removed from the Big River watershed and contribute substantially to ongoing cumulative adverse effects in southern New England where urban development has already significantly reduced the diversity of natural communities. The destruction of 575 acres of wetlands would be unprecedented, more than any project permitted in New England since the inception of the Clean Water Act in 1972. In addition, the dam and slurry wall will impede the movement of groundwater into Mishnock swamp and reduce flows to the South Branch of the Pawtuxet River. This long term alteration of the hydrologic regime threatens the viability of over 700 acres of nearby and downstream wetlands. The project would markedly reduce downstream water flow: 45% less flow to the Flat River Reservoir, 34% less flow to the South Branch of the Pawtuxet River, and 15% less flow to the mainstem of the Pawtuxet River. Depriving the downstream areas of flow would exacerbate existing water quality problems and adversely impact the already severely stressed biological communities.

Finally, the reservoir would have substantial adverse impacts on the recreational values at the site. Under current state laws and policies, all recreational uses within the entire management area would be lost. Even if state policies change and the Corps builds the project with a recreation component, many of the existing recreational opportunities would be eliminated or greatly reduced.

The §404(c) regulations (40 CFR §231.2(e)) direct EPA to consider the relevant portions of the section §404(b)(1) guidelines (40 CFR Part 230) in evaluating the unacceptability of a project's impacts. One such portion, section §230.10(c), forbids the discharge of dredged or fill material if it would cause or contribute to significant degradation of waters of the U.S.. Effects contributing to significant degradation include (but are not limited to) significant adverse effects on aquatic ecosystem diversity, productivity, and stability, such as loss of fish and wildlife habitat, and significant adverse effects on recreational values. Special emphasis is to be placed on the persistence and permanence of the effects outlined in part 230, subparts B through G. Based on the administrative record, I conclude that the proposed Big River reservoir would cause a significant adverse loss of fish and wildlife habitat and a significant adverse impact on recreation.

A. Fish and Wildlife Impacts[6]

The most immediate and severe impacts to wildlife communities would occur within the impoundment area, as a result of 1) removing all the vegetation by site clearing and flooding; 2) reducing the diversity and interspersion of habitats; 3) reducing nutrient enrichment of the floodplain; and 4) preventing animal movement along the long riparian corridors (Figure 7). As explained in the site description, nutrients, water and site topography combine to produce different types of vegetation in close proximity providing ample food and cover for wildlife. Impounding the river would provide water, but it would also smooth the varied topography and remove the vegetation. As a consequence, the food, cover, and reproductive sites for the vast majority of the 250 species expected at the Big River site could disappear. In contrast, the dam may improve habitat conditions for only 10 - 20 species, an order of magnitude less than it would impact.

Clearing of vegetation from the project site and subsequent inundation would destroy much of the existing habitat values of the site. As part of the state project, an additional 400 acres would be cleared of all vegetation within a 300 foot buffer zone around the reservoir perimeter. Although the degree of impact to wildlife would vary with the species and season, animals unable to escape the project area would die immediately. More mobile species would attempt to relocate in adjacent areas. However, in all likelihood

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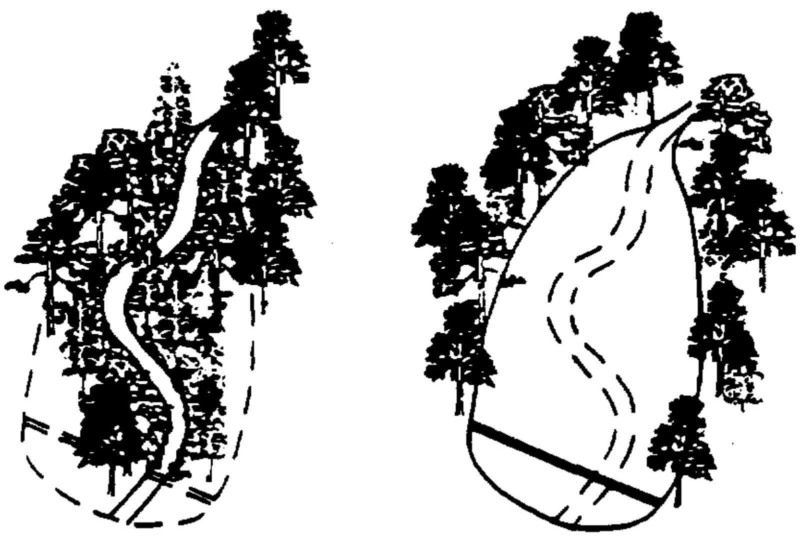
[6]For purposes of this §404(c) recommendation, I have considered impacts to fish as falling within the adverse impacts to wildlife.

Figure 7: General Impacts to Fish and Wildlife from Impounding a Stream



BEFORE IMPOUNDMENT	AFTER IMPOUNDMENT
Habitat for stream-dwelling fish	Habitat for lake-dwelling fish
Predominantly floodplain/terrestrial wildlife habitat	Predominantly aquatic fish habitat
Streambank habitat for many specialized wildlife species	Streambank habitat replaced by extensive, often unstable shoreline; altered species assemblage
Natural hydrologic regime provides exchange pathways for nutrients, detritus and organisms between channel and floodplain	Permanent inundation eliminates floodplain vegetation and vital pathways of exchange
Downstream transport of detritus and sediments	Retention of detritus and sediments behind dam
Corridor for fish and wildlife movements	Corridor altered and interrupted

SOURCE: Brinson, 1981

these nearby habitats are at or near carrying capacity (equilibrium). Thus, animals from the project site may not successfully relocate and could suffer high indirect mortality.

Many species of wildlife at the site either require wetland habitat for survival, or depend upon wetlands for a portion of their life cycle. Over 3/4 of the species recorded at the Big River site use wetlands during some portion of their life cycle, and approximately 1/3 of these species prefer wetland habitat. Since the proposed impoundment area is 17% wetland, while the remainder of the watershed is 7% wetland, many species would be forced into less suitable habitat. Further, the impoundment generally supports higher quality wildlife habitat than the rest of the management area and watershed (URI, 1984).

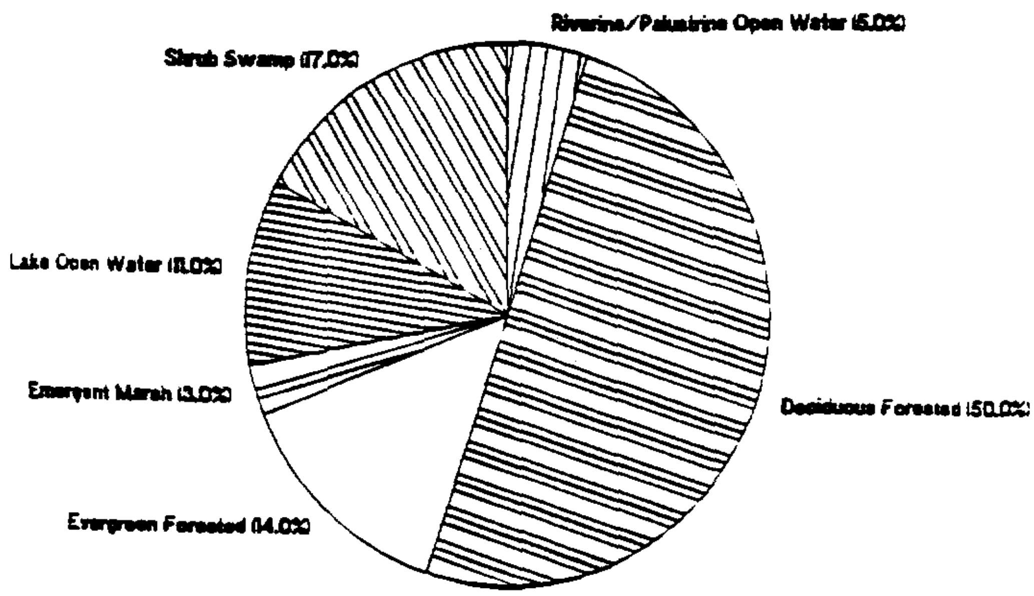
Some of the wildlife habitat value could return if the vegetation were allowed to grow back. However, flooding the site would prevent the regrowth of the complex vertical stratification of herbaceous, shrub, and tree layers in the wetland and upland communities. This vegetation provides protection, resting, breeding, feeding, denning, roosting, and spawning areas for a variety of terrestrial, arboreal, and aquatic wildlife. The loss of mast producing vegetation from the area would reduce the available food for a broad range of wildlife species. The standing dead trees and snags important to resting, nesting, denning, and feeding habitat for numerous wildlife species would be lost. The many different wetland and upland habitat types would be reduced to a single aquatic type, a large lake. This would greatly impact aquatic diversity in the 30 sq. mi. watershed as well (Figure 8). Lake open water would increase from 11% to 77% of the aquatic habitat types in the watershed.

Destruction of the vegetation would effectively halt leaf production in the reservoir area and thereby eliminate the principal biological source of nutrient cycling in the wetland and upland habitats. The annual litterfall in these habitats provides an important energy source to saprophytic food chains as well as a substantial release of nutrients from vegetation. The organic matter supports food chains of invertebrates, fish, birds, mammals, and herptiles both on the reservoir site, and downstream.

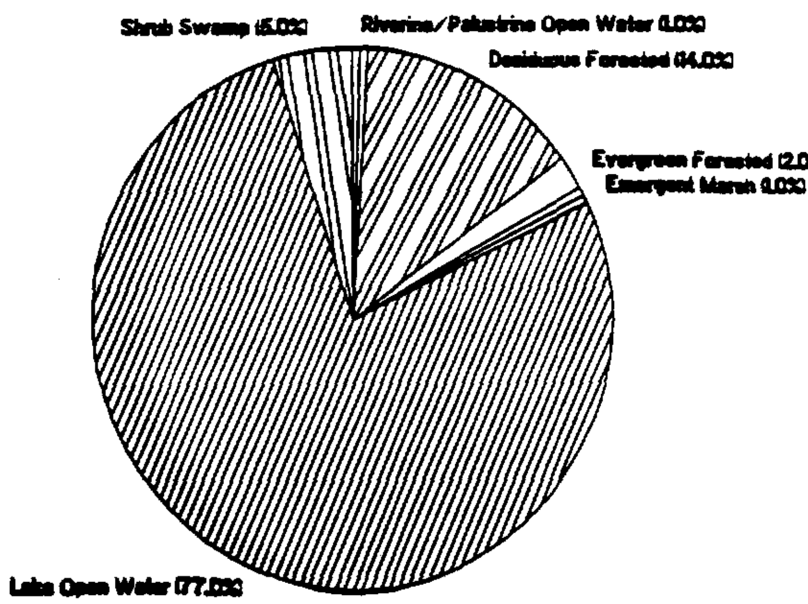
The reservoir would not only destroy almost all of the wildlife-rich riparian wetlands in the watershed, but it would also inundate the relatively large secure forest-interior habitats in the center of the watershed. In these large and unfragmented interior forests dwell the abundant numbers of area-sensitive breeding birds as well the large terrestrial predators. The long, linear riparian habitats in the proposed reservoir site serve as important corridors for resident and migratory animals to move within and between the watershed and among other habitat patches in the region. The continuity of these forest and riparian habitats maintain large viable wildlife populations and allow

Percent Change in Aquatic Habitat Types in the Big River Watershed

Before Project



After Project



dispersing animals to recolonize smaller habitat patches throughout the region that have suffered local extinctions. Construction of the reservoir would not only significantly reduce the diversity and abundance of wildlife species in the watershed but also block these natural corridors that fish, amphibians, reptiles, birds, and mammals travel.

In addition to looking at gains and losses in cover type acreage, project impacts can also be determined by examining wildlife habitat assessments and impacts to specific groups of species. Potential wildlife habitat losses can be quantified by a HEP analysis as acres lost or average annual habitat units (AAHU's) lost, which attempts to estimate quality of wetlands as well. The U.S. Fish and Wildlife Service HEP study revealed that wetlands in the 8,000 acre management area support 488 AAHU's, 390 in the dam area and 98 in the remainder of the management area (USFWS 1979). (This also illustrates that even though the dam area is less than half the size of the management area, it contains the vast majority of wetlands which are valuable to wildlife.) Including the 90 acres of subimpoundments the Corps proposed as mitigation, the entire management area after the dam is built would support 180 AAHU's, a decrease of 308 AAHU's overall. Therefore, even with the proposed mitigation the majority of the wetland habitats in the management area would be lost to wildlife. The loss of habitat for all cover types in the management area would be 1,854 AAHU's (USFWS 1979).

The Golet Wildlife evaluation system cannot be used to make quantitative before and after comparisons. However, one can examine the criteria of the method and determine how they would change. Six of the 10 criteria used - class richness, dominant class, subclass richness, cover type, wetland juxtaposition, and vegetative interspersion - would be dramatically reduced in value because a large lake provides no vegetation or diversity of habitat types.

Birds. Clearing of vegetation and inundation of the Big River reservoir site would eliminate habitat for a significant number of bird species which utilize the complex of wetlands and uplands during some part of their life cycle. The U.S. Fish and Wildlife Service indicates that at least 90 bird species would be adversely affected. These include 8 state-listed species, 43 area-sensitive species, 35 riparian-associated species, and a wide variety of wetland-dependent and upland species. In contrast, only a few waterbird species would use the reservoir once completed.

Some of the state-listed species which would be adversely affected include the Cooper's hawk, acadian flycatcher, winter wren, worm-eating warbler, and grasshopper sparrow. While secure in most of their natural range, these species exist in an uncertain situation in Rhode Island and elsewhere in New England. The loss of these individuals or populations probably would be irreversible in Rhode Island and could hamper conservation of some of these species in the New England region.

A number of area-sensitive species would also be adversely affected. These species typically require extensive tracts of land for breeding and decline with habitat fragmentation and reductions in forest patch sizes. Area-sensitive species most likely to be eliminated as breeding species in the Big River watershed by the proposed project include the northern goshawk (Accipter gentilis), broad-winged hawk, red-shouldered hawk, barred owl, yellow-throated vireo, northern and Louisiana waterthrushes, American redstart, and Canada warbler (Appendix II). Because of continued urbanization and fragmentation of natural habitats throughout New England, many of these area-sensitive species that require large contiguous tracts of land have declined in both range and number.

Loss of extensive riparian wetlands in the proposed site would adversely affect the 35 bird species closely associated with riverine ecosystems. Included among these are common forest and edge species, and others that clearly depend on the aquatic-forest interface. Because these latter species require aquatic habitat and have a more restricted distribution, they succumb most quickly to the hydrologic alterations of streams. These riparian edge specialists include such species as American redstart, yellow warbler, rufous-sided towhee, northern oriole, and indigo bunting. In contrast, forest-dwelling riparian birds will be most affected by activities that reduce the size of forests. This group includes species such as the red-eyed vireo, wood thrush, acadian flycatcher, tufted titmouse, and ovenbird (Brinson et al. 1981).

In addition to adverse impacts to state-listed, area-sensitive, and riparian-associated species, birds with more general habitat requirements would also suffer deleterious effects from the proposed project. The forested wetlands and uplands of the impoundment area which now provide breeding and foraging habitat for many species of wading birds, ducks, raptors, woodpeckers, game birds, and passerines would be largely destroyed. The area currently provides breeding habitat for colonial nesting birds such as herons, as well as snags for cavity nesting species such as owls, woodpeckers, and many species of songbirds. The existing vertical stratification of the vegetation and interspersion of habitats which encourage substantial bird nesting, feeding, and resting habitats would be eliminated. Further, the productive upland and wetland tree species supply food for a substantial population of herbivorous insects, which in turn provide a primary food source for a diverse population of bird species. This is particularly important to migratory species of waterfowl and neotropical migrants such as warblers, which utilize the rich insect fauna characteristic of these ecosystems during critical migration and breeding periods. The project if constructed would eliminate these critical habitat components in the impoundment area.

In summary, implementation of the proposed reservoir project would eliminate habitat critical to the life cycles of many avian species, decrease the ability of the area to support a large and diverse avifauna, and force many bird species to abandon the area for alternative habitats in surrounding areas with concomitant high mortality. Additionally, the habitats of many state-listed, area-sensitive, and riparian-associated species would be destroyed, significantly impacting the conservation of these bird populations locally and within the region.

Mammals. Construction of the proposed reservoir would destroy substantial habitat for the 25 mammal species observed within the project area. Once completed, the reservoir would provide sparse habitat for aquatic mammals such as beaver, river otter, mink, and muskrat because of the periodic drawdowns (3-6 feet) planned for the reservoir. These aquatic mammals require relatively consistent water levels to successfully establish dens and raise young. Further, the frequency and magnitude of the drawdowns would preclude development of emergent and aquatic vegetation zones that provide necessary food and cover for muskrat and beaver.

The 15 mammal species associated with riparian wetlands would suffer major impacts. These mammals are important in riparian systems as part of the food chain and their ability to modify wetland communities (e.g., beaver). The reservoir would either eliminate or fragment the connected riparian habitats that mammals use for travel within the watershed. Further, two state-listed mammals reported to be in the area, the bobcat and fisher, are considered area-sensitive species. These two species would be eliminated from the project site and may be extirpated from the management area due to the loss of secure interior habitat (Appendix II).

The extensive riparian wetlands on the reservoir site support abundant mammalian prey populations that contribute significantly to food chain support in wetland and upland habitats. Small mammals, such as mice, voles, and shrews, are important prey for foxes, coyotes, minks, weasels, fishers, and bobcats, as well as a variety of hawks and owls. Larger predators such as coyotes, foxes, red-tailed hawks, and great-horned owls prey upon medium size mammals, such as rabbits, raccoons, and opossums. The loss of the abundant and diverse small and medium size mammal communities on the project site will also adversely affect mammalian and avian predator populations.

In summary, the removal of vegetation from the project site and subsequent creation of the reservoir would destroy substantial amounts of habitat for nearly all mammalian wildlife which occur in the project area. The reservoir would severely impede the dispersal, movement and migration of aquatic and terrestrial mammals. Further, loss of the abundant small and medium size mammal communities of the reservoir site would have significant adverse effects on avian and mammalian predator populations.

Herptiles. Destruction of the diverse wetland communities, flooding of uplands, and loss of the interspersion of upland and wetland habitats will devastate most amphibian and reptile populations on the project site. Of the 33 herptile species that potentially occur within the project area, all but 4 species will be either extirpated or severely reduced within the reservoir area. With completion of the reservoir, only the snapping turtle (Chelydra serpentina) and painted turtle are expected to increase in numbers, and populations of the green frog and Fowler's toad are projected to be unaffected (Appendix II). The proposed reservoir would provide little habitat to support the other 30 amphibian and reptile species now in the area. Moreover, the presence of fish in the reservoir would increase predation on the few amphibian species that may continue to use the margins of the reservoir. These fish populations would sharply increase predation on amphibians and their eggs.

All 7 state-listed species which occur on the project site would be extirpated, including 2 salamander, 1 turtle, and 4 snake species. The other 5 salamander species and 6 terrestrial snake species would also be eliminated by the project. All frog and toad species will be extirpated from the deep-water portions of the reservoir except for the Fowler's toad, which is known to occur only outside the impoundment area, and the green frog, which may remain stable or increase. Additionally, the large periodic drawdowns (3-6 feet) planned for the reservoir will inhibit the establishment of emergent and aquatic vegetation in the littoral zones, further reducing the potential habitat available for the other 5 frog and toad species which breed in shallow, vegetated aquatic zones.

Clearing of the vegetation and dead wood from the reservoir site would eliminate breeding, feeding, and escape cover for all herptile species. Further, inundation of the upland communities would extirpate all 11 terrestrial snake and turtle species on the reservoir site. Loss of the majority of seasonally flooded riparian zones and small ponds in the watershed will significantly reduce the availability of habitat for all amphibians and semi-aquatic reptiles in the watershed as a whole. Since many herptiles, especially amphibians, exhibit a strong fidelity to their natal wetlands, additional populations that inhabit areas adjacent to the reservoir may be eliminated or significantly reduced due to loss of their breeding sites.

The loss of a significant proportion of the amphibians and reptiles in the watershed would in turn adversely affect avian and mammalian communities. Herptiles are important links in the food chain. For example, herons, egrets, raptors, raccoons and other mammals, and snakes eat frogs and salamanders. Snakes in turn are eaten by large wading birds, raptors, and fur-bearers. These complex food chains also play a critical role in transferring energy from wetland to upland systems. The capacity of the herpetofauna to provide this food chain support would be markedly reduced with construction of the proposed reservoir.

In summary, the proposed project would extirpate most of the amphibian and reptile species that now occur within the reservoir site, and significantly reduce the diversity and number of herptile species utilizing the watershed. The interspersion of wetland and upland habitats in the watershed would be destroyed, significantly limiting availability of habitat for the few herptile species not killed by the vegetation clearing and subsequent inundation.

Fish. The proposed impoundment would eliminate the stream trout fisheries from the site (USFWS 1978; Appendix II). In the EIS main report, the Corps states that the reservoir would support a warm and cold water lake fishery. Elsewhere, however, the EIS states that without stripping the organic materials from the basin, the dissolved oxygen concentrations in the hypolimnion could become anaerobic during summer stratification, thereby reducing or eliminating the availability of cold, oxygenated water needed for brook trout survival (Volume II, Appendix E). The US Fish and Wildlife Service determined that the impoundment may support a cold water lake fishery only if the Corps removed the organic debris at the site, especially the extensive organic soils (see Figure 9), and devised a multiple outlet structure for releasing water. Otherwise, the microbial populations in the pool area would consume the organic soils, deplete oxygen levels, and cause anoxic conditions in deeper levels of the waterbody during summer stratification. The Corps indicated that it would remove only a small section of the organic soils at the site (Corps, EIS, 1981, Appendix E).

The record is unclear whether the Corps plan would remove enough of the organic soils to support a self-sustaining cold water fishery. The U.S. Fish and Wildlife Service believes that it would not be adequate, and that there does not appear to be enough available spawning habitat to promote self-sustaining cold water populations. The FWS also believes that brook trout may be eliminated from the watershed because of the loss of critical spawning, rearing and refuge areas (Appendix II). It is certain that cold water stream fisheries would be lost as a result of the project, and EPA is not convinced that a cold water lake fishery could be established in its place.

In addition, the dam would severely reduce downstream flows to other important waterbodies with aquatic life. The Flat River Reservoir provides the best warm water fisheries in the Pawtuxet River basin, but it is showing some signs of eutrophication (RI Water Res. Brd., 1986). The FWS concluded that the reduced water budget would adversely impact fisheries in Flat River Reservoir.

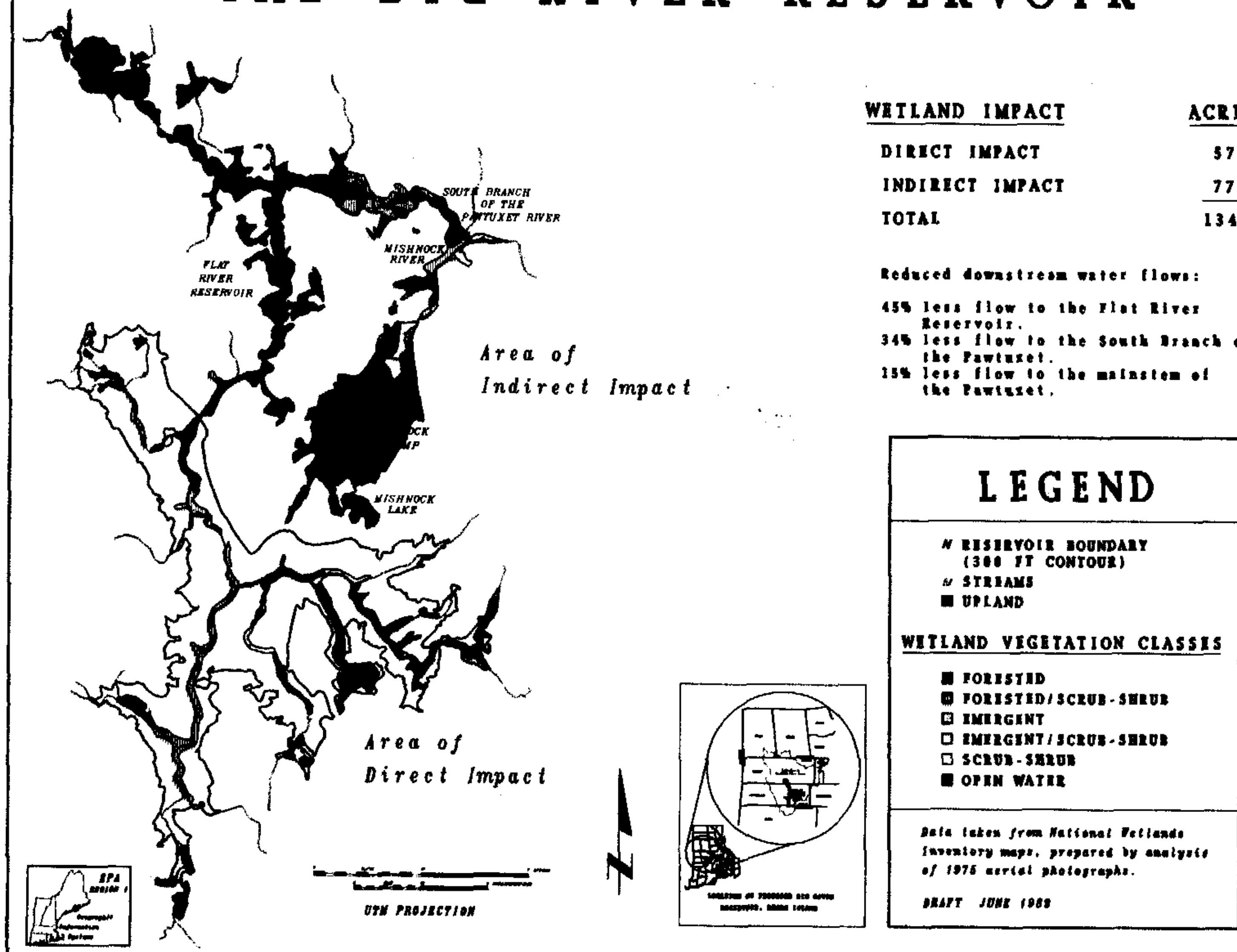
Figure 9

WETLANDS TO BE IMPACTED BY THE BIG RIVER RESERVOIR

WETLAND IMPACT	ACRES
DIRECT IMPACT	575
INDIRECT IMPACT	770
TOTAL	1345

Reduced downstream water flows:

45% less flow to the Flat River Reservoir.
34% less flow to the South Branch of the Pawtuxet.
15% less flow to the mainstem of the Pawtuxet.



The South Branch Pawtuxet and the mainstem Pawtuxet would also lose as much as 40% and 15% of their flows, respectively (Corps, EIS 1981). This would cause additional impacts to the fisheries in the streams, especially the Pawtuxet River. FWS also indicates that loss of flow to the Pawtuxet River could jeopardize any future effort at restoring American shad (USFWS, 1978).

Invertebrates. Clearing of vegetation and inundation of the Big River Reservoir site would eliminate habitat for a significant number of wetland and upland invertebrate fauna. The habitat of at least one state-listed species, the buck moth, would be destroyed. This species is found in the pitch pine community within the reservoir site and represents one of the largest concentrations of buck moths in the State. Further, two amphipod species, Crangonyx aberrans and Synurella chamberlaini, unique to the region, would also be extirpated or significantly reduced within the reservoir area.

The U.S. Fish and Wildlife Service predicts that at least 9 genera of mayflies (Ephemeroptera), 5 genera of dragonflies (Odonata), 2 genera of stoneflies (Plecoptera), 7 genera of beetles (Coleoptera), 3 genera of caddisflies (Trichoptera), and 8 genera of flies (Diptera) will be eliminated from existing lotic habitats as a result of inundation. These aquatic insects are adapted to lotic conditions and cannot be expected to survive in the reservoir. Numerous other wetland macroinvertebrate taxa, such as annelid worms, molluscs, crustaceans, and other insect groups will also most likely be eliminated by the reservoir.

These diverse aquatic and terrestrial invertebrate fauna support the ecosystem by serving as links in food chains and processing dead organic matter, making it available to detrital food chains. Aquatic invertebrates supply food to fish, waterbirds, and amphibians. Wading birds and aquatic mammals such as river otters eat large molluscs and crayfish; swarms of flying insects are snapped up by fish, bats, and insectivorous songbirds. Terrestrial invertebrates also provide an important food source for an array of herptiles, small mammals, and birds. In addition to their direct trophic role, many wetland and upland invertebrates play an indirect role by decomposing and processing organic matter so that it is available to detrital food chains and nutrient cycling.

In summary, the proposed project will severely deplete the existing diverse aquatic and terrestrial invertebrate fauna. Further, because of the magnitude and frequency of the planned drawdowns in the proposed reservoir, few aquatic and emergent plant communities will develop in the shallow areas of the reservoir. This will further decrease both the diversity and abundance of the potential invertebrate fauna in the completed reservoir. The reduction in the number and diversity of invertebrates will result in less available food for higher level consumers.

Indirect and Secondary Impacts.[7] The project would cause a number of additional impacts beyond the direct loss of habitats within the impoundment area (Figure 10). These adverse effects would be of three main types. First, construction of ancillary facilities and related project actions, such as the treatment plant, utilities, tunnel shafts and roadway relocations, will directly impact additional aquatic habitat. Second, as discussed earlier, construction of the dam will adversely impact wildlife communities within the watershed as a whole, especially for species which are area sensitive or require large home ranges. Third, and possibly most significant, construction of the dam and slurry wall will disrupt the existing surface and groundwater hydrology. The slurry wall is designed to intercept groundwater which now exits the watershed and feeds Mishnock Lake and swamp. The dam, if operated as currently proposed, would markedly reduce downstream flows to the Flat River Reservoir and to wetlands adjacent to the South Branch of the Pawtuxet River.

Relocating six highways, and building the treatment plant, water transport tunnel and dewatering shaft will impact an additional 25 wetlands, including several of high value (RI Water Res. Brd. unpub. data 1987). The Water Resources Board completed modified Golet wildlife evaluations for 10 of these wetlands, resulting in one score of "outstanding," four of "high value" and five of "medium value." Neither the State nor the Corps has determined the acreage of wetlands which would be affected by these activities, so the extent of the impacts is uncertain.

The reservoir site and Big River watershed comprise a large contiguous, natural vegetated habitat in a region of New England where urban development dominates land use. The watershed has remained relatively unaffected by habitat fragmentation and human disturbance and so provides an unusual mosaic of habitats capable of supporting large and diverse wildlife communities. In addition to its direct impacts, the reservoir would fragment the watershed, interrupt travel corridors and isolate habitat patches. These effects diminish the overall wildlife value in the remainder of the watershed and in other nearby areas (e.g., Mishnock swamp). Species sensitive to these large scale effects - area sensitive

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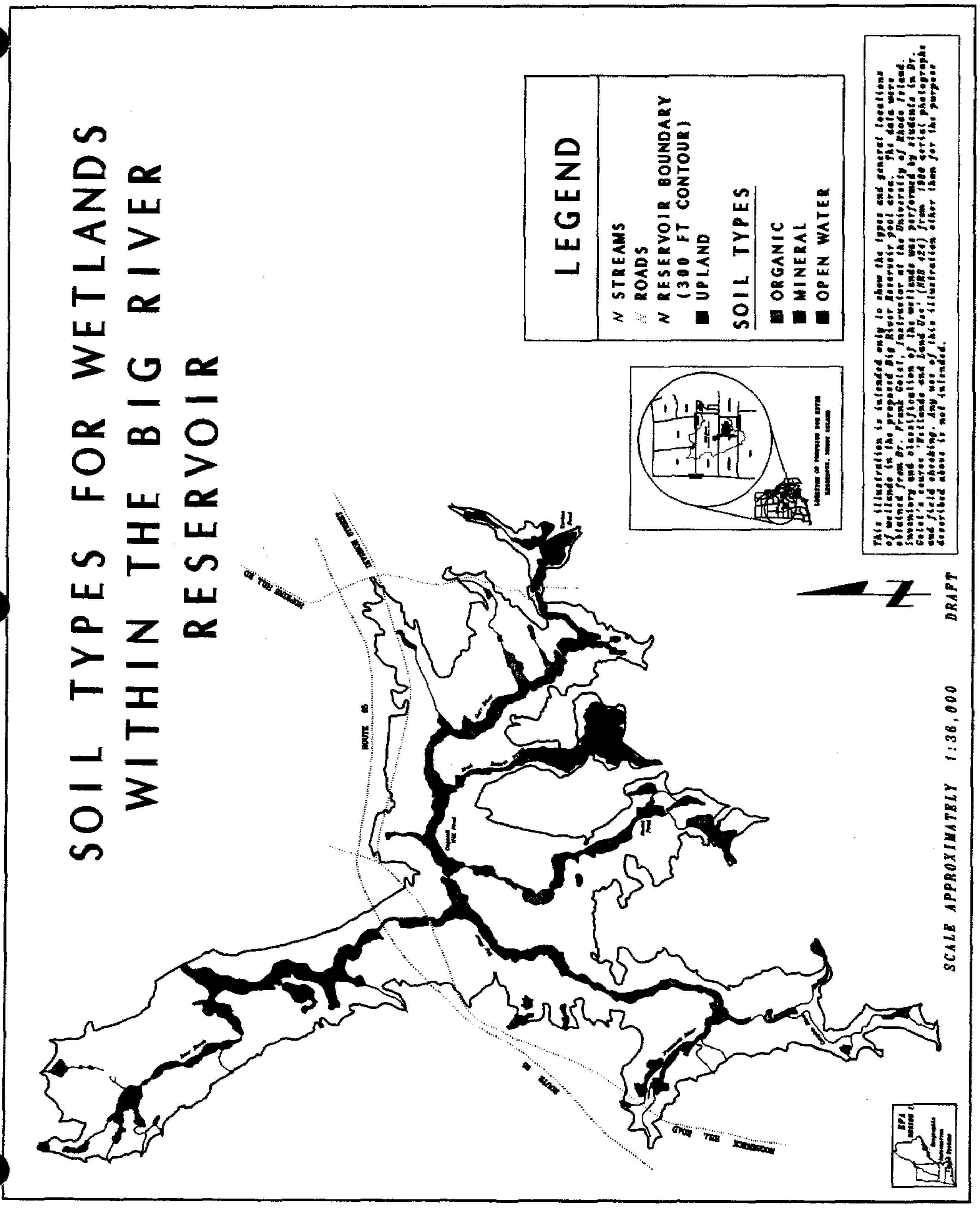
[7] As originally conceived, the Big River reservoir was to be operated in tandem with another impoundment constructed on the upper Wood River. A number of commenters expressed concern that the State may eventually intend to construct a dam on the Wood river and that such an impoundment would cause serious environmental and recreational impacts. Since neither the State nor Corps currently proposes a Wood River dam, EPA Region I has not evaluated the issue in this recommended decision. However, based on the information currently available, construction of an impoundment on Wood River would incur substantial adverse environmental impacts.

Figure 10


SOIL TYPES FOR WETLANDS
WITHIN THE BIG RIVER
RESERVOIR
LEGEND
STREAMS
ROADS
RESERVOIR BOUNDARY
(300 FT CONTOUR)
UPLAND
SOIL TYPES
ORGANIC
MINERAL
OPEN WATER
ROUTE 95
SCALE APPROXIMATELY 1:36,000
DRAFT

breeding birds and large terrestrial predators for example - would suffer proportionately greater declines. Animals from the impoundment area likely colonize and replenish the wildlife population in surrounding habitats. By destroying the most undisturbed and valuable habitat in the watershed, the reservoir would eliminate this important function.

A slurry wall would be built along Division Road to prevent reservoir leakage via infiltration into the groundwater. Since the slurry wall would be built to bedrock, it may also interrupt a major component of groundwater flow that replenishes the Mishnock system (RI Water Res. Brd. 1986). The State proposed to maintain water levels in Mishnock Lake by piping water from the reservoir. However, there are no plans to mitigate the reduced flow of groundwater to Mishnock swamp, a 500 acre forested wetland. This may have significant consequences because Mishnock swamp is the largest forested wetland block in the Pawtuxet River basin providing habitat for interior wetland dependent species.

Although precise predictions about the impact of the slurry wall are difficult without further study of the hydrology and biology of Mishnock swamp, the State acknowledges that it could alter the water table, dehydrate portions of the swamp and eventually cause a significant loss of wetland habitat (RI Water Res. Brd. 1986). Loss of water could reduce suitable habitat for the swamp pink, a species of state concern, and other wetland dependent plants and animals. Development surrounds Mishnock swamp, except for where it is connected to wetlands along the South Branch of the Pawtuxet River and the Big River site. Thus, the Big River dam would isolate Mishnock swamp from adjacent habitat blocks, thereby reducing its use as a travel corridor for area sensitive species.

The impoundment would affect the hydrology and biology of downstream areas (effects on water quality are discussed separately in Section C below). Previous studies have not considered the full impacts of the Big River dam on the downstream flow regime (RI Water Res. Brd. 1986). For example, approximately 270 acres of riverine wetlands, including 50 acres of emergent marshes, border the Mishnock River and the South Branch of the Pawtuxet River. Flows will be reduced over 40% at the start of the South Branch of the Pawtuxet and 34% at the USGS gage station downstream of the Mishnock River. Wetlands along the South Branch of the Pawtuxet River form a rich mosaic of cover types. Extensive patches of emergent dominated wetland types are noteworthy aesthetically, recreationally, and for wildlife, especially waterfowl. Removing over one-third of the water from these areas will likely result in pronounced changes in these wetlands. Deprived of water, the existing plant communities would become stressed and susceptible to invasion by opportunistic species such as purple loosestrife (*Lythrum salicaria*) and *Phragmites*. Eventually, some downstream wetlands could become upland.

The impoundment would interrupt the export of nutrients and organic matter to downstream areas. Destruction of the wetlands within the impoundment would disrupt the pattern of energy flow and movement of materials, causing adverse impacts to fish and wildlife communities far removed from the reservoir site. These wetlands function as transition zones between aquatic and terrestrial systems and facilitate the exchange of material and energy to nearby and downstream ecosystems. Placement of a dam on the Big River would reduce energy export from the watershed and adversely affect the food chain support for downstream fish and wildlife communities. The impoundment would collect the majority of organic detritus produced by the watershed and prevent it from reaching downstream aquatic communities.

B) <u>Recreation</u>

The proposed reservoir would alter or eliminate many of the recreational opportunities currently available within the Big River management area, including fishing, swimming, hunting, river canoeing, and nature observation. Some of the adverse impacts on recreation are certain to occur. The extent of other impacts would depend on whether existing state law and policy changes. The state project does not include recreation as a component. Although the Corps project envisions recreation, final decisions about recreational uses will be made by the Rhode Island General Assembly and the agency which operates and manages the impoundment (Corps, EIS, 1981, Appendix C).

The Rhode Island Water Resources Board and the Providence Water Supply Board have a policy which prohibits any recreation on primary reservoirs and surrounding environs. (May 6, 1979 letter in Corps, EIS 1981, Vol. II, Appendix C; Vol. III, Appendix H). Since the Providence Water Supply Board will manage and operate the reservoir if it is built (Corps, 1981, EIS; P. Calise, 1988, Water Resources Board, pers. comm.), it is likely that it would be managed in the same manner as the Scituate Reservoir, i.e., no recreation would be permitted. Although some state agencies have recommended that some recreational uses be allowed at water supply reservoirs, EPA is unaware of any effort underway to change state laws or policies (SCORP 1986; DEM response to Corps, EIS, 1981, Vol. II, Appendix C). Therefore, it appears that if the reservoir were built, all of the recreational activities described in Chapter III above would be eliminated from the entire 8,000 acre Big River management area. Because of the possibility that such policies will change, however, I have also evaluated the Corps' maximum recreation option, Option III (Corps, EIS, 1981, Vol. III), in assessing potential changes in recreation at the site.

The proposed impoundment would completely eliminate the cold water stream fisheries from the site. As discussed earlier, while there is a potential for a cold water lake fishery to be established, EPA Region I is not convinced this will occur. The likelihood is that the cold water fisheries will be replaced with a warm water fishery. Cold water fisheries are rare in Rhode Island, while there appears to be little additional demand for warm water fishing (SCORP 1986; RI Water Res. Brd. 1986; Appendix II). The Corps would allow fishing at the impoundment under Option III. But, since the Big River reservoir would be built next to Flat River Reservoir, the best warm water fishery in the Pawtuxet River basin, it is doubtful that the Big River impoundment would offer any warm water fishing opportunities not already available at Flat River Reservoir. Finally, there would be adverse impacts on the warm water fisheries in Flat River reservoir because of reduced flows and from more frequent drawdowns, upsetting circulation patterns, changing nutrient recycling, and reducing overall biological production. (USFWS 1978).

Swimming within the impoundment area would be lost entirely, regardless of whether the State or Corps builds the dam, because Rhode Island state law prohibits swimming on reservoirs and tributaries to reservoirs (R.I.G.L. 46-14-1). Under Option III, the Corps would allow swimming at some ponds within the management area and would increase swimming opportunities at Flat River Reservoir. However, since swimming can already occur in these areas, and enhanced opportunities at these locations can be achieved independent of whether a dam is built at Big River, the Corps proposal is not sufficient to offset the loss of swimming the impoundment would cause.

The impoundment would substantially diminish opportunities for hunting, birdwatching, and nature observation. This is because the project would destroy the most productive area for wildlife and decrease available land for such activities by 3,400 acres. FWS estimated that the impoundment would remove about 1/2 of the wildlife management potential of the site. It would also fragment an otherwise continuous stretch of habitat into many separate patches, adversely affecting the wildlife that would otherwise be associated with active and passive recreation.

River canoeing at the site would no longer be possible if the reservoir were built. On the other hand, canoeing and boating would be allowed at the impoundment under the Corps' proposal. Although the Corps plan would probably increase boating because of greater access to the site, it is important to note that the same types of boating opportunities exist at nearby Flat River Reservoir. There are no similar river canoeing opportunities nearby.

Finally, the reservoir would adversely impact hiking, off-trail bicycling, and horseback riding, by removing the middle portion of the site and making at least 3,400 acres of open public land unavailable for these activities.

Based on the impacts identified above, EPA Region I concludes that the Big River reservoir would likely cause significant adverse impacts on recreational values at the site. Under any circumstances, the following impacts would occur: cold water stream fishing would be lost, and replaced with a more common warm water fishery; fishing downstream at Flat River Reservoir would likely be adversely affected; swimming would be eliminated from the impoundment area; existing opportunities for hunting, hiking, and horseback riding would be substantially reduced, along with the opportunity to observe uncommon wildlife species less than 20 miles from a major metropolitan area; and riverine canoeing would be eliminated.

The Corps asserts that if it builds the reservoir, there would be more recreation than what currently exists at the site. It is true that boating and warm water fishing would increase if such activities were permitted on the impoundment, although similar lake fishing and boating are currently available 100 yards away at the Flat River Reservoir. The other "improvements" would simply make the site more accessible to the public with parking lots, trails, boat ramps, and playing fields in the gravel pit area (Corps, EIS, 1981). These actions would not offset the losses described above. Moreover, better access can be achieved whether or not a reservoir is built. Finally, regardless of any measures the Corps would take to mitigate impacts on recreation, based on current state law and policy, people would lose all recreational values of over 8,000 acres of State property.

C. <u>Water Quality Impacts</u>

The Pawtuxet River, one of the most polluted rivers in New England, currently violates state water quality standards for dissolved oxygen and toxics (metals). Over $60 million dollars has been spent by EPA during the past 15 years attempting to clean the river, and local communities must spend an additional $60 million or more for advanced treatment in the coming years. The Big River dam would dramatically reduce downstream water releases from an average annual flow of 60 cfs to 6 cfs (4 MGD). Impounding all but 6 cfs would reduce flows into the Flat River Reservoir by 45%, into the South Branch Pawtuxet by 34%, and into the mainstem of the Pawtuxet River by 15%. This would undermine the expensive federal, state and local clean-up efforts currently underway to enable the river to achieve water quality standards. Several communities expressed concerns to EPA during the comment period that the Big River dam could negate the gains that would be realized from investing in advanced wastewater treatment.

The adverse impacts of restricting flows would be most pronounced during the summer months when downstream aquatic life is already stressed by reduced water volumes, depressed levels of dissolved oxygen, and elevated levels of metals. Sharply reducing water flow causes problems besides increasing pollutant concentrations. Water depth and velocity decrease, reducing feeding and breeding areas for aquatic life, and the temperature increases, causing greater dissolved oxygen deficiencies. As described above, diminished flows may adversely affect the wetlands along the South Branch of the Pawtuxet River thereby reducing their value to aquatic life for feeding and resting.

The proposed release of 4 MGD equals the calculated 7Q10 flow of the Big River (i.e., the lowest flow for seven consecutive days during a ten year period). The 7Q10 flow represents an infrequent and stressful condition that aquatic life cannot be expected to withstand for an extended period of time. To avoid compounding water quality problems during the summer and protect downstream aquatic life, the dam would need to release a flow considerably greater than the 7Q10. The U.S. Fish and Wildlife Service (1981) calculated the minimum flow release to sustain aquatic life to be 18 cfs (12 MGD). Neither the State nor the Corps has indicated a willingness to release water substantially above the 7Q10 since this would mean a corresponding reduction in reservoir yield for drinking water.

Precise water release requirements would require extensive water quality modeling. One factor which complicates modeling, however, is that the current owner of the Flat River Reservoir (Quidneck Reservoir Company) claims a right to release no water downstream if it so chooses (RI Water Res. Brd., 1986). In fact, rather than augmenting downstream flows, the owner has a contract with Coventry to retain water during the summer to maintain water levels in Flat River Reservoir for recreation. Since the Big River Reservoir would virtually halve the amount of flow into Flat River Reservoir, it may prompt the owners of Flat River Reservoir to release even less than the 7Q10 flows at times during the summer.

While reduction of flow most directly affects water quality, the reservoir would have other effects as well. The value of the wetlands within the impoundment area for contributing to base flow by groundwater discharge and maintaining water quality will be lost. The extent to which the reservoir will replace those functions is unclear and would depend upon a number of factors including time of year, contaminants in question and the manner in which the impoundment is operated.

D. Mitigation

As described above, the project would replace a large area of prime wildlife habitat with a shallow lake of value to only a few species. The State did not submit a mitigation plan with its permit application. The Corps, in its 1981 EIS, proposed several structural and nonstructural measures to mitigate adverse impacts including management of forests adjacent to the reservoir, reclaiming a mined area and putting up some birdhouses. The Corps proposed to mitigate the loss of wetlands chiefly by constructing "subimpoundments" in the upper reaches of the reservoir in an attempt to enhance or create wetland habitat. If fully successful, these subimpoundments would contain about 90 acres of wetlands.

EPA Region I does not believe the adverse environmental impacts of the reservoir proposal can be mitigated. To even attempt meaningful replacement of the full spectrum of existing wetland values would require a mitigation plan enormous in scope, phenomenally expensive and so complex as to be infeasible from both a scientific and practical standpoint. Even if a plan could be devised which theoretically replaced wetland values, the Region doubts it could be relied upon to prevent the unacceptable adverse environmental impacts of this project given the inherent risks associated with mitigation.

Recent studies in New England and elsewhere point to a number of scientific and practical difficulties associated with mitigation, especially wetland creation. The scientific base is too incomplete to support any belief that artificial wetlands will provide the functions of natural wetlands, let alone replace the diverse values of the many hundreds of acres of wetlands that would be lost at this site. Some wetland functions, such as flood storage, can normally be replicated successfully. Attempts to mitigate wildlife habitat losses have met with mixed success, and often benefit only a few select species. There has been little demonstrated ability to recreate on a broad scale other wetland values such as groundwater discharge and recharge or the complex interactions of water, soil and plants involved in the uptake and transformation of nutrients and pollutants. Finally, it would be extremely difficult, if not impossible, to replicate the important role Big River system plays in the watershed (i.e., its landscape attributes). The FWS has concluded that to "design and successfully implement a compensation plan to replace the functions and values lost...is clearly beyond the current state-of-the-art in mitigation planning." (Appendix II)

After considering the project's impacts, unprecedented in New England, and the poor track record of wetland creation and enhancement projects to compensate for projects involving much less severe impacts, I conclude that the adverse effects of the Big River project cannot be adequately mitigated. In any case, the mitigation scheme briefly described in the 1981 EIS could not begin to compensate for the severe impacts to wildlife and other wetland values which the Big River project would cause. Even if 90 acres of subimpoundments could be successfully created and maintained, they would largely involve manipulation of existing wetland habitat. This would increase the value of these areas for select wildlife species at the expense of others. It would not measurably offset the impacts associated with the loss of 575 acres of diverse, natural wetlands nor would it even attempt to address the many secondary impacts the project would cause. Moreover, most of the wetlands which the project would destroy are forested. The subimpoundments would provide little or no value for the many species adapted to life in the forested systems.

E. Summary

The Big River reservoir would disrupt aquatic ecosystems on a massive scale. Nearly 600 acres of diverse and productive wetlands would be immediately destroyed with potential long term adverse impacts affecting more than 700 additional acres. Roughly 2500 acres of upland forests would be destroyed. Seventeen miles of predominately cold water streams would be lost. These direct and indirect impacts would sharply reduce the current outstanding wildlife values of the site. The numbers and variety of birds, mammals, fish, herptiles and invertebrates would all suffer major declines. The reservoir would degrade water quality and by depriving downstream areas of water. The project would substantially reduce the extent and diversity of recreation available in the impoundment and management areas.

I conclude that these adverse impacts are significant and violate the §404(b)(1) guidelines. I reach this conclusion after examining the quality and quantity of the affected aquatic ecosystems, the direct and indirect effects and the persistence of the impacts. I further conclude that significant adverse impacts would remain even after all practical mitigation occurred. I believe that any mitigation plan would fall far short of replacing the outstanding values that would be lost to the project, let alone reduce the impacts to a level which would comply with the §404(b)(1) guidelines.

V. ALTERNATIVES

In addition to evaluating the significance of the potential impacts from the proposed reservoir, the Region has considered whether the impacts are avoidable. The preamble to the §404(c) regulations explains that:

> one of the basic functions of 404(c) is to police the application of the section 404(b)(1) guidelines. Therefore, those portions of the guidelines relating to alternative[s] ... may be considered in evaluating the unacceptability of the environmental impact. ...Of course, even when there is no alternative available, and "vetoing" the site means stopping the project entirely, the loss of the 404(c) resources may still be so great as to be "unacceptable."

44 Fed. Reg. 58076, 58078 (October 9, 1979).

The 404(b)(1) guidelines prohibit the discharge of dredged of fill material if there is a practicable alternative to the discharge which is less environmentally damaging to the aquatic environment. 40 C.F.R. §230.10(a). An alternative is practicable if it is available and feasible in terms of cost, technology, and logistics in light of the basic project purpose. In this case, the basic project purpose of Big River reservoir is to satisfy future needs for drinking water in the Greater Providence area.[8]

In order to evaluate the practicability of the Big River reservoir, the Region first examined need for and cost of the project. As described below and in Appendix III, this inquiry shows that there is no demonstrated need for new sources of water. The Region nevertheless went on to consider whether, even if a need did exist, there are alternatives to meet that need. In so doing, the Region examined the projected costs of water from the Big River reservoir, in order to compare costs of otherwise feasible alternatives, and evaluated a number of possible ways to increase water supplies.

Region I retained the services of Dr. John Boland, an expert in the field of water supply planning and economics and professor of

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[8] The State project is a water supply project only. The Corps project would serve the additional purposes of providing flood control and recreation. According to the EIS, construction of the dam would not be economically justified for flood control or recreation alone. Therefore, the Region focused its analysis on alternatives to satisfy the water supply purpose. Nevertheless, insofar as the Corps project would provide flood control or recreation benefits, the Region concludes that they can be achieved through less environmentally damaging alternatives.

Environmental Engineering at Johns Hopkins University, to assist in the evaluation of the need for, and alternatives to, building the Big River reservoir. His report is appended hereto as Appendix III. Dr. Boland's analyses, and additional information in the record, demonstrate that there is no established need for increased water supplies within the planning period used by the Corps in the Big River feasibility study (i.e., until the year 2030), and that even if a need did exist, it could be satisfied through a variety of practicable and less environmentally damaging alternatives.

A) Need for Water Supply

Prior to 1980, three major studies of future drinking water needs in Rhode Island (Maguire, 1952; Metcalf and Eddy, 1967; RI Statewide Comprehensive Transportation and Land Use Planning Program, 1969) had recommended building the Big River reservoir to meet anticipated shortfalls in future public water supply capacity. In 1981, the Corps of Engineers completed the Big River feasibility study. The Corps study area (Big River study area) consisted of the service areas of the Providence Water Supply Board (PWSB), Bristol County Water Authority (BCWA), and Kent County Water Authority, with the PWSB supplying over 80% of the water. While the Corps used a study area somewhat smaller than that used in the earlier reports, it Corps also concluded that the reservoir was needed. These studies greatly over estimated the need for drinking water, and greatly under estimated the cost of building the reservoir. (Appendix III).

The three earlier studies predicted that by 1990, the demand for water would exceed the supply, and they recommended that Big River reservoir be built immediately. The more recent Corps report predicted that demand would exceed capacity by either 1997 (Corps, EIS, 1981) or 2007 (Corps, 1982) and that the deficit would range from 20 to 34 MGD by 2030. All of these studies relied on population and per capita estimates to forecast future water needs.

Several factors explain why the studies over estimated need. First, they projected population increases that were greater than the State's actual population growth. Rhode Island's population has remained essentially stable for the last decade (SCORP, 1986), in contrast with the predictions in the previous studies. The State indicated during the comment period that Rhode Island's population has grown more rapidly in the last couple of years, but the population is still considerably below the Corps' earlier projections. Second, and more importantly, the per capita assumptions which underlie the forecasts have been proven wrong. Each of the studies assumed continued future increases in per capita water use. Even though population growth levels in Rhode Island were projected to be moderate, estimates of water use were predicted to rise at a rapid rate. For example, the Corps estimated that in 1975 people used Scituate water at a rate of 150 gallons per capita per day (gpcd), and projected that in the year 2000 residential and commercial use would rise by another 20 gpcd. The 1967 Metcalf and Eddy study had assumed an even faster increase in the per capita rate.

These assumptions of water use trends directly conflict with current information from Rhode Island and other areas across the country, which shows that the average person uses the same or less water today than 10 years ago (Appendix III). The Providence Water Supply Board testified at a 1988 Public Utility Commission hearing that per capita use in 1986 was 138 gpcd, and in 1987 was 124 gpcd, or 17% below the Corps' estimate for 1975 (Mainelli, 1988). Other estimates imply current average use rates in the range of 107 to 138 gpcd (Appendix III). Moreover, Rhode Island recently passed a law requiring 1.5 gallon low flow toilets for all new construction, renovation, and replacement purposes in the State. This will further reduce the per capita use of water in the State, since toilets account for the largest single indoor use of household water.

Third, questionable assumptions related to industrial water use underlie the need projections. For example, the Corps study relied heavily on the Metcalf and Eddy data from the 1960's and did not predict any decrease in industrial water use despite the effects of the implementation of the 1972 Clean Water Act and its 1977 amendments. Pretreatment requirements have frequently resulted in decreased industrial water use, especially in the electroplating and metal finishing industries. There are over 100 such facilities in Rhode Island, and it is logical to assume that these as well as other industries in the Providence area (Narragansett Bay Commission, 1988), and have reduced their water consumption. The Corps, however, projected industrial water use to grow faster than any other sector of water use through 2030.

Fourth, the studies also underestimated the existing supply capacity, which the Corps defined as the sum of the safe yields of existing surface and ground water supplies. For example, the Corps calculated a 1975 supply capacity based in part on an assumed safe yield of 77 MGD for the Scituate system. Managers of the Providence Water Supply Board (PWSB), however, have recently estimated the safe yield of the Scituate to be 80.3 MGD, with an additional 9 MGD for release downstream (Archer, 1988). This additional yield would extend the use of existing water supplies, as discussed below.

The Corps 1981 EIS predicted that demand would exceed supply in 1997 and that there would be a supply deficit of 34.1 MGD for the Big River study area in the year 2030. However, revising the underlying assumptions to reflect the best current information shows that existing supplies will exceed demand until sometime after 2030 (Appendix III):

- PWSB estimates that the dependable yield of the Scituate Reservoir is 89.3 MGD, and that 9.0 MGD must be released to the River. This leaves an available yield of 80.3 MGD, 3.3 MGD higher than the 77 MGD used by the Corps.

- The Corps assumed that BCWA would shortly develop an additional 3.0 MGD of ground water capacity. To date, no additional wells have been drilled in Bristol County, and there are no current plans to do so.

- The Corps estimated the dependable yield of the BCWA system at 3.2 MGD. In 1989, a consultant for BCWA estimated yield at 4.0 MGD, 0.8 MGD higher than the Corps assumption.

- Per capita use has not increased in the study area since 1975, and it is unlikely to do so in the future. In fact, there has been a significant decrease in the PWSB area in the last ten years. If per capita use is held constant at 1975 levels (more than 20 percent above the 1986 level reported by PWSB), and if the Corps population projections are accepted, projected residential and commercial water use for 2030 will be 21.5 MGD below the Corps forecast.

- The Corps offers no explanation for its projection of rapidly increasing industrial water use. In fact, industrial water use is decreasing throughout the U.S. If industrial use in the study area is held constant at 1975 levels, the year 2030 projection will be 13.9 MGD below the Corps projection.

The effect of these adjustments is the following:

	Dependable yield
Corps estimate	94.1 MGD
Addtl.Scituate yield	+ 3.3 MGD
BCWA ground water	- 3.0 MGD
Addtl.BCWA yield	+ 0.8 MGD
Total supply Year 2030	95.2 MGD

	Projected water demand
Corps, 2030	128.2 MGD
Stable per capita rates	-21.5 MGD
Stable industrial use	-13.9 MGD
Total water demand Year 2030	92.8 MGD
2030 Surplus	2.4 MGD

These assumptions are highly conservative, because they: 1) use Corps population estimates which over estimate growth; 2) assume no decrease in per capita water use after 1975, despite evidence to the contrary; 3) use a dependable yield which is calculated at a very high level of reliability (at approximately a 1.0 percent level, as discussed below); and 4) do not include water use reductions expected from recent pricing changes and new state requirements governing new and replacement toilets (discussed below).

Based on the record, EPA Region I concludes that previous predictions by the Corps and others of a water supply deficit in the Big River study area within the next twenty to forty years are unfounded. Using conservative assumptions of supply and demand, the Region believes that existing water capacity will be sufficient to satisfy future needs at least through the year 2030. Therefore, even without consideration of demand and supply alternatives, the Region concludes that construction of Big River reservoir is unnecessary in order to meet drinking water needs.

B) <u>Cost of Big River Reservoir</u>

EPA has reviewed the cost figures for the Big River reservoir in order to assess the practicability of alternatives to the proposed project. The cost of the project has escalated dramatically with each study. The 1952 Maquire study estimated the reservoir would cost $32 million (1989 dollars). The 1967 Metcalf & Eddy report and the 1981 Corps study estimated the cost to be $92 million and $210 million, respectively (1989 dollars). The most recent (1988) cost estimates place the project at $282 million for construction costs alone.[9]

The average cost of water delivered from Big River reservoir would exceed $9.14 per 1000 gallons, based on the latest construction cost estimate of $282 million and yield estimate of 32 MGD (Appendix III).[10] The PWSB now charges about $.40 per 1000 gallons,

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[9] The Corps 1981 EIS assigned the project a positive benefit/cost (B/C) ratio by the slimmest of margins (1.12 to 1). Region I has not performed an update of the B/C analysis of the project. However, since the cost of the reservoir has risen while the benefits appear to have remained unchanged (or decreased given the lack of need), an accurate B/C ratio would likely be less than 1:1.

[10] In addition, EPA believes that this figure is extremely conservative because it underestimates the cost and overestimates the yield. Costs for operation and maintenance, environmental studies, wildlife mitigation efforts, recreation mitigation, and a closed drainage system for I-95 have not been added to the cost figures. Moreover, the water yield from the Big River reservoir would be substantially less than 32 MGD if the State releases flows sufficient to protect downstream water quality (see discussion in chapter IV on water quality).

somewhat less for larger users. Hence, water from Big River reservoir would cost over 2000% more than what Providence users currently pay. The simple demand alternatives presented below would cost only a fraction of what Big River reservoir would cost. Almost any conservation alternative, as well as the supply augmentation alternatives EPA considered, would be cost effective compared to the expense of the Big River dam (Appendix III).

C) Demand Management

Demand management consists of measures that can be taken to decrease water use, thereby allowing current supplies to meet existing and future needs. These include pricing controls, various forms of water conservation, and drought management programs. In March, 1988, Rhode Island adopted its first water supply planning document, entitled Water Supply Policies for Rhode Island. It requires water utilities to adopt demand management measures, including conservation, as an integral part of all water supply planning. If properly applied, these policies will reduce the need for future water supplies.

Pricing Policies. Since the amount of water used in any given area depends, in part, on the price at which it is sold, increases in the cost of water can lead to decreases in use (Appendix III). Prior to a 1988 price increase of 37%, Providence had one of the lowest water rates of any city in the United States. Although its rates are still relatively low, the recent price increase should reduce water use in the Providence system alone by approximately 3.6%, within the next five to ten years. This would reduce year 2030 water use for the Big River study area by 2.8 MGD (Appendix III).

The PWSB expects to make further changes in its rate design to save additional water (Russell, 1988). Providence still employs declining block rates, which allow larger water users to pay less for water than small, mostly residential, users. This discourages conservation and the use of non-potable water for many of the larger industrial and commercial users. Changing this structure, and adopting other rate design options such as uniform rates, increasing block rates, summer surcharges, and excess use charges, would likely result in conserving an additional 4% of water from the PWSB distribution system, amounting to a reduction of 3.0 MGD for the Big River study area (Appendix III).

Conservation. Water conservation methods unrelated to pricing policies also have great potential in Rhode Island, because very few conservation programs exist.[11] In general, the PWSB has not seriously applied the water conservation mandates of the State's recent water policy document. In 1988, the Rhode Island Public Utilities Commission found the PWSB to have "no policy or directives" on water conservation, "no public education program," "no program of technical assistance for water use reduction" for any user class, and "no staff trained in, experienced with, or devoted to conservation matters" (RI PUC, 1988, p. 33).

The water reductions which can result from long term water conservation measures vary, depending on a number of factors, including cost and thoroughness (Appendix III). Predicted reductions for Rhode Island range from 9% (Corps, 1982) to over 50% (Metcalf and Eddy, 1979a, 1979b). A 50% reduction would postpone the need for additional supplies for well over 100 years. Chernick (1988) estimated that Rhode Island could reduce its residential water use by 44% by retrofitting homes with low-flow toilets and flow reducers in showers and faucets, saving over 20 MGD. Hospitals, hotels, and schools, which use a substantial amount of water in the Providence area, offer a large untapped potential for water conservation. In Boston, Massachusetts, for example, the Lenox Hotel recently reduced its water use by 40% by installing low flow toilets, low flow showerheads and efficient faucet aerators in its 220 rooms (Atkins, 1989). Ongoing leak detection and repair could also save a substantial amount of water. The Massachusetts Water Resources Authority, for example, expects to save roughly 7 1/2% of current demand through leak detection (CLF, p.18).

The State is making some advances in conservation. Rhode Island Public Law 89-326, adopted January 1989, provides for the mandatory installation of ultra-low flush toilets (1.6 gallons/ flush) in all new and replacement construction. This law should save approximately 15 - 20 gpcd (12% - 16%) in Rhode Island over the next 30 - 40 years (Appendix III). Taking the Corps estimate of 585,000 people in the Providence area by 2030, between 8.7 and 11.7 MGD will likely be saved in the Big River study area by implementing this new requirement. Additional water savings would be possible much sooner by retrofitting toilets and other plumbing fixtures in residential and commercial buildings. At least 5 - 8 gpcd can be saved by changing devices other than toilets, such as showers, faucets, and appliances (Brown and Caldwell, 1984). Thus, in the PWSB area, these changes would likely save between 2.9 and

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[11] In recent months, the Water Resources Coordinating Council, overseeing the State study of water needs, began several conservation demonstration projects and acquired water conservation education material for distribution. An important beginning, this water conservation effort is not yet part of the water utility infrastructure in the State.

4.7 MGD.

Water conservation techniques are available for industries as well. One study has shown a potential for savings of up to 45% (CLF, p.19). However, without better water supply management records, it is difficult to estimate the potential water savings for industries in Rhode Island. Industries could conserve drinking water by using non-potable water for purposes such as cooling water or machinery wash water. Indeed, Rhode Island water policy states, "water of pristine quality is not necessary for non-potable uses, and should not be committed to such uses if other alternatives exist" (RI Division of Planning, 1988, p. 2.25). The State could actively pursue its policy directive of matching water quality needs with appropriate supplies by changing pricing policies for large users and requiring industries to switch to non-potable water or document why they cannot. Issuing matching grants to industries for pumping and treatment costs may also prove cost effective.

Thirty-five years ago the Providence-Warwick aquifer supplied over 10 MGD for various industrial needs; today, however, businesses use less than 2 MGD from the aquifer (USGS, 1989). Therefore, at least 8 MGD of non-potable water is available to meet industrial needs in Providence. The Corps estimates that industry uses approximately 20% of Scituate's water, or, 13 MGD of drinking water. If even half of the industries using non-potable water 30 years ago in the Providence area switch to non-potable water before 2030, approximately 4 MGD could be saved.

In summary, pricing changes and modest conservation measures, some of which are already underway in the Providence supply area (80% of the Big River study area), can be expected to result in water use reductions by 2030 of 12-15 MGD. Other pricing changes and conservation measures which could readily be adopted could save an additional 9-13 MGD. Therefore, based on modest existing and potential water conservation programs, the PWSB system could save 21-24 MGD. Additional reductions from more aggressive pricing and conservation measures cannot be quantified at this time, but based on experiences elsewhere, they could be much greater (Chernick, 1988; Metcalf & Eddy, 1979).

Drought Planning. Drought planning to reduce water use during dry weather is another demand management technique which could reduce the need for additional water supplies. Water supply planners predict a safe yield for a water supply source based on a certain risk of drought conditions. To respond to a drought, a community can either rely on having available a very large amount of water that it would normally not need or use, or use less water by following a drought plan, or do both. However, it is highly inefficient and generally impossible to have enough water for every drought condition (Boland, 1988). Minor adjustments in lifestyle during a low water year generally do not cause major inconveniences (Appendix III).

The PWSB bases the safe yield of the Scituate Reservoir (estimates range from 72 to 89 MGD) on a 1% probability drought. In other words, the Scituate Reservoir can produce approximately 80 MGD during drought conditions expected to occur once every 100 years. The PWSB indicates that 110 MGD is available in normal weather years, although this may underestimate the yield which could be realized (Appendix II).

The Corps, in the Big River feasibility study, apparently accepted the State's reliability target of a 1% probability drought and did not analyze the possibility of reducing water use, rather than increasing supply, during periods of drought. Many utilities, however, base their planning on a 2% - 3% drought risk criterion. If the criterion were changed for the Scituate Reservoir, to a 3% probability drought, statistically expected once in every 33 years, its "safe yield" would increase by 20%, (17.9 MGD) to 98.2 MGD (Appendix III). Water use reductions of up to 23% would be needed during the worst case drought, but reductions in this range could be achieved through conventional drought management plans with no more than moderate disruption and cost (Appendix III). For example, during the drought in the 1960's in New England, water use greatly decreased with little disruption, and Pawtucket, RI, reported a reduction of 16-18% in its water use. California reduced its water use 50% during the 1976-1977 drought (Appendix III).

Obviously, drought planning and management can have a substantial effect on the safe yields of existing supplies, and hence the projected need for new supplies. While savings are possible on an ad-hoc basis, water supply planners typically prepare a drought plan for reducing water use during unusually dry years. Unfortunately, to EPA's knowledge, no utility in Rhode Island has a drought plan, including the PWSB. Developing and implementing a drought plan for the Scituate system alone could significantly increase the effective yield of supplies in the Big River study area (Appendix III).

In summary, demand management alternatives such as those described above are clearly feasible, having been implemented in numerous communities across the country. The alternatives discussed above represent only some of the choices available to Rhode Island. A more comprehensive analysis would likely derive additional options. For example, more detailed knowledge of user groups and water systems would allow further estimates of water saving by leak detection and repair, industrial and commercial recycling, and outdoor conservation techniques. While the exact cost of implementing each of the strategies is difficult to quantify, they are clearly less expensive than the cost of building and operating the Big River reservoir (Appendix III). Individually, each demand management alternative could offset a portion of the water from the reservoir. Combined, they would produce more water than would the proposed project (see Table 2). In addition, these alternatives would be far less environmentally damaging. Since they would involve decreases in water use rather than creation of new sources of water, they would not cause adverse environmental impacts.

TABLE 2: DEMAND MANAGEMENT ALTERNATIVES*

	Amount of water (MGD)
Recent RI Program Changes:	
1. changed plumbing codes for new construction	9-12
2. increased price for Scituate's water	3
Potential Programs:	
1. additional changes in pricing structure	2-4
2. residential and commercial retrofit program not including toilets	3-5
3. use of non-potable water for industry	4-?
4. other -- education, fixing leaks, outdoor uses, industrial assistance	?
Demand Management - Drought Plan	
3% risk	18
Demand Management Total:	**39-46**

* Demand management is projected until 2030 for the PWSB area only. Adoption of similar measures in other parts of the Big River service area would lead to additional water savings.

D) **Supply Management**

Supply management alternatives increase supplies rather than decrease water use. Some of the possible alternatives, including developing groundwater sources, improving existing surface water yields, using impoundments together with groundwater, developing unconventional water supplies, and avoiding abandonment of water supplies are discussed below. EPA Region I has not analyzed each of these alternatives in detail to identify precise yield estimates, costs, logistical difficulties and environmental impacts. When compared to the Big River reservoir, however, with its tremendous costs and environmental consequences, it appears likely that some or all of the measures described below would, upon further analysis, prove to be practicable and less environmentally damaging.

Groundwater. Rhode Island contains approximately 140 MGD of groundwater, 113 MGD of which is available for use (Johnson, USGS, 1989). The USGS also indicates that the groundwater is generally suitable for human consumption, with little treatment necessary. Exceptions to high water quality include the Providence - Warwick aquifer and possibly some areas along the Blackstone Valley and localized areas of contamination.

Unlimited withdrawal of groundwater would be ill-advised, since it could reduce surface stream flows and cause water quality problems during drier times of the year. With proper management, however, there appear to be at least 10 - 20 MGD of high quality groundwater available for drinking water in the central portion of the State (Appendix III). Additional groundwater is available in other parts of the State, especially most of South County, which EPA recently designated as a sole source aquifer requiring greater federal protection. While transmission and pumping costs would be higher than such costs for Big River reservoir, the well field construction and treatment costs would be far less than the construction costs associated with the reservoir project. With proper well-head protection and measures to guard against environmental impacts from excessive withdrawals, groundwater development would appear to be a practicable alternative for increasing water supplies.

One way to help prevent excessive groundwater removal during low flow conditions would be to operate groundwater sources in tandem with some of the 34 largest water impoundments and ponds in the Pawtuxet River basin. Groundwater removal could occur during wet weather seasons, when it would have less environmental impact on downstream low water flows; during drier conditions, surface water supplies could provide the majority of the water.

Increasing yields from existing impoundments. Another alternative could be to increase the yields of current supplies through improved management and to use existing impoundments not currently used for water supply. The Scituate system consists of five reservoirs which drain into the two large branches of the Scituate impoundment. The upstream reservoirs could be operated in tandem with the main reservoir to maximize the yield of the entire watershed and still protect downstream water quality. The State could construct several gates just downstream of roadways crossing the watershed, which could not only control flow but also increase PWSB's ability to contain spills of hazardous materials in case of an accident.

Some additional water supply could be obtained from the South Branch Pawtuxet River basin by utilizing existing impoundments and flood skimming (Appendix III). The basin contains over 10 ponds and impoundments of significant size. Some of these might be enlarged to store additional water during periods of high rainfall. This excess water could be pumped to the Mishnock aquifer or the Scituate Reservoir to increase their respective yields, similar to what the Corps expected to do if Big River reservoir were built. (Corps, EIS, 1981).

In addition, during wet periods, flood waters could be skimmed from full reservoirs and transferred to other surface and groundwater reservoirs for storage and use during drier seasons. This could increase effective yields from existing systems. For example, the State could skim floodwater from the Flat River Reservoir during wet weather seasons without producing unacceptable changes in water level (Appendix III). Monitoring would be needed to determine if the water requires treatment in order to be potable. The wetlands in Mishnock swamp could prove effective at reducing coliform levels if the State were to pump Flat River water to the Mishnock aquifer.

Pumping and transmission facilities would be needed for the skimming and transfer scenarios described above. In the absence of detailed studies, it is impossible to determine the costs of such options. When compared to the Big River reservoir costs, however, any such alternative may be feasible if the construction cost, not including pumping or other operating costs, does not exceed $36 million/MGD (Appendix III).

Unconventional water supplies. There is no technological barrier to producing drinking water from brackish water or seawater; the only constraint is cost (Appendix III). During the last few decades, desalination has become much more common, and its costs have declined markedly (OTA, 1987). Indeed, the Congressional Office of Technology Assessment recommends that desalination be included "as a viable option in any evaluation of water supply alternatives." (OTA, 1987, p.17).

There are several variables which influence the cost of desalination. For example, up to 10 MGD of brackish water containing less than 6,000 to 8,000 mg/l total dissolved solids (TDS) can be treated through desalination (reverse osmosis) to the level of drinking water in a facility costing about $10 million (Taylor, 1989). If extensive pretreatment is required, however, the cost could rise by $1 million to $8 million. Operation and maintenance costs could be as low as $0.50 to $0.75 per thousand gallons, but could rise to $1.15 to $1.75 per thousand gallons if the pretreatment were required.

EPA could not find any information on brackish groundwater in Rhode Island from shallow or deep wells. If such water is available with less than 6,000 - 8,000 TDS, and pretreatment is not required, then the construction and operating costs combined for desalinating 10 MGD would be approximately $1.00 per 1000 gallons (Appendix III). Water needing extreme pretreatment would cost approximately $1.75 per 1000 gallons. This is cheaper than what Bristol County Water Authority users currently pay and seven times less expensive than the expected costs of water from Big River reservoir based on capital costs alone. Therefore, if such brackish water were available, its exploitation would appear to be a practicable alternative.

Seawater containing up to 25,000 mg/l TDS can be treated to produce drinking water for about $10 - $11 per 1000 gallons, including operating costs, depending on the quality and quantity of the raw water and the alternatives for brine disposal (Taylor, 1989). This is less than 20% higher than just the capital costs of the Big River project (Appendix III). If all of the expected costs of the reservoir, such as operating and environmental mitigation costs, were included in the comparison, it is highly likely that the average unit cost for desalinated seawater would be less than the average unit cost for the reservoir water. Detailed studies would be needed to evaluate the existence of any logistical difficulties, such as the availability of energy sources and disposal sites for brine. Based on current information on cost and technology, however, it appears that even desalination of seawater would be a practicable alternative. With proper siting of withdrawal, treatment, and disposal facilities, it would also be less environmentally damaging than the Big River reservoir.

Avoid abandoning water supplies. The Bristol County Water Authority (BCWA) currently plans to abandon its existing water supplies, with a dependable yield of 4.0 MGD, and to tie into the Providence system. Aquidneck Island may attempt to do the same sometime in the future. The BCWA apparently bases its plan largely on economic considerations (Appendix III). BCWA can purchase water from the PWSB for $.30 per 1000 gallons. Although a new pipeline would be required at a cost of $30 - $40 million, BCWA states that this would cost less than the combination of upgrading the Child Street Treatment Plant ($20 million), and expanding its existing supply to meet future needs (approximately $30 million) (CDM,1989). Because the State plans to pay 50% of the pipeline costs (100% if a bond issue passes this year), this plan is even more attractive to the BCWA.

BCWA's plan fails to consider the likely increases in the cost of water from PWSB if the Big River reservoir were built. The average unit cost of water if the treatment plant were upgraded would be considerably cheaper than the cost of the Big River reservoir water (Appendix III). To the extent that BCWA would need additional supplies in the future, it already has the ability to purchase supplemental water as needed from PWSB through the existing connections in East Providence. These options appear to be viable alternatives for the BCWA system to satisfy its needs without resorting to Big River reservoir water. There may well be others, such as desalination of brackish water.

BCWA's current plan, and the State's decision to help fund the project, seem clearly to violate the state policy against abandoning existing supplies (RI Division of Planning, 1988). Moreover, the abandonment of the surface water supplies would probably prove irreversible (Appendix III). Once abandoned, continuing siltation, land use changes, and new reservoir activities would likely preclude any future use of the surface water sources for drinking water without significant treatment. The total supply available in Rhode Island would be permanently reduced, therefore, by the yield of these sources, currently about 4.0 MGD. However, if the supplies are not abandoned, and water conservation and drought management are given a higher priority, the needs of Bristol County would have minimal impact on PWSB's future needs (Appendix III).

In summary, there appear to be numerous ways in which the water supplies in the Big River study area can be increased without exacting the high environmental costs of the Big River reservoir. Increasing the yield of existing systems, developing groundwater resources, pursuing unconventional systems such as desalination, and not abandoning existing supplies are all likely to be practicable alternatives to the proposed reservoir.

E) Recreation and Flood Control

As explained above, the Big River reservoir is fundamentally a water supply project.[12] If built by the Corps, it would also

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[12] There has been some suggestion that the Big River reservoir could also serve as a back-up water supply in case the Scituate Reservoir becomes contaminated. Neither the State nor the Corps has listed this aspect as a project purpose or benefit. EPA Region I is unaware of any reservoir, let alone one which would cause such serious environmental damage, that has been constructed to provide a back-up water supply. Moreover, Big River reservoir would be an odd choice for such a purpose, since I-95 cuts through the middle of the impoundment area. In any

provide some recreation and flood control. Since neither of these secondary aspects would justify its construction apart from the water supply purpose (Corps, EIS, 1981), it is unnecessary to conduct a separate alternatives analysis for them. In any case, the Region believes that there are ways to provide recreation and flood control benefits which would be less environmentally damaging than the proposed reservoir.

The Region has concluded that the reservoir would have an adverse effect on existing recreation. Therefore, the no build alternative would be preferable for recreation. The State could also choose to further enhance recreation by providing better access and information about the site.

Flooding of the mainstem of the Pawtuxet River does cause property damage in several communities during large storms. Increased urbanization, which causes flash run-off, and extensive development in floodplain areas are the primary causes of the problem (Corps, EIS, 1981). A dam at Big River could reduce some of the flooding downstream on the Pawtuxet, but the benefits would be limited. Unless the local communities adopt active floodplain protection and control local urban runoff, the flood protection benefits of a Big River dam would barely keep pace with increased urbanization and additional development in the floodplain (Corps, EIS, 1981, Vol. IV, Chapter 2). Each community could, for example, build detention basins to control flash run-off from urbanization, which could decrease peak floods, similar to wetlands. In addition, even the Corps acknowledges that the Big River watershed represents only about 13% of the total Pawtuxet River watershed, so that the flood reductions on the main stem Pawtuxet resulting from a dam on Big River would be "quite limited" (Corps, EIS, 1981, Vol. II, Appendix D; Vol. IV, Appendix IV). EPA also believes that the Corps has not fully considered the flood protection values of the Big River wetlands, and as a result overestimated the flood control benefits of the dam.

In the EIS and in the 1987 re-analysis of flooding on the Pawtuxet River, the Corps concluded that the Scituate Reservoir could provide a significant modifying effect on flooding in the Pawtuxet River (Corps, EIS, 1981, Vol. IV, Chapter 2; Corps, 1987). The dams at Scituate and Flat River control 40% and 25% of the drainage basin of the Pawtuxet River watershed, respectively, in contrast to the Big River watershed, which comprises only 13% of the Pawtuxet River watershed. Thus, there is clearly more opportunity to control flood waters at the existing Scituate and Flat River

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event, some of the alternatives to constructing the reservoir could also serve as back-up supplies to Scituate. Finally, it is likely that there are other alternatives to protect the Scituate from becoming contaminated in the first place, or to restrict or treat any contamination that does occur.

reservoirs, and possibly at other downstream dams, in a way that would not cause extensive environmental damage. These efforts, coupled with serious urban flood control and floodplain management by the communities along the Pawtuxet River, could achieve whatever limited flood control benefits may be available from building the Big River dam, with less environmental damage.

F) Summary

Based on the administrative record, I conclude that the impacts from the Big River reservoir are avoidable. As stated above, the record shows no demonstrable need for new supplies of drinking water before the year 2030. Even if the Corps' most generous predictions were to prove true, however, or if unforseen needs develop in the future, ample information in the record shows that there are numerous alternatives to building the proposed Big River reservoir which are practicable and less environmentally damaging. These options include demand management alternatives, such as pricing changes, drought management and conservation; supply alternatives, such as groundwater and increasing yields on existing surface water supplies; or a combination of both demand and supply alternatives. These alternatives appear to be less costly than the proposed project, and would be far less environmentally damaging.

VI. CONCLUSIONS AND RECOMMENDATION

The Big River impoundment area contains some of the finest wetlands in Rhode Island. Numerous studies conducted at the site over the past 13 years by a number of experts all confirm that the aquatic habitats at the site support a rich array of wildlife including mammals, birds, reptiles, amphibians and fish. Largely unspoiled and comprised of a diverse mixture of habitat types, the Big River watershed provides refuge for wildlife in a heavily developed region of New England. In addition to being outstanding wildlife habitat, the project site provides valuable recreational opportunities uncommon in the area. The wetlands of the Big River watershed also function to store floodwaters, recharge and discharge groundwater, maintain water quality, and provide open space.

The adverse impacts of the proposed reservoir would be indisputably significant. If constructed, the reservoir would profoundly alter the hydrology and biology of the watershed and drastically reduce its value for wildlife and recreation. The immediate loss of 575 acres of wetlands and 17 miles of free flowing streams would be unprecedented in New England. Moreover, the project could have far-reaching indirect and secondary impacts including the possible degradation of 700-800 additional acres of wetlands in Mishnock swamp and downstream of the dam by reduced groundwater and surface water flows. If operated as proposed by the State and Corps, the dam would worsen downstream water quality and impede efforts underway to clean up the Pawtuxet River. Many of those commenting on EPA's proposal to prohibit this project spoke of their frequent use and enjoyment of the Big River area for fishing, canoeing, hiking and observing wildlife. Under existing state law and policies, the project would completely deprive the public of these important recreational opportunities. Even if the law and policies change, the extent and diversity of recreation would be substantially reduced.

To determine whether the significant adverse impacts to wildlife and recreation could be avoided, I examined potential alternatives to the Big River project. This in turn led me to review the underlying assumptions and rationale on which the project rests. Based on that analysis, I conclude that the need for the project has not been established. Under very conservative assumptions, a new water supply would not be needed until well into the next century. However, even if a need for a new 30 mgd water supply materialized sooner, I conclude that less environmentally damaging practicable alternatives or combinations of alternatives are available which would satisfy that need. Demand management alternatives include modifying pricing policies, leak detection and repair, plumbing code changes, drought planning and other conservation measures. Increasing the proportion of non-potable water used for power cooling, irrigation, and industrial purposes can also increase potable water supplies. If implemented in combination these demand alternatives would provide more water than the Big River reservoir would supply. Other alternatives which are either practicable or warrant investigation include exploitation of groundwater supplies (possibly with treatment as needed), increasing the yield of existing surface water dams, avoiding abandonment of existing water supplies and desalination. Most if not all of these alternatives would cost less than the Big River reservoir from both an environmental and economic standpoint.

The regulations implementing §404(c) define an unacceptable impact to include "significant loss or damage to fisheries...or wildlife or recreation areas" or as an impact which the "aquatic and wetland ecosystem cannot afford." The §404(c) regulations direct me to consider the relevant portions of the §404(b)(1) guidelines in evaluating whether an adverse impact would be unacceptable. As explained earlier in this document, I have concluded that the Big River proposal does not comply with the §404(b)(1) guidelines on two counts. First, the project would cause or contribute to significant degradation of the aquatic environment in violation of the guidelines. The Corps of Engineers and the U.S. Fish and Wildlife Service agree. The 1981 EIS concedes that the project would cause a significant disruption to the biological integrity of the aquatic ecosystem and food chain. In 1988, the Corps confirmed that the project could not comply with the §404(b)(1) guidelines because of these significant impacts. Second, the Big River proposal does not pass the "alternatives test" in the guidelines since less environmentally damaging practicable alternatives exist.

After fully considering the record in this case, I conclude that these significant and avoidable impacts to wildlife and recreation would be unacceptable under §404(c). The direct loss of 575 acres of valuable wetlands and 17 miles of free flowing streams is in itself unacceptable. Indeed, after considering the outstanding value of the aquatic habitat at the site and the severity of the adverse impacts, I do not believe the record could support any other finding. The numerous indirect impacts the project could cause, including the possible degradation of another 700-800 acres of wetlands, reinforces my conclusion. As described above, the impacts to wildlife are unnecessary and avoidable and I conclude that the proposed reservoir is environmentally unacceptable on that basis as well. With respect to recreation, I have examined both the extent of the impacts and whether they are avoidable. Because the project would cause substantial and avoidable adverse impacts to recreation, I conclude they are unacceptable. Therefore, I recommend that the discharge of dredged and fill material be prohibited in Big River, Mishnock River, their tributaries and adjacent wetlands for construction of the proposed Big River reservoir and its ancillary facilities.

In formulating this recommendation, I carefully evaluated the environmental values of the Big River system, its sensitivity to disruption and the adverse impacts a reservoir would cause. The U.S. Fish and Wildlife Service and others submitted convincing and well documented evidence of the value of the Big River project area to wildlife, and the devastating impacts the project would cause are undisputed in the record. I have also examined the need for and alternatives to the project. While there has been some debate about Rhode Island's present and future requirements for water, I am satisfied that any need that does exist can be met at far less environmental and economic cost than the proposed project. By preventing significant and avoidable impacts to wildlife and recreation, a final §404(c) action would enforce the requirements of the §404(b)(1) guidelines, a function envisioned by the §404(c) regulations.

Paul Keough
Paul G. Keough
Acting Regional Administrator

Oct 6, 1989
Date

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APPENDIX I

Appendix I: Birds

BIRDS OF THE BIG RIVER STUDY AREA
(SOURCES: MODIFIED FROM CORPS, 1981; BY
OBSERVATIOS AND THE RI NATURAL HERITAGE PROGRAM, 1989)

COMMON NAME	STATUS	ASSOCIATED WITH WETLAND HABITAT	OBSERVED
Common Loon	W	WP	
Pied-billed grebe	M	WP	
Canada goose	A	WP	X
Mallard	A	WR	X
Black duck	A	WR	X
Pintail	M	WP	
Gadwall	M	WP	
American wigeon	M	WP	
Shoveler	M	WP	
Blue-winged teal	M	W	
Green-winged teal	M	W	
Wood duck	B	WR	X
Redhead	M	WP	
Canvasback		W	
Ring-necked duck	M	WP	
Lesser scaup	M	W	
Bufflehead	W	W	
Ruddy duck	M	W	
Hooded merganser	M	W	
Common merganser	W	WP	
Goshawk*	A		X

Status: **B** - breeding; **W** - winter use; **M** - migratory;
A - all seasons

Associated with wetland habitat:

WR: Riparian-dependent or associated species (Brinson et al., 1981).

WP: Wetland preferred species (RI Heritage Program, 1989; DeGraaf and Rudis, 1983).

W: Regularly uses wetlands during part of its life cycle (RI Heritage Program, 1989, DeGraaf and Rudis, 1983).

***:** area sensitive species

+: State or federal-listed species: either a state threathened species or a rare and vulnerable species which may become threathened if current trends persist.

X: Observed in study area

Appendix I: Birds (Continued)

COMMON NAME	STATUS	ASSOCIATED WITH WETLAND HABITAT	OBSERVE
Cooper's hawk*+	A	W	X
Sharp-shinned hawk	A		
Marsh Hawk	B	W	
Red-tailed hawk	B	W	X
Red-shouldered hawk*	B	WR	X
Broad-winged hawk*	B	WR	X
Bald eagle*+	WM	WP	
Osprey*+	M	W	
Peregrine falcon*+	M	W	
Merlin	M	W	
Kestrel	A	W	X
Ruffed grouse*	A		X
Yellow-billed cuckoo*	B	WR	X
Black-billed cuckoo	B	W	X
Screech owl	A	WP	
Great horned owl	A	W	X
Long-eared owl	A	W	
Barred owl	A	WP	X
Saw-whet owl	A		
Whip-poor-will	B		X
Common nighthawk	M		
Chimney swift	B	WP	X
Ruby-throated humingbird	B	W	X
Belted kingfisher	B	W	X
Common flicker*	A	WR	X
Pileated woodpecker	A	W	
Red-headed woodpecker	B	W	
Yellow-bellied sapsucker	M	W	
Hairy woodpecker*	A	WR	X
Downy woodpecker*	A	WR	X
Eastern kingbird	B	WR	X
Great-crested flycatcher*	B	WR	X
Eastern phoebe*	B	W	X
Yellow-bellied flycatcher	B	WP	
Alder's flycatcher	M	WP	
Least flycatcher	B	W	X
Willow flycatcher	B	WP	X
Acadian flycatcher*+	B	WR	X
Eastern wood pewee*	B	WR	X
Olive-sided flycatcher	M	W	
Horned lark +	A	W	X
Barn swallow	B	WP	X
Cliff swallow	M	W	
Tree swallow	B	WP	X
Bank swallow	B	W	X
Rough-winged swallow	B	WP	X
Purple martin	B	W	

Appendix I: Birds (Continued)

COMMON NAME	STATUS	ASSOCIATED WITH WETLAND HABITAT	OBSERVE
Blue jay*	A	W	X
Common Crow*	A	W	X
Black-capped chickadee*	A	W	X
Tufted titmouse*	A	WP	X
White-breasted nuthatch*	A	W	X
Red-breasted nuthatch*	A	W	X
Brown creeper*	A	W	X
Wild Turkey	A	WR	X
Bobwhite	A	W	X
Ring-necked pheasant	A	W	
Great blue heron	BW	WP	
Green heron	B	WP	X
American bittern	M	WP	
Virginia rail	B	WP	X
Sora	B	WP	X
Common gallinule	M	W	
American coot	M	WP	
American golden plover	M	W	
Black bellied plover	M	W	
Killdeer	B	WR	X
Upland sandpiper +	B		
Solitary sandpiper	M	W	
Spotted sandpiper	B	WR	X
Greater yellowlegs	M	W	
Lesser yellowlegs	M	W	
Short-billed dowitcher	M	W	
Pectoral sandpiper	M	W	
Bairds sandpiper	M	W	
Least sandpiper	M	W	
Semipalmated sandpiper	M	W	
American woodcock	B	WR	X
Common snipe	M	WP	
Herring gull	M	W	
Ring-billed gull	M	W	
Great black-backed gull	W	W	
Rock dove	A		X
Mourning dove	A	WR	X
House wren	B	WR	X
Winter wren +	B	W	X
Carolina wren	A	W	
Long-billed marsh wren	M	W	
Blue-gray gnatcatcher*	B	W	X
Mockingbird	A	W	X
Catbird*	B	WR	X
Brown thrasher	B	W	X
Robin	A	WR	X

Appendix I: Birds (Continued)

COMMON NAME	STATUS	ASSOCIATED WITH WETLAND HABITAT	OBSERVE
Wood thrush*	B	WR	X
Hermit thrush*	B	W	X
Swainson's thrush	M		
Gray-cheeked thrush	M		
Veery*	B	WP	X
Eastern bluebird	B		X
Golden-crowned kinglet	A		
Ruby-crowned kinglet	M		
Water pipit	M	W	
Cedar waxwing	A	W	X
Starling	A	WR	X
Solitary vireo	B	W	X
White-eyed vireo*	B	W	X
Yellow-throated vireo*	B	WP	X
Red-eyed vireo*	B	WR	X
Philadelphia vireo	M		
Warbling vireo	B	WP	X
Black-and-white warbler*	B	W	X
Worm-eating warbler*+	B		X
Golden-winged warbler	M		
Blue-winged warbler	B	W	X
Tennessee warbler	M	W	
Nashville warbler	B	W	X
Parula warbler	M	W	
Yellow warbler	B	WR	X
Magnolia warbler	M		
Cape May warbler	M		
Myrtle warbler	B		
Black-throated green warbler*	B	W	X
Black-throated blue warbler	M		
Yellow-ramped warbler	B	W	X
Blackburnian warbler +	B		
Chestnut-sided warbler	B	W	X
Bay-breasted warbler	B	W	
Blacpoll warbler	M		
Cerulean warbler +	M	WP	
Prothonotary warbler	M	WP	
Pine warbler	B		X
Prairie warbler	B		X
Palm warbler	M	WP	
Ovenbird*	B	WR	X
Northern waterthrush*	B	WP	X
Louisiana waterthrush*	B	WP	X

Appendix I: Birds (Continued)

COMMON NAME	STATUS	ASSOCIATED WITH WETLAND HABITAT	OBSERVE
Yellowthroat*	B	WR	X
Yellow-breasted chat	M	WP	
Mourning warbler	M		
Hooded warbler	B	WP	
Wilson's warbler	M	WP	
Canada warbler*	B	W	X
American redstart*	B	WR	X
House sparrow	A		X
Bobolink	B	W	X
Eastern meadowlark	B		X
Red-winged blackbird	B	WR	X
Rusty blackbird	B	WP	
Common grackle	A	W	X
Brown-headed cowbird	A	W	X
Orchard oriole	B	W	
Northern oriole	B	WR	X
Scarlet tanager*	B		X
Cardinal*	A	WR	X
Rose-breasted grosbeak*	B	W	X
Evening grosbeak		W	
Indigo bunting	B	WR	X
Purple finch	A		X
House finch	A		X
Pine grosbeak	W		
Common redpoll	W		
Pine siskin	W		
Rufous-sided towhee*	B	WR	X
Savannah sparrow	B	W	X
Grasshopper sparrow +	B		X
Vesper sparrow	B	W	
Slate-colored junco	A		
Tree sparrow	W	W	
Chipping sparrow	B	W	X
Field sparrow	A		
White-crowned sparrow	M		X
White-throated sparow +	A	W	X
Fox sparrow	M		
Lincoln's sparrow	M	W	
Swamp sparrow	B	W	X
Song sparrow	A	WR	X
Snow bunting	M	WP	
American goldfinch*	A		X

Appendix I: Mammals

MAMMALS OF THE BIG RIVER STUDY AREA
(SOURCES: MODIFIED FROM CORPS, 1981; BY OBSERVATIONS
THE RI NATURAL HERITAGE PROGRAM, 1989; AND U.S. FWS, 1989)

COMMON NAME	SCIENTIFIC NAME	ASSOCIATED WITH WETLAND HABITAT	OBSERVED
Opposum	Didelphis virginiana	WP	X
Masked shrew	Sorex cinerus	WP	X
Water shrew*	Sorex palustris	WR	X
Smoky shrew*	Sorex fumeus	WP	
Short-tailed shrew	Blarina brevicauda	WR	X
Star-nosed mole	Condylura cristata	WP	
Little brown myotis	Myotis lucifugus	WP	
Keen's myotis	Mytotis keeni	WP	
Silver-haired bat	Lasionycterus noctivagans	WP	
Eastern pipistrel	Pipistrellus subflavus	WP	
Big brown bat	Eptesicus fuscus	WP	
Red bat	Lasirus borealis	W	
Hoary bat	Lasirus cinereus	W	
Raccoon	Procyon lotor	WR	X
Fisher*	Martes pennanti	W	
Ermine	Mustela erminea	W	
Long-tailed weasel	Mustela frenata	WP	X
Mink	Mustela vison	WR	X
Striped skunk	Mephitis mephitus	WR	X
River otter	Lutra canadensis	WR	X
Coyote	Canis latrans	W	X
Red fox	Vulpes vulpes	W	X
Gray fox	Urocyon cinereoargenteus	W	X
Bobcat*	Lynx rufus	W	X
Eastern chipmunk	Tamias striatus		
Woodchuck	Marmota mona		X
Gray squirrel	Sciurus carolinensis	WR	X
Red squirrel	Tamiasciurus hudsonicus	W	X
Southern flying squirrel	Glaucomys volans		
Beaver	Castor canadensis	WR	X

Appendix I: Mammals (Continued)

COMMON NAME	SCIENTIFIC NAME	ASSOCIATED WITH WETLAND HABITAT	OBSERVED
White-footed mouse	Peromyscus leucobus	WR	X
Boreal red-backed vole	Clethrionomys gapperi	WR	X
Meadow vole	Microtus pennsylvanicus		X
Pine vole	Microtus pinetorum		
Muskrat	Ondatra zibethicus	WR	X
Southern bog lemming*	Synaptomys cooperi	WP	X
Black rat	Rattus rattus		
Norway rat	Rattus norvegicus		
House mouse	Mus domesticus		
Meadow jumping mouse	Zapus hudsonius	WR	X
Woodland jumping mouse*	Napoeozapus insignis	WR	X
Porcupine	Erethizon dorsatum	W	
Eastern cottontail	Sylvilagus floridanus	WP	X
New England cottontail	Sylvilagus transitionalis	WR	
Snowshoe hare	Lepus americanus	WP	
White-tailed deer	Odocoileus virginiana	WR	X

Associated with wetland habitat:

WR: Riparian wetland-dependent or associated species (Brinson et al., 1981).

WP: Wetland preferred species (RI Heritage Program, 1989; DeGraaf and Rudis, 1983).

W: Occasionally uses wetlands during part of its life cycle.

***:** State listed species

X: Observed in study area

Appendix I: Herptiles of the Big River Management Area (USFWS 1989).

Common Name	Scientific Name
<u>Salamanders</u>	
Marbled salamander*x	*Ambystoma opacum*
Spotted salamander*	*Ambystoma maculatum*
Red-spotted newt*	*Notophthalmus v. viridescens*
Northern dusky salamander*	*Desmognathus f. fuscus*
Redback salamander	*Plethodon cinereus*
Four-toed salamander*x	*Hemidactylium scutatum*
Northern two-lined salamander*	*Eurycea b. bislineata*
<u>Frogs and Toads</u>	
Eastern American toad*	*Bufo a. americanus*
Fowler's toad*	*Bufo woodhousii fowleri*
Northern spring peeper*	*Hyla c. crucifer*
Gray treefrog*	*Hyla versicolor*
Bullfrog*	*Rana catesbeiana*
Green frog*	*Rana clamitans melanota*
Wood frog*	*Rana sylvatica*
Pickerel frog*	*Rana palustris*
<u>Turtles</u>	
Common snapping turtle*	*Chelydra s. serpentina*
Stinkpot*	*Sternotherus odoratus*
Spotted turtle*	*Clemmys guttata*
Wood turtle*x	*Clemmys insculpta*
Eastern box turtle	*Terrapene c. carolina*
Painted turtle*	*Chrysemys picta*
Red-eared slider*	*Pseudemys scripta*
<u>Snakes</u>	
Northern water snake*	*Nerodia s. sipedon*
Northern brown snake	*Storeria d. dekayi*
Northern redbelly snake x	*Storeria o. occipitomaculata*
Eastern garter snake	*Thamnophis s. sirtalis*
Eastern ribbon snake x	*Thamnophis s. sauritus*
Northern hognose snake	*Heterodon platyrhinos*
Northern ringneck snake x	*Diadophis punctatus edwardsi*
Eastern worm snake	*Carphophis a. amoenus*
Northern black racer	*Coluber c. constrictor*
Eastern smooth green snake	*Opheodrys v. vernalis*
Eastern milk snake	*Lampropeltis t. triangulum*

* - Aquatic or wetland-dependent species.
x - State listed species

Appendix I: Fish Observed Big River Site

Streams

1.	Brook trout	Salvelinus fontinalis
2.	Redfin pickerel	Esox americanus
3.	Chain pickerel	E. niger
4.	Bridle shiner	Notropis bifrenatus
5.	Fallfish	Semotilus corporalis
6.	White sucker	Catostomus commersoni
7.	Creek chubsucker	Erimyzon oblongus
8.	Brown bullhead	Ictalurus nebulosus
9.	Pumpkinseed Sunfish	Lepomis gibbosus
10.	Langmouth bass	Micropterus salmoides
11.	Swamp darter	Etheostoma fusiforme
12.	Bluegill	Lepomis macrochirus

Ponds

1.	Redfin pickerel	Esox americanus
2.	Chain pickerel	E. niger
3.	Bridle shiner	Notropis bifrenatus
4.	Creek chubsucker	Erimyzon oblongus
5.	Pumpkinseed sunfish	Lepomis gibbosus
6.	Yellow perch	Perca flavescens
7.	Banded sunfish	Enneacanthus obsesus
8.	Largemouth bass	Micropterus salmoides
9.	Swamp darter	Etheostoma fusiforme
10.	Smallmouth bass	Micropterus dolomieni

Source: Corps EIS, 1981
University of MA, 1979

APPENDIX II

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

July 28, 1989

Mr. Michael R. Deland
Regional Administrator
U.S. Environmental Protection Agency
JFK Federal Bldg.
Boston, Massachusetts 02203

Dear Mr. Deland:

I. This report is in response to the February 1, 1989 request for comments pertaining to your proposed determination to prohibit the use of Big River, Mishnock River, their tributaries and adjacent wetlands as disposal sites.

The Fish and Wildlife Service fully supports your proposed determination. Field data that has been collected on aquatic, wetland and terrestrial species and their habitat in the Big River Management Area and evaluations of this data provide sufficient justification for EPA to prohibit the Big River Reservoir Project based on unacceptable adverse impacts (significant degradation) to wildlife and fishery areas. This report reviews the various field studies and reports issued on this project from the mid-1970's up to the date of your Federal Register Notice (February 1, 1989) (copies previously furnished to EPA). We also review field studies that have been conducted since February 1, 1989 (copies enclosed). Additional analyses are included regarding effects of the proposed reservoir on area-sensitive species and species with strong homing instincts to natal areas. Lastly, we provide our views demonstrating the reasons why the Big River Reservoir fails to comply with 40 CFR 230.10(a),(b),(c), and (d) as identified under the 404(c) procedures at 40 CFR Part 231.

II. Project Description

The Big River Reservoir would be formed by an earth fill dam across the Big River near the location of the Harkney Hill Road Crossing (Zekes Bridge) in the Town of Coventry, Rhode Island. Big River Reservoir would be contained within the Big River Management Area, a tract consisting of about 8,270 acres. The Reservoir would inundate approximately 3,400 acres of upland, wetland and open water at pool elevation 300 msl. Approximately 3700 acres of land would be cleared for the project. Streambed elevation at the dam site is 240 feet msl, maximum water supply pool elevation is 300 feet msl, maximum depth in the impoundment would be 60 feet, and average depth would be about 25 feet. The project would have a drainage area of about 29.7 square miles at the dam. Approximately 16.9 miles of cold- and warmwater streams and several ponds including Capwell Mill and Tarbox ponds would be inundated. Other features of the project are more fully described in the Corps of Engineers Feasibility Report and various reports developed by the Rhode Island Water Resources Board.

III. Project Environs

The Big River Management Area contains 5 named streams and 7 named ponds. These are the Big River which is formed by the confluence of the Congdon and Nooseneck Rivers, Carr River, Mud Bottom Brook, a tributary to the Carr River and Bear Brook. The ponds include Carr, Tarbox, Sweet, Phelps and Capwell Mill Pond all in the Carr River drainage; Rathbon Pond on the Congdon River and Reynolds Pond in the Big River drainage. All of these ponds except Carr Pond are shallow and support abundant emergent and submersed aquatic macrophytes. Carr Pond is deep and contains a rocky bottom. Rooted macrophytes are scarce.

The 20.8 miles of streams on the Management Area contain both warm- and coldwater habitat. The Congdon and Nooseneck Rivers and Bear Brook are coldwater habitat supporting brook trout. Most sections of the Carr River and Mud Bottom Brook are warmwater habitat. Brook trout are generally not found in these waters during the summer season. The Big River south of Route 3 is coldwater habitat. North of Route 3, the gradient drops and the river becomes broad and sluggish and is characteristic of a warmwater habitat. With the exception of Carr Pond, all of the waters are colored (dystrophic) and acidic. The pH values are generally between 5.0-6.0.

Approximately 800 acres of wetlands exist on the Management Area. Forested wetlands are the most abundant type. These are predominately red maple swamps with Atlantic white cedar stands occurring much less frequently. Shrub swamps are next in abundance. Herbaceous wetlands are least common and are generally found associated with the perimeters of the ponds located on the Management Area.

Upland vegetation on the Management Area is predominantly deciduous and coniferous forest. Several old fields still exist on the Management Area, a reflection of the past when portions of this area were actively farmed. The evergreen forest consists of white pine and pitch pine either as pure stands or in combination with each other. White pine is the predominate species presently as it has greater site adaptability and is a successional species. The deciduous forest stands are generally mixtures of beech, maple, white oak, red oak, and black oak. Mixed woodlands containing tree species found in these two major cover types are commonly found.

IV. Review of previous investigations/reports

1. KAME 1976

The KAME report was conducted as a joint venture by Keyes Associates, Inc., and Metcalf and Eddy, Inc., under contract from the Rhode Island Water Resources Board. Originally, the study was to be conducted in two phases, however, only Phase I was completed. It was funded using receipts from the sale of sand and gravel on the Big River Management Area.

The Phase I report entitled "Preliminary Inventory of Vegetation, Wildlife and Aquatic Biota in Big River Study Area" was completed on November 8, 1976. Much of the report consisted of a general literature review of environmental resources that could be found on the study area. However, the vegetation of the study area was mapped from black and white photography and later field verified. In addition, eight (8) aquatic sites were sampled to obtain information on water quality parameters, benthic communities and fish. The benthic samples were later sorted and individuals were identified to genus and counted. During the field verification work on the vegetation transects, observations on wildlife sightings were recorded. A copy of the Phase I Report is available for inspection at the Rhode Island Water Resources Board.

The Phase II investigations were never started due to funding limitations at the state level. Seasonal field investigations were to have taken place during Phase II.

2. Fish and Wildlife Service Planning Aid Letter, November, 1978

In 1978, Governor Garrahy requested the New England Division, Corps of Engineers to complete a feasibility study of the Big River Project for water supply and related uses. During this initial phase, the Corps investigated a number of alternative reservoir and/or diversion sites on Big River, Flat River Reservoir, Wood River, Moosup River and Bucks Horn Brook. This November 27, 1978 report provided a preliminary analyses of the impact of developing these water supply projects on area fish and wildlife resources. No field data was collected. The analysis was based on existing information and the man-day of use approach (method now obsolete) for hunting, fishing or other passive recreational use.

3. Normandeau Reports, 1979

In 1978, the New England Division contracted with Normandeau Associates, Inc. (NAI), for field and literature investigations on terrestrial and aquatic wildlife in the Big River Management Area. Field work was conducted in late summer of 1978. These reports are discussed separately below:

a. Aquatic Ecosystem Report, January 1979 - The primary objective of this study was to collect information from field surveys in order to accurately describe the existing water quality and physical features of the major streams and ponds and identify any existing or potential sources of point and non-point pollution. In addition, an inventory of the existing aquatic biota was conducted which included an analysis of the phytoplankton, periphyton, zooplankton, benthic macroinvertebrates, herptile and finfish communities.

The NAI investigators described the phytoplankton species as being generally characteristic of summer aquatic communities and overall as typical members of communities found in temperate free-flowing and still water habitats (pg. 27-28). They described the periphyton genera encountered as typical of temperate softwater streams and ponds. In addition, they concluded that the periphyton communities observed in the Big River study area were generally indicative of naturally occurring acidic waters (pg. 43). The composition and abundance of the zooplankton phyla observed by the NAI investigators were described as being representative of temperate freshwater communities (pg. 51). With respect to macroinvertebrates, the lotic locations supported benthic communities of higher densities, standing crop and species richness (number of taxa) than those observed from lentic locations. It was also apparent the lotic habitats supported stable benthic communities of higher diversity and lower faunal repetition than those observed from the lentic habitats. These observations are related to an observed greater substrate microhabitat complexity and a corresponding complex and diverse association of benthic taxa present within the lotic habitats (pg. 58-60). Only two species of reptiles (snapping and painted turtles) and two species of amphibians (pickerel and green frogs) were collected or observed by the NAI investigators. The existence of a diversity of suitable habitats within the study area suggested to the NAI investigators that the herptile community is more diverse and dynamic than was apparent from the limited field surveys of August 21-September 1, 1978 (pg. 61). A total of 10 species of fish were collected from the lentic habitats (Flat River Reservoir, Tarbox Pond and Capwell Mill Pond) in August, 1978. The most abundant fish in decreasing order of abundance were largemouth bass, golden shiner, pumpkinseed, yellow perch and banded sunfish (pg. 65). In the lotic habitats, 11 species of fish were collected. The bridle shiner, swamp darter, largemouth bass, pumpkinseed, and redfin pickerel collectively represented over 78% of the total numbers (pg 71). Brook trout were collected only in the lower Nooseneck River in August of 1978. A total of 15 species of fish were collected from the lentic and lotic habitats in the study area.

b. Terrestrial Ecosystem Report, January 1979 - Like its companion report discussed above, field work for this study was conducted during a one-week period in late August 1978. The NAI investigators also prepared a cover map of the study area. The more detailed cover types found on the KAME map were consolidated into 5 cover types. Representative stands in each cover type were field checked by NAI for the purpose of characterizing the vegetation. Six census transects were established to determine avian species composition, relative abundance and habitat utilization. A total of 49 species of birds were observed in the study area (pg. 34). Seven species of mammals were also observed during these field studies (pg. 39). A habitat evaluation was completed for each of the 5 cover types found on the study area. For the wetland cover type, the NAI investigators describe them as follows: Vegetative and structural diversity in the red maple and shrub swamps was very high and wildlife habitat value was excellent (pg. 44). The shallow and deep marshes were described as providing excellent waterfowl, wading bird and aquatic furbearer habitat (pg. 50). Carrying capacity estimates were also developed for 9 species of birds and mammals found on the study area.

4. University of Massachusetts Study, 1979

On May 30-31 and June 1, 1979, the Fish and Wildlife Cooperative Unit at the University of Massachusetts, Amherst conducted field investigations in the Big River Management Area. The purpose of the study was to determine species composition and relative abundance of small mammals, birds, fish and herptiles on the Management Area. Bird transects were established at 8 sites within the Management Area, small mammal traps were established on 5 of these transects also. During the 3-day period, a total of 61 species of birds were observed. The transect at Tarbox Pond (#8) had the most diverse avian community with 37 species and the pine barrons transect (#7) had the least avian diversity with 11 species. However, comparisons of the bird transect data are cautioned due to a wide array of bird watching experience of the observers.

Small mammal trapping was largely unsuccessful. This was attributed to heavy rains prior to the field work and vandalism at the trap sites. Only one (1) meadow vole and one (1) red squirrel were collected by trapping. Few signs of mammals were observed during this 3-day survey as well. The investigators only reported observing sign of raccoon, chipmunk and gray squirrel.

Fish were collected from 8 lotic and 4 lentic locations within the Big River watershed using gill nets, seines and electro-fishing equipment. A total of 15 species of fish were collected. Thirteen of the 15 species collected had been reported by Normandeau in their August 1978 survey. The bluegill sunfish and smallmouth bass had not been reported by Normandeau. In addition, this survey did not collect largemouth bass, nor the redfin X chain pickerel hybrid reported by Normandeau. Brook trout were collected at sampling stations in the Nooseneck River, Congdon River and Bear Brook. They along with white suckers were the most abundant species collected in the lotic sites. A total of 7 species were collected in lotic sites, 11 in lentic sites. The most abundant fish in lentic sites in decreasing order were golden shiners, yellow perch, and swamp darters. The remaining species were collected much less frequently. The crayfish Procambarus acutus was frequently collected in the Carr, Nooseneck and Congdon Rivers. A single clam, Elliptio complenata, was collected in the Carr River downstream from Capwell Mill Pond.

Ten species of herptiles were observed in the Big River study area in the vicinity of the fish collection sites. This included 4 species of frogs (green, wood, pickerel, northern leopard), 2 species of toads (Fowlers and American), 2 species of salamanders (two-lined and red-backed), one snake (northern water) and one turtle (painted).

5. Fish and Wildlife Coordination Act Report, September 28, 1979

This report considered the effects of the proposed reservoir on aquatic, wetland and terrestrial wildlife resources in the Big River Management Area and downstream areas. The fishery evaluation utilized regression formulas to predict standing crop and productivity for the new reservoir. Water quality information developed by the Corps was utilized to predict the potential for a 2 story (warm- and coldwater) fishery in the impoundment. Based on data available at the time, the Service predicted a warmwater fishery. This conclusion was reached by utilizing Corps water quality data (CE, Appendix D, June 1979), professional experience, and the limited degree of reservoir site preparation proposed. The Service also predicted that the stream trout fishery would be eliminated. Additional studies were also recommended to more clearly predict reservoir limnological conditions and downstream water quality related impacts on Flat River Reservoir, South Branch Pawtuxet and the main stem.

The terrestrial and wetland investigations were carried out by utilizing the habitat evaluation procedures (HEP) developed by the Service (USFWS, March 1979). The forest and other land use types of the study area (entire Big River Management Area) were condensed into six habitat types for evaluation purposes. A total of 26 species of wildlife were used as evaluation elements in the study. This included 11 mammals, 11 birds, 2 amphibians and 2 reptiles. At least 6 species were used to evaluate each habitat type except scrub/shrub wetland for which 5 species were used. Sample sites within each habitat type were randomly selected both inside and outside the pool area. Thus, the baseline habitat values reflect the habitat conditions in the entire Management Area. In addition, to estimating baseline (1979) habitat values, the Service also estimated the management potential value for each cover type. This evaluation was based on the habitat requirements of the evaluation species and management practices that could be employed to increase the quality of the habitat for evaluation species. The Service determined the baseline habitat values for scrub/shrub and forested wetlands to be 0.81 and 0.65 respectively. The management potential values were determined to be 0.84 and 0.76 respectively (a value of 1.0 is the maximum theoretically attainable). Thus, these wetlands were found to be functioning at 96 and 86 percent respectively of their management potential value. Compensation for these losses was found to be extremely questionable because it would require the acquisition and management of an additional 3,400 and 2,573 acres of similar value scrub/shrub and forested wetland, respectively. This is after deducting the values gained by management of remaining wetlands including 90 acres of open water herbaceous wetlands to be created as sub-impoundments in the reservoir.

As a result of the serious adverse effects of the proposed project on fish and wildlife resources on the Management Area and downstream areas, the Fish and Wildlife Service formally opposed the Big River Reservoir project on September 28, 1979.

6. Department of Interior Report August 1982

On August 12, 1982, the Office of the Secretary issued formal comments on the Chief of Engineers report on the Big River Reservoir Project. Major issues raised by Interior included: (1) adequate mitigation of fish and wildlife habitat losses, (2) fish and wildlife impacts associated with reservoir development and downstream flow depletion, (3) water quality impacts (4) population projections, and (5) future water needs. Interior also stated that the direct loss of 570 acres of wetlands made the project environmentally unsatisfactory.

7. University of Rhode Island Wetlands Study, Spring 1984

During the spring semester in 1984, the Wetlands and Land Use Class (FOR 424) in the Department of Natural Resources conducted an inventory and wildlife evaluation of the wetlands and deep water habitats of the Big River watershed. The conclusions of this report state that the reservoir project would convert over 500 acres of wetland to deep water habitat, and it would destroy the majority of the most valuable wetland wildlife habitat in the watershed. In all, 33% of the watershed's wetlands would be lost. The FOR 424 project results predict that the construction of the Big River Reservoir would have a severe, irreversible impact on wetlands and their wildlife.

8. University of Massachusetts Breeding Bird Study, 1986

During May, June and July 1986, data on breeding birds was collected on 10 circular (0.25ha, 28.2m radius) plots within the Big River Management Area. A total of 28 bird species were recorded. Upland forest and wetlands within the pool area contained the greatest diversity of species. Wetlands within the pool area contained the greatest numbers of birds. Six additional avian species were recorded outside of the 10 study plots.

9. Rhode Island Division of Fish and Wildlife, 1986

During April, May, and June 1986, bird and other wildlife surveys were conducted on the Big River Management Area. Most of this effort was concentrated on Big River and adjacent lands but at least one survey was conducted in the Carr River (Capwell Mill Pond) Basin. Some 67 different avian species were observed during these field surveys. This included transient and breeding species, although most would be expected to nest in the study area. Searches were also made for herptiles during the outings. Four species of turtles were observed; painted, musk (stinkpot), spotted and snapping. Other herp species reported included ring-necked snakes, green frogs, spring peepers, American toads and the pickerel frog.

The Division (Lapisky 1989) has also reported observations of bobcat on Fish Hill Road and other sightings within 5 miles of the project boundary. A recent fisher sighting was reported in the Division Road area. Other observations include beaver, otter, coyote, white-tailed deer, snowshoe hare, turkey and black duck.

10. Rhode Island Water Resources Board Wetlands Evaluations - December 1986

As part of the environmental studies for the Big River Reservoir Project, the Water Resources Board obtained the services of Wetland Management Specialists, Inc., et al, to evaluate the wetlands within the Management Area. While this effort was never fully completed due to NEPA and Section 404 questions concerning the reservoir project, the data do reveal that the pool area contains many high value and outstanding wetlands based on the Golet evaluation method. Thus, the evaluations completed to-date by the Water Resources Board consultants concerning the habitat value of the study area wetlands, support the conclusion reached independently by several other previous investigators.

11. Breeding Bird Atlas Project (1981-1986)

During this 5-year period (1981-1986), birders in Rhode Island observed birds during the breeding season in 7 survey blocks that included most of the Big River Management Area. It should be noted that the 7 survey blocks included an area many times the size of the Big River study area. The results of this survey reveal that 104 species of birds breed in or adjacent to the Big River Management Area.

12. Other Investigations - During the past 40 or more years various individuals have made observations on fish and wildlife within the Big River area. Unfortunately, most of these data remain in the minds of these observers as few field notes were recorded. In a few instances where data has been recorded, it remains unpublished and thus, generally unavailable.

V. Review of Current Investigations

1. Mollusc Survey, Spring, 1989

During May and June 1989, Mr. Douglas Smith, Museum of Zoology, University of Massachusetts, conducted searches for mussels (bivalves) and other invertebrate fauna in the streams and ponds located on the Big River Management Area. The results of this investigation are included in Appendix A. Only one bivalve species, Elliptio complanata, and one gastropod species, Campeloma decisum, were found. The naturally acidic waters and development history of the watershed (impoundments) are thought to be limiting factors for these faunal groups. In addition to the molluscs, Mr. Smith located and identified seven (7) other invertebrate species on the Management Area that would be unable to tolerate life in the proposed reservoir. These include three (3) freshwater sponges, one (1) isopod, two (2) amphipods, and one (1) crayfish. The two amphipod and single crayfish species are of special interest. Crangonyx aberrans is endemic only to southeastern New England, where it is fairly well distributed in coastal drainage systems. This species was discovered by D. Smith in 1981 and later described by him as a new species (Smith, 1983). The other amphipod, Synurella chamberlaini, is a disjunct species in New England (Smith, 1987). It is fairly widely distributed along the middle Atlantic Coastal Plain from South Carolina to Maryland. Previously, Smith (1987) located this species at one location in Massachusetts and one location in Rhode Island. This extremely rare species for this region was found by Smith this spring in Bear Brook which represents only the third known location for this amphipod in New England.

The crayfish Procambarus acutus acutus is also a disjunct species. It is widely distributed in the Mississippi River, Gulf and Atlantic Coast drainage from New Jersey southward. However, it is absent in the drainages of southern New York and along the Connecticut coastline. It is well distributed in the coastal drainages of southeastern New England.

2. Large and Medium Size Mammal Survey, Winter-Spring, 1989

During the period February-June, 1989, Mr. Chester McCord, a consulting wildlife biologist, conducted a survey for large and medium size mammals on the Big River Management Area, Appendix B. This investigation was based on observations of mammals (actual sightings) and more importantly, by reading sign such as tracks, cuttings, pellets, scats, scratchings, etc. Emphasis was placed on the rare or unusual species such as bobcat, fisher, and black bear.

McCord identified 17 species of wild mammals and one bird, the wild turkey during his searches on the Management Area. White-tailed deer, red fox and raccoon were the most frequently noted species. Due to the lack of snow cover during the study period, tracking was difficult for certain species/species groups. As a result, McCord felt that species groups such as the mustelids (otter, mink, fisher, weasel) were probably under-represented in abundance in his survey, along with muskrat and opossum. The red fox was found to be the most widely distributed medium size mammal on the Management Area. Sign of this species (tracks) were abundant and observed throughout the study area. The white-tailed deer was found to be widely distributed in the reservoir area south of I-95. He reported finding deer concentration areas adjacent to the Big River and along portions of the Carr River drainage. No rare species were located during this survey, however, both bobcat and fisher have been reported on the Management Area (Lapisky, 1989). McCord concluded that the lack of sign on the Management Area indicates that the bobcat is not a permanent resident. The observations of this species on and near the study area indicates that it is used by bobcats during dispersal and it is possible that a dispersing bobcat could establish a home range in the area. With respect to fisher, McCord felt that the area has more potential to sustain a resident fisher population than the other rare species (bobcat, black bear).

3. Small Mammal Survey - Spring 1989

During the period April 22-June 20, 1989, Dr. Thomas Husband, University of Rhode Island, and students in Natural Resources Science conducted a small mammal survey of the Big River Management Area, Appendix C. Small mammals were trapped at 12 different sites on the study area using snap traps and can traps. Emphasis was placed on sampling the riverine and wetland habitats within the proposed reservoir area.

A total of 101 small mammals comprised of eight (8) species were trapped from the 12 sites. The meadow vole, Microtus pennsylvanicus, was the most numerous species captured. The water shrew, Sorex palustris, a rare species in Rhode Island, was captured on the Congdon River. This capture represents the third record of this species in Rhode Island. According to Dr. Husband, the Big River and its tributaries probably represent one of the last remaining habitats in Rhode Island for this species. Dr. Husband also emphasized the ecological role small mammals play in the Big River ecosystem. In particular, they provide an essential link in the food chain for several reptilian, avian and mammalian predators. McCord (1989) also recognized that the Big River Management Area must have a substantial prey base to support the large fox population that he found.

3. Breeding Bird Survey - Spring 1989

During May and June 1989, Mr. Rick Enser, Coordinator, Rhode Island Natural Heritage Program and Mr. Adam Fry, Naturalist, Rhode Island Audubon Society, conducted breeding bird surveys on the Big River Management Area, Appendices D and E. In addition, Mr. Fry conducted weekly surveys for birds and other wildlife during the period from February until the start of the breeding bird surveys, Appendix E.

Mr. Enser's breeding bird survey was conducted utilizing seven (7) transects in upland habitat, three (3) wetland transects (canoe routes) on Big River (2) and Carr River (1) and an automobile route to sample habitats not adequately represented by the other transects. Sampling emphasis was placed on the reservoir pool area since this would be the place of primary impact.

A total of 80 species were recorded on all surveys, 72 species on canoe routes and 64 species on upland transects including the automobile routes. These data were combined with information collected during the Breeding Bird Atlas project and other field investigations to develop a comprehensive list of breeding birds on the Big River Management Area. This list currently stands at at least 106 species.

Mr. Fry's migrant and breeding bird survey was conducted using upland transects, wetland transects and random searches to sample underrepresented habitats. Sampling emphasis was placed on the reservoir pool area since this would be the place of primary impact.

A total of 110 species were recorded consisting of 85 breeding species and 84 migrant species. In addition to the bird species, the Audubon investigators observed 9 species of mammals including bobcat sign (tracks), 9 species of amphibians, 8 species of reptiles and 18 species of butterflies. They also draw special attention to 5 birds observed on the Management Area (pileated woodpecker, northern goshawk, red-breasted nuthatch, white-throated sparrow and northern junco) and 1 mammal, the bobcat. Each of these birds is considered to be a rare breeder in Rhode Island, and the bobcat is rarely observed in the State.

Data from these most recent breeding bird surveys confirm that the Big River Management Area provides suitable habitat for and does support a highly diverse breeding bird fauna. This list includes many species that are dependent on or closely associated with aquatic habitats (18) and/or are considered area-sensitive species; forest interior (21) and interior-edge (22) species (Tables 1 and 2). The five most common species recorded on all canoe routes were common yellowthroat, song sparrow, gray catbird, swamp sparrow and yellow warbler. The five most common species recorded on upland transects were ovenbird, black-capped chickadee, veery, rufous-sided towhee and pine warbler.

4. Amphibian and Reptile Survey - Spring 1989

During the period March - June, 1989, Mr. Chris Raithel, Non-Game Specialist, Rhode Island Division of Fish and Wildlife, conducted searches for amphibians and reptiles within the Big River Management Area. Mr. Raithel has been making periodic searches in the Big River Management Area during the past 4 years as part of a statewide herptile survey. During this time period, he has developed a list of herptiles that occur in the study area, Appendix F. This species list includes 7 salamanders, 2 toads, 6 frogs, 7 turtles, and 11 snakes for a total of 33 species. Seven of these species are listed as probably occurring but specific documentation by him is presently lacking.

VI. Review of Special Topics

1. Impacts on area-sensitive species

At the time the Service completed its Coordination Act report on the Big River Project (September 1979), insufficient attention was directed at the concept of forest fragmentation and associated effects on area-sensitive species (forest-interior and interior-edge species) in and adjacent to the Management Area. In the intervening decade, a substantial amount of literature has been published describing the results of habitat fragmentation research. We now have empirical evidence, as has long been expected, that the impact on wildlife populations will extend far beyond the actual footprint of the reservoir (elevation 300 feet msl and its clear zone, elevation 310 msl). The past and current field investigations in the study area reveal that at least 21 forest-interior and 22 interior-edge migratory bird species nest in the impact area (Table 2). In addition, at least 3 forest-interior mammal species (bobcat, fisher and otter) also utilize the Management Area. We anticipate regional impacts to occur to many of these most sensitive species as a direct result of the loss of over 3,700 acres of habitat. The most sensitive breeding birds on the Management Area to patch area (forest size) based on available evidence (Robbins et al, 1989; Askins et al, 1987) include, but are not limited to, the black-and-white warbler, Louisiana and northern waterthrushes, black-throated green warbler, Canada warbler, worm-eating warbler, hermit thrush, yellow-throated vireo, red-shouldered hawk, Coopers hawk, and broad-winged hawk. The bobcat, fisher and otter are the most sensitive mammals found on the study area to forest size and forest fragmentation effects. A number of interrelated effects are associated with habitat fragmentation. These include the direct loss of habitat, an increase in edge, increased nest parasitism and predation, increased isolation of remaining forest, a decrease in the abundance and diversity of area-sensitive breeding birds, a decrease in the size of remaining forest patches and increased human disturbance (Whitcomb et al, 1981; Small and Hunter, 1988; Wilcove, 1985; Ambuel and Temple, 1983; Brittingham and Temple, 1983; Robbins, 1979, 1980; Robbins et al, 1989; Blake and Karr, 1984, 1987; Askins et al, 1987; Lynch and Whigham, 1984; Lynch, 1987). All of these factors would occur to varying degrees of intensity if the reservoir is constructed. As a result of reservoir construction practices, a sharp edge or habitat discontinuity will be formed around the 31 mile perimeter of the reservoir (i.e., clearing and grubbing between elevations 290-303 feet msl and clearing only to elevation 310 msl). Most of this edge will be formed by the water surface and a narrow clear zone butting up against forest habitat. Forest-interior bird species that previously nested in the zone between the edge of the reservoir and for a distance of up to 200 meters landward within the forest would find this habitat to be unsuitable and/or less suitable (personal communication V. Lang and C.S. Robbins; Robbins, 1988). This would occur from a combination of factors. Forest-interior birds do not nest nor establish nesting territories on forest edges (Whitcomb et al, 1981; Robbins, 1988). Depending on the sensitivity of the individual species, this distance from an edge can vary from a few meters to over 100 meters (Stauffer and Best, 1980). Both nest parasitism and nest predation are greatest near edge (Small and Hunter, 1988; Gates and Gysel, 1978; Wilcove, 1985). These factors decrease in intensity as distance from edge increases. The smooth characteristics of the shoreline edge would be an efficient predator pathway similar to roads and transmission line ROW's which would serve to increase the intensity of this impact (Small and Hunter, 1988). Several remaining forest patches such as those adjacent to I-95 and other developed areas would be too small to function as suitable nesting habitat for the area-sensitive migratory birds (Robbins et al, 1989; Askins et al, 1987). Some remaining patches may be large enough in terms of acreage but may be oblong or linear in shape and hence, be unsuitable because of extensive edge and lack of secure interior habitat (Temple, 1984). The degree of isolation of these remaining forest patches may also be sufficient to deter forest-interior or other area-sensitive species from using this habitat (Blake and Karr, 1984, 1987; Robbins et al, 1989; Askins et al, 1987). This impact zone (0-200 m) around the 31 mile reservoir perimeter encompasses an area of approximately 2,300 acres of land. It is also necessary to consider the relationship of the reservoir edge to other existing edges such as road relocations to accommodate the project, I-95, Route 3, cleared land and residential areas. In essence, we would have a double edge or in places, a multiple edge effect created because the perimeter of the Management Area would be surrounded by edges created by highways or existing developments. This project would carve the "heart" or most secluded interior portions of habitat out of the Management Area. The remaining lands (public and private) in the Big River Watershed would be less suitable or entirely unsuitable for area-sensitive species. As development proceeds on private land around the perimeter of the Management Area, the habitat fragmentation syndrome would become more severe. This would be especially evident along the south and southeast boundaries of the Management Area where sizeable blocks of undeveloped forested habitat currently exist.

Several researchers have linked local animal populations such as area-sensitive breeding birds to those occurring on a regional basis (Robbins et al, 1989; Blake and Karr, 1984, 1987; Lynch and Whigham, 1984; Whitcomb et al, 1981). In essence, forest-interior species may occur in suboptimal sized blocks of habitat if large reserves are nearby to provide recruitment or replacement individuals. The Big River Management Area is sufficiently large enough to provide this function for species such as the black-and-white warbler, veery, and ovenbird. It may not be large enough to provide this function for species such as Louisiana waterthrush, northern waterthrush, Canada warbler, worm-eating warbler, red-shouldered hawk, American redstart, barred owl and northern goshawk, as these species occur in low to moderate numbers on the study area. This suggests that the Big River Area is a reserve for these species. It is interesting to note that area-sensitive species with minimum breeding areas greater than 500 hectares (cerulean warbler, northern parula) are not represented in the breeding bird fauna on the study area (Robbins et al, 1989). The pileated woodpecker has a minimum breeding area of 165 hectares according to Robbins et al, 1989, and it is also not represented on the study area. This suggests that the Big River Reservoir would have regional impacts on area-sensitive birds that occur in moderate to low numbers in central Rhode Island because the reserve for these species would be eliminated.

A similar conclusion appears to be reasonable for mammals such as bobcat and fisher. These species occur infrequently on the Management Area from dispersal sites to the north and west. With the elimination of the core area due to the impoundment, the study area would no longer be suitable habitat for these species. This may tend to limit the regional population of these species due to the loss of suitable dispersal habitat at Big River.

Within the forest-interior category of migratory birds is a group referred to as long-distance or neotropical migrants, the warblers, vireos, tanagers, most of the flycatchers, and many of the thrushes. This group comprises more than half of our breeding bird population in the eastern deciduous forest (Robbins, 1988). This group of migratory birds is of concern to the Fish and Wildlife Service for several reasons. They are concurrently being subjected to habitat destruction on their wintering grounds in Latin America and on their breeding grounds in North America. Long-term population declines have been observed in this group of birds in sections of the United States undergoing rapid urbanization. Since these species are forest-interior dwellers during their breeding season, they are adversely impacted by forest fragmentation. Their breeding strategy also makes this group susceptible to many effects associated with habitat fragmentation (Whitcomb et al, 1981). As a rule, this group of birds nests only one time during the breeding season. Therefore, they have a low recruitment rate because they only produce one clutch each year. They generally build an open cup type nest near or on the ground which makes them susceptible to predation and parasitism in fragmented habitats. Because this group of birds requires extensive tracts of land for breeding, management for these native songbirds requires long-range ecosystem planning (Robbins, 1988).

2. Impacts on Species with Fidelity to Natal Areas

During the past several decades, a substantial body of information has been developed concerning homing and dispersal behavior in wildlife. Certain amphibian species exhibit a strong fidelity to their natal pond (Shoop, 1965; Williams, 1973; Ewert, 1969; Gill, 1979; Wilson, 1976; Dole, 1971; Semlitch, 1981). Salamanders, newts, toads, and to a lesser extent, frogs exhibit this homing instinct. Williams (1973) studied the movement of Ambystoma salamanders away from their natal woodland pond into their home range territory in Indiana. He found that Jefferson salamanders moved up to 625m, spotted salamanders 125m, and marbled salamanders 450m away from the natal pond. Bishop (1941) collected Jefferson salamanders in New York up to 1610m away from the nearest breeding pond. Wilson (1976) followed the movements of spotted and Jefferson salamanders away from a breeding pond in New York. This Ambystoma population moved about 75m from the breeding pond. Gill (1979) documented homing behavior in the red-spotted newt in Virginia and also showed that this species could navigate over a distance of 400m to the natal pond. Healy (1974) showed that the red eft stage of this species moved up to 800m from their natal pond into the terrestrial environment in Massachusetts. Douglas (1981) studied the post-breeding movements of marbled, Jefferson and spotted salamanders in Kentucky. He found the initial movements away from the natal ponds to be 30m, 250m, and 150m for these species, respectively. Later movements to summer home range were reported for each species indicating that some individuals moved yet further away from the breeding pond. Kleeberger and Werner (1983) studied the post-breeding migration of spotted salamanders in northern Michigan. They found these salamanders moved an average distance of 192m (range 157-249m) from the natal pond to summer home range. Ewert (1969) studied movements of the American toad (Bufo americanus) in northern Minnesota. He found homing behavior (fidelity) to breeding ponds and post-breeding migrations to summer range averaging 1200 feet (range 170-3,300). Clarke (1974) studied a population of Fowlers toad (B. woodhousei fowleri) in Connecticut. He found they moved up to 312m from the breeding pond to summer home range. Dole (1971) studied the dispersal of leopard frogs (Rana pipiens) in Michigan. He found that young leopard frogs commonly moved over 800m from their natal ponds. A few were recorded to have moved over 5km from the natal pond. Schroeder (1976) studied the dispersal and movements of young green frogs (R. clamitans) from their natal pond in Virginia. He found they commonly moved 183-448m from the larval pond. Some moved up to 4.8km from the natal pond.

Based on our knowledge of amphibian life cycle processes, the local frog, toad, and salamander species would be eliminated from the lands and waters to be occupied by the reservoir pool area, and depending on the species, would be adversely affected in the remaining lands on the Management Area. Within the reservoir pool, but excluding the shoreline, approximately 3400 acres of suitable habitat would be permanently eliminated. This includes the breeding ponds (reproductive habitat) and terrestrial habitat for the adults. Adjacent areas within the Management Area would over a period of 1-5 years gradually lose existing populations of certain amphibians. This would occur as a result of the adults perishing from natural causes and the lack of recruitment to replace those lost. Those species with the strongest fidelity to their natal ponds, such as the Ambystomid salamanders, would be most adversely affected. Unfortunately, it is not possible to precisely define the areas outside of the reservoir that would be affected as described above. Discrete studies would be required for each breeding pond to identify the exact areas that are "seeded" by amphibian species (adults and newly metamorphosed juveniles) dispersing from natal or breeding ponds. It seems reasonable, however, that areas within 200-300 meters of the reservoir edge would be most affected. The effects would lessen with increasing distance from the edge of the reservoir and become difficult to detect beyond 800m, as only the American toad, the red-spotted newt and some frogs move greater distances from natal ponds.

We should also recognize that in addition to habitat effects, discrete breeding populations of these amphibian species with a strong fidelity to their natal pond such as the spotted and marbled salamanders and red-spotted newt may also be lost. This would represent an irreversible and irretrievable loss of genetic material in these wildlife populations.

VII. Compliance with the 404(b)(1) Guidelines

Compliance with 40 CFR 230.10(a)

During the formal Departmental level review process of the Big River Reservoir Feasibility Report in 1982, the Department of Interior raised several questions concerning the need and environmental acceptability of the proposed project (DOI letter August 12, 1982). These issues raised by Interior concerning need for the project, demand modification alternatives and other issues remain unresolved, despite a time lapse of 7 years in which the Water Resources Board and/or the Corps of Engineers had ample opportunity to conduct studies that would allow them to refute or agree with the analysis and comments made by Interior. Neither of the project proponents chose to supplant the administrative record with data to demonstrate that the Big River

Reservoir was the least damaging practicable alternative to fulfill Rhode Island's future water supply needs. Rhode Island's future water supply needs remain an unknown because the necessary studies have not been conducted to accurately identify these needs and all practicable alternative approaches to satisfy them. Therefore, we conclude that the Big River Reservoir Project does not comply with 40 CFR 230.10(a) for the reasons set forth in Interior's August 12, 1982 letter.

We understand that the State of Rhode Island has recently obtained the services of a consultant (A.D. Little, Inc.) to investigate the needs issue and water supply alternatives as a means of addressing this important issue. The results of this study are not expected before March or April, 1990. As a result, Agency and public review of this data would likely not occur until some time in mid-1990, well after the comment period is closed for this 404c proceeding.

Compliance with 40 CFR 230.10(b)

The Big River Reservoir does not comply with Rhode Island Water Quality Standards, hence it fails to comply with Section 230.10(b) of the 404(b)(1) Guidelines. As demonstrated in this report, the Big River Reservoir would eliminate existing uses presently occurring on the various aquatic environments found below the flow line of the impoundment (elevation 300 feet msl). These uses include breeding, foraging and cover habitat for over 100 species of migratory birds that utilize these aquatic habitats for one or more critical life cycle phases. The reservoir would be unsuitable habitat for over 90 species of migratory birds presently found there and hence, these species would be eliminated from the impoundment. The waterbird group (waterfowl and wading birds) would be the least adversely affected by the proposed impoundment. Some members of this group would benefit from the proposed project. However, other species such as black duck and green-backed heron would possibly be eliminated as nesting species on the Management Area despite the proposed subimpoundments along the perimeter of the reservoir.

At least 28 species of mammals utilize these stream, pond, floodplain and wetland habitats for requisite life cycle needs such as breeding, rearing young, foraging and cover. The proposed impoundment would be unsuitable habitat for 25 species and less suitable for the remaining 3 (beaver, muskrat and otter). Some use would be made of the shoreline areas by species such as raccoon. However, the value of the impoundment for any of these aquatic mammal species is expected to be limited because of water level fluctuations. Greater utilization would be anticipated for the subimpoundments. Hence, 25 of the 28 mammals presently utilizing habitats below elevation 300 feet msl on the Management Area would be eliminated from these areas by the impoundment.

Fourteen species of amphibians and 18 species of reptiles utilize these aquatic habitats for one or more critical life cycle processes. The resulting impoundment excluding the shoreline area would be unsuitable habitat for 13 of these amphibian species and 12 of the reptile species. It would be less suitable for at least one other, the spotted turtle. Of the 14 amphibian species, only the bullfrog would be expected to utilize portions of the reservoir proper and those would be restricted to areas with floating-leaved and emergent vegetation, providing any such littoral zone develops, given the range of water level fluctuations expected. We anticipate that it would attempt to breed around the perimeter of the reservoir, especially in protected coves, bays and the subimpoundments. The green and pickerel frogs may also utilize the subimpoundments and perhaps some other shoreline areas as breeding sites. In general, any use of the impoundment by amphibians other than the bullfrog would be limited to the shoreline. We would not expect the reservoir to be used as breeding habitat by salamanders, toads, peepers, tree frogs or woodfrogs as these species prefer to utilize small ephemeral and permanent ponds. These isolated breeding sites lack fish and other predators that prey on egg masses and juveniles of these species. The adult phase of most of these species except red-spotted newt is essentially or entirely terrestrial; hence, the reservoir would be unsuitable habitat for this life stage.

Within the reptiles, only the water snake, painted turtle, snapping turtle, and stinkpot would be expected to use the reservoir proper. The wood and box turtles and remaining 10 snakes are terrestrial species and would be eliminated from the reservoir area. The red-eared slider is considered an exotic and is not known to be reproducing in Rhode Island. The spotted turtle generally does not co-exist in the same habitat with painted turtles in Rhode Island; hence, it may not utilize the reservoir (personal communication, V. Lang and C. Raithel, RI F&W). The proposed subimpoundments would provide the bulk of the suitable habitat for the aquatic turtles and the water snake as they would have stable water levels and hence, the best developed, if not the only littoral zone with well developed macrophytes in the reservoir.

The existing brook trout population would be eliminated as would the 9 aquatic species identified by Smith, 1989 (Appendix A). None of the 9 species identified by Smith (1989) and the brook trout could tolerate the expected environmental conditions of the proposed reservoir. This would result from the inability of many benthic species to obtain adequate oxygen and food and eliminate waste products. Most species adapted to lotic habitats have limited or no ability for long-term survival in a lentic habitat. Species such as brook trout would not survive over the long-term due to the loss of stream habitat including the critical spawning, rearing and refuge areas. The dissolved oxygen and temperature profiles anticipated in the proposed reservoir would preclude this as a viable habitat during the summer stratification period for coldwater species such as brook trout. Hence, we conclude that this wild, self-sustaining population would be eliminated from the watershed. Based on the benthic data collected by KAME (1976) and Normandeau (1979), we expect species in at least 9 genera of mayflies (Ephemeroptera), 5 genera of dragonflies (Odonata), 2 genera of stoneflies (Plecoptera), 7 genera of beetles (Coleoptera), 3 genera of caddisflies (Trichoptera), and 8 genera of flies (Diptera) to be eliminated from existing lotic habitats as a result of inundation. These aquatic insects are not expected to survive in the reservoir as they are adapted only for lotic conditions.

The Rhode Island Division of Fish and Wildlife manages the Big River Management Area for outdoor recreation and related purposes. The Division maintains records on some recreational uses of the area. They estimate that the Management Area provides 1,000 mandays of deer hunting, 2,300 mandays of small game hunting, 1,000 mandays of trout fishing, and 800 mandays of warmwater fishing (personal communication, V. Lang and J. Stolgitis, RI F&W). In addition, other recreational activities include canoeing, hiking, and bird watching. However, no estimates are available to predict the level of use for these activities on the Management Area. In any event, creation of the impoundment would eliminate many of these uses. Hunting, hiking, stream fishing and bird watching for instance would be eliminated by the impoundment. If recreational activities are allowed on the reservoir, then flatwater (lentic) fishing and canoeing opportunities might be retained although the setting would be radically altered.

Thus, this project could not comply with even the base level of protection provided by Rhode Island's Antidegradation Policy, Section 17(a) because existing uses would not be maintained and protected. In addition, the Big River and its tributaries are Class A waters whose qualities make these waters critical to the propagation or survival of important natural resources as described in this report. Therefore, the Big River and its tributaries constitute "High Quality Waters of the State" under Section 17(c). This classification invokes additional protection as provided by Section 17(d). However, since the project cannot pass muster at 17(a), we need not consider this provision further.

The Big River Reservoir could not meet the dissolved oxygen standards established for Class A waters under Section 6.32 of Rhode Island's Water Quality Standards. This criterion requires the dissolved oxygen to be not less than 5 mg/l at any place or time except as occurs naturally. Section 6.5 allows waters in their natural hydraulic condition to have excursions from established standards but not waters in an unnatural hydraulic condition. As we have discussed previously, the D.O. levels in the hypolimnion are expected to fall below 5.0 mg/l and possibly become anoxic (COE Appendix D, 1981). Hence, the project cannot meet this standard. Sections 7.1 and 7.3 provide additional restrictions on these issues.

We conclude, for the reasons set forth above, that the project does not comply with 40 CFR 230.10(b).

Compliance with 40 CFR 230.10(c)

The proposed Big River Reservoir would cause or contribute to significant degradation of waters of the United States. This results from: (1) Significant adverse impacts on at least 25 species of mammals, 90 species of birds, 1 species of fish, 12 species of reptiles and 13 species of amphibians and numerous species of invertebrate wildlife dependent on the aquatic habitats (streams, ponds, wetlands, floodplains) that would be eliminated if the reservoir is constructed [230.10(c)(2)]; (2) significant adverse effects on ecosystem diversity, productivity, and stability resulting from the loss of 3,700 acres of highly diverse fish and wildlife habitat [230.10(c)(3)] and; (3) a significant aesthetic and recreational resource would be lost if the reservoir is constructed [230.10(c)(4)].

As described elsewhere in this report, significant adverse impacts would occur to over 144 species of vertebrate wildlife (fish, birds, reptiles, amphibians, and mammals) and an undefined number of invertebrate species. Many area-sensitive species and others with specific habitat requirements (i.e., coldwater streams, ephemeral ponds) would be extirpated not only from lands and waters occupied by the reservoir, but the remaining lands and waters within the Management Area and lands and waters outside the Management Area if this project is constructed. The native brook trout population would be eliminated from the area occupied by the reservoir due to predicted low dissolved oxygen (D.O.) levels in the hypolimnion. A similar fate would await the single mussel Elliptio complanata and snail Campeloma decisum species found in these waters. These species could not survive the lentic conditions, sedimentation, low D.O. or water fluctuations. In addition, the native brook trout population would, over time, be extirpated from the watershed due to the loss of spawning, nursery and refuge habitat (cold, well oxygenated water). Seven of the 9 species identified by Smith (1989) would fall into this situation as well. All nine species identified by him would perish in the reservoir. Since the clam E. complanata and snail C. decisum only exist within the reservoir area, they would be eliminated as the storage pool filled. The remaining 7 species would survive initially in the remaining lotic aquatic habitat in the watershed. However, due to the limited amount of stream habitat remaining, increased isolation of these remaining populations and their susceptibility to environmental perturbations such as pollution incidents, D.O. and pH excursions, drought conditions, and other hydrologic extremes, we anticipate that all 7 species would gradually be eliminated from the watershed. In addition, due to the extensive loss of stream habitat, the increased isolation of remaining habitat and other factors identified above, we anticipate that several genera of insects would, over time, no longer be represented in the Big River watershed.

Most of the refuge habitat for coldwater stream species in this watershed occurs within the bounds of the Management Area, and much of this within the conservation pool. This results from topography, soils, groundwater discharge zones, extensive wetlands, and impoundments or ponds located in the extreme upper reaches of the 4 main tributaries to Big River. As an illustration, the Congdon River is typical warmwater habitat in its upper reaches due to Rathbon, Hopkins and Money Swamp Ponds. The typical coldwater profile for this stream develops some distance below Rathbon Pond where groundwater discharges bring the water temperature into the 60°F range as opposed to 73°F and above found in Rathbon Pond (FWS, July 1989). The Carr and Nooseneck Rivers also have ponds, extensive wetlands, and/or impoundments in their upper reaches above the conservation pool. Normandeau (1979) found no brook trout in the upper Nooseneck due ostensibly to low D.O. and pH below an extensive wetland. Bear Brook has 2 small ponds in its headwaters and in addition, has the smallest drainage area of any tributaries to Big River. Because several other fish species currently found in the watershed require lotic habitat for spawning sites, we anticipate that the fallfish, creek chubsucker, creek chub, and possibly white sucker would be subject to wide fluctuations in year-class strength due to hydrologic extremes, water quality excursions, and other events in the remaining lotic habitat in Nooseneck River and Bear Brook. Over a period of years, one or more of these species could be extirpated from the watershed.

Amphibians, with the possible exception of the bullfrog, would be eliminated from the reservoir pool area. In addition, some amphibians, such as the spotted salamander, would be eliminated from adjacent lands on the Management Area that are presently used as adult home range for salamanders breeding in areas to be inundated. All but one species of snakes and most turtle species would be adversely affected by direct habitat loss within the reservoir area. In addition, the turtles would be affected by the loss of winter hibernacula. The spotted and wood turtles would be the species most affected by loss of hibernacula, as they have specialized requirements (boggy areas with hummocks, clear streams with undercut banks). Area-sensitive bird and mammal species would be eliminated not only from the area occupied by the reservoir but adjacent areas within and outside the Management Area as well. In previous sections of this report, we identified a zone 200 meters deep around the 31 mile perimeter of the proposed reservoir that would be the principle secondary impact zone for area-sensitive birds and mammals. Based on data developed by Askins, et al (1987), and Robbins, et al (1989), we anticipate that the following migratory birds would have the greatest potential to be eliminated as breeding species from the Management Area and/or watershed: Coopers hawk, northern goshawk, broad-winged hawk, red-shouldered hawk, barred owl, yellow-throated vireo, northern waterthrush, Louisiana waterthrush, American redstart, worm-eating warbler, and Canada warbler. The most sensitive mammal species, the fisher and bobcat, would also be eliminated from the Management Area due to the loss of secure interior habitat. This loss of habitat would be sufficient to insure that these species could not become resident or breeding species in the watershed.

Species of special concern in Rhode Island such as the fisher, bobcat, water shrew, white-throated sparrow, winter wren, Acadian flycatcher, and the amphipod Synurella chamberlaini would be eliminated from the Management Area and/or watershed. While these species are secure elsewhere in their natural range, they exist in an uncertain situation in Rhode Island. The loss of these individuals or populations probably represents an irreversible and irretrievable loss in Rhode Island.

Ecosystem diversity, productivity and stability would be significantly adversely affected due to the direct loss of 3,700 acres of wildlife habitat including over 500 acres of wetlands. In addition, another 2,300 acres of habitat within a zone of 0-200 meters around the 31 mile reservoir perimeter would be made unsuitable or less suitable for area-sensitive species of wildlife. The 3,700 acres of habitat to be cleared for the reservoir represent the most secluded or secure habitat on the entire 8,270 acre Management Area. Once this secure interior habitat has been eliminated, the fragmentation syndrome will become much more severe as development progresses around the perimeter of the Management Area. This combination of factors will lead to a continual decline in the diversity and abundance of area-sensitive birds and mammals and other species of wildlife that are presently represented on the Management Area in restricted habitats, limited numbers or both. The project will encourage the common, edge, or ubiquitous wildlife populations (ecological generalists) to increase in numbers at the expense of species with specialized habitat requirements. Normandeau (1979) described the lentic systems as containing a much lower habitat and faunal diversity than the lotic systems. We anticipate that the proposed reservoir would likewise have a low habitat and faunal diversity compared to the existing lotic habitats.

Ecosystem productivity would be reduced because the reservoir would provide about 3,400 acres of oligotrophic water in place of the productive wetlands, floodplains, upland forests and old fields presently existing on site. The organic carbon production in the existing vegetation communities exceeds that which would be predicted for the proposed reservoir (Odum 1971, Wetzel 1975). The Corps also predicted that Big River Reservoir would be very oligotrophic (COE, 1981, Appendix E). In addition, reservoir drawdowns associated with water supply activities would prohibit the development of an emergent vegetation (littoral) zone which would be the most productive part of the waterbody. The shoreline would have the familiar bathtub ring around it similar to that found at other water supply reservoirs in New England since it would have average drawdowns of 3-6 feet and maximum drawdowns in excess of 30 feet on an infrequent basis, assuming a 6 cfs release from the dam (COE, 1981, Appendix D). However, these drawdowns would be much greater than the 3-6 feet estimate due to the requirement to maintain the aquatic base flow in the South Branch Pawtuxet River. The FWS recommended that a minimum flow of 18 cfs be released from the dam to maintain downstream aquatic communities, hence the drawdowns would be in the range of 9-18 feet on average with more severe drawdowns in drought years.

Ecosystem stability would be reduced in our opinion because fewer species of wildlife would remain in the Management Area and watershed as a result of removing 3,700 acres of highly diverse habitat from the area. These 3,700 acres contain highly structured and stable vegetation systems as described by KAME (1976) and Normandeau (1978). Only the gravel mines and roads on the Management Area would be considered disturbed and hence, unstable ecologically. The existing food chains would be disrupted and/or eliminated also. The vegetation present on the study area is responsible for the organic carbon production that drives the herbivore food chain. These herbivores are largely represented by insects, small mammals and a single large mammal, the white-tailed deer. Both Husband (Appendix C) and McCord (Appendix B) made reference to the mammalian predator-prey system they observed on the study area. Other predators in this system include the snakes and raptors. Similar predator-prey relationships exist between insects and songbirds, insects and amphibians, aquatic and terrestrial insects and fish, fish and their predators consisting of reptiles, birds and mammals, amphibians and their predators, again consisting of reptiles, birds and mammals and other more complex relationships dealing with herbivore-omnivore-carnivore-decomposer systems and various combinations of the above. If the project was implemented, the fluctuations in the reservoir for water supply would cause the impoundment to remain unstable in an ecological sense. The littoral zone would remain in a constant flux preventing the establishment of macrophytes and other nearshore plant and animal communities. This, in turn, would cause the reservoir to be dominated by algae and diatoms, species that are subject to wide fluctuations during the annual cycle and from year to year. Due to expected low dissolved oxygen levels or even anoxic conditions in the hypolimnion, we anticipate the reservoir to have a very unstable benthic community below the epilimnion layers. This would be similar to the "August effect" commonly found in estuaries such as Boston, New Haven and Bridgeport Harbors. We anticipate the benthic community in these lower levels to be dominated by opportunistic colonizers such as oligochaetes and chironomid larvae during fall-spring. During summer stratification, it would likely be devoid of life forms requiring oxygen for growth or survival.

The fish and wildlife habitat losses associated with the Big River Reservoir project were investigated and reported on by the Fish and Wildlife Service in September 1979. The habitat evaluation procedures (HEP) were used to quantify and display these losses for wildlife in standardized units called habitat units (HU). The total loss of wildlife habitat as expressed in habitat unit values is 1,854 habitat units (U.S. FWS, 1979, Table 4). These unit values were predicted to change slightly during the period of analysis for the reservoir project (U.S. FWS, 1979, Table 9). Based on the analyses completed during the planning process, the Service concluded that the construction of Big River Reservoir would cause significant adverse impacts to fish and wildlife resources (U.S. FWS, 1979). The significance of these losses prompted the Service to oppose the reservoir project.

In a July 1, 1988 letter to Governor DiPrete, Colonel Rhen, New England Division, Corps of Engineers, stated that it was his position that the Big River Reservoir Project would have significant impacts. These significant impacts include the loss of 570 acres of highly diverse and productive wetlands by inundation within the proposed impoundment; loss of approximately 150 acres of wetland habitat for the dam construction and roadway relocations; potential impacts to Mishnock Lake and its adjacent 450 acres of Mishnock swamp through groundwater fluctuation and loss of freshwater stream habitat to coldwater fisheries (COE, 1988).

A significant loss of recreational resource values would occur if the Big River Reservoir is constructed. The Rhode Island Division of Fish and Wildlife has maintained records on certain uses in the Management Area such as hunting and fishing. They estimate the Management Area provides 1,000 mandays of deer hunting, 2,300 mandays of small game hunting, 1,000 mandays of trout fishing and 800 mandays of warmwater fishing. Opportunities for coldwater fishing such as stream trout fishing are considered to be in extremely short supply in Rhode Island (personal communication, V. Lang and J. Stolgitis, RI F&W). Hence, the loss of the stream trout fishery at Big River is considered a significant adverse impact. Other recreational activities such as hiking, mushroom and other edible plant harvesting, bird watching, canoeing and cycling occur on the Management Area, but accurate estimates of this use are unavailable. Based on the short distance to the Providence area, we assume these passive uses exceed traditional consumptive activities (hunting, fishing). The State of Rhode Island has a statute regulating recreational uses and other activities on waters used for water supply. It remains unclear what recreational activities, if any, would be permitted on the proposed reservoir and adjacent lands and waters in the Management Area.

Given the limited supply and availability of large tracts of highly diverse, undeveloped land for open space in Rhode Island, we believe the loss of 3,700 acres from the most secluded sections of this tract would constitute a significant adverse impact on recreational uses and aesthetic values.

We conclude, for the reasons set forth above, that the Big River Reservoir project does not comply with the provisions of 40 CFR 230.10(c).

Compliance with 230.10(d)

The Big River Reservoir does not comply with this requirement in the Guidelines. The Congressionally authorized version of this project recognized that mitigation of fish and wildlife habitat losses was an outstanding issue. The Congress directed the Corps of Engineers to reevaluate the acquisition of mitigation lands within one year after enactment of the Act (Water Resources Development Act of 1986, Title VI, Section 601). This reevaluation has not been conducted as directed by Congress.

The Fish and Wildlife Coordination Act report dated September 1979 identified the need to acquire an additional 8,437 acres (evergreen forest-2,464, scrub/shrub wetland-3,400, forested wetland-2,573) for in-kind compensation of habitat losses (U.S. FWS, 1979, Table 9). This takes into account management of remaining lands for wildlife as recommended by FWS. However, if these remaining lands could not be managed for wildlife, then the requirement for additional lands outside the Management Area would increase. The Service was not provided the opportunity during the feasibility study to determine if a suitable tract or tracts of land were available in Rhode Island to serve as a mitigation area. This issue was raised by Interior in the August 12, 1982 letter concerning the project. In addition, Interior stated that the *feasibility of finding suitable mitigation lands had not been demonstrated.* Interior also noted a contention by the Corps that additional mitigation lands should not be acquired because of socio-economic and political complications (DOI, 1982). We agree with the Corps on this issue that acquisition of additional lands in Rhode Island for mitigation purposes would be extremely difficult, if in fact, suitable lands could be located.

It is also important to consider the mitigation plans in light of the 404(b)(1) Guidelines. This was not done by FWS or other agencies during the planning process in 1979. Consequently, many of the wildlife management techniques, especially the high intensity—high profile actions that were traditionally employed in the past, may themselves no longer be permissible by today's environmental standards. This is important because much of the mitigation was to be accomplished through management of existing wildlife habitat including wetlands. The end result of such a review might dictate a need for low intensity management on existing wildlife habitat including wetlands. This would probably require greater acreages than originally estimated for a suitable compensation plan.

In our discussion on area-sensitive species, we draw attention to a shortcoming in the 1979 HEP analysis. The models (narrative and verbal) used in the 1979 analysis did not take into consideration these landscape effects that are associated with the habitat fragmentation syndrome. We simply lacked the empirical data and state-of-art that we now have for evaluating habitat fragmentation effects. The direct effects of the project on wildlife were determined based on the flow line (elevation 300 feet msl) of the reservoir in 1979. We now realize that that was an inaccurate assumption. The direct effects on wildlife extend far beyond the actual footprint of the reservoir. Direct effects will occur on remaining lands in the Management Area and lands outside the boundaries of the Management Area. This will drive the area needed for in-kind compensation much higher than the 8,437 acres originally determined in 1979. An exact figure has not been determined.

During the 10-year period since the original mitigation proposal was developed by the Service for the Big River Reservoir, we have had the opportunity to study wetland mitigation projects including wetland creation. Most of these attempts have either been failures or have met with very limited success. The best, but limited, success rate has been for herbaceous wetlands, followed in decreasing order by scrub/shrub and forested wetland. We remain unaware of any reports where successful restoration or creation of forested wetlands has occurred. In recent meetings with COE, EPA, FWS, ConDOT and consultants and ConDEP on the CCE and I91/291 highway projects in Connecticut, all agencies present agreed that it was impossible to create a forested wetland to replace those that would be lost if certain highways were constructed as proposed. The best that could be hoped for would be to create a scrub/shrub wetland which over a long period of time (>100 years) might grow and mature into a forested wetland. When the landscape features are added into this mitigation problem, the outcome looks even more dubious. The majority of these forested and scrub/shrub wetlands in Big River are associated with a stream system. Thus, in order to replicate the functions and values of those being lost, a similar stream system would need to be created or one found without floodplain wetlands. We seriously doubt that either of these are doable in Rhode Island or elsewhere.

In our opinion, it is impossible to compensate for the forested and scrub/shrub wetland losses and landscape effects that would occur if the Big River Reservoir is constructed. These landscape effects include: the loss of 16.9 miles of free-flowing warm- and coldwater streams, their attendant ponds, floodplains, tributaries, groundwater seeps and living resources; the loss of 3,700 acres of highly diverse wildlife habitat consisting of mixed forest, softwood forest, hardwood forest, old fields, floodplains, wetlands, ponds and streams with complex juxtaposition patterns, seral stages and vegetation composition; the loss of a highly diverse fauna utilizing the wildlife habitat and; the loss of 3,700 acres of secure forest-interior habitat from the center of a 8,270 acre tract of land in a highly urbanized region.

In conclusion, we believe it would be extremely difficult, if not outright impossible, to design and successfully implement a compensation plan to replace the functions and values lost because this is clearly beyond the current state-of-art in mitigation planning.

We conclude, for the reasons set forth above, that the Big River Reservoir project does not comply with 40 CFR 230.10(d).

VIII. Conclusions

The Fish and Wildlife Service has had the opportunity to review the Big River Reservoir Project on three separate occasions during the last decade. Our views of the project have not changed appreciably during this decade. We identified the project as having significant adverse impacts to fish and wildlife resources, including wetlands and other aquatic habitat, at the time the Coordination Act Report was published on September 28, 1979. Based on this review, the Service formally opposed the project due to predicted adverse impacts on fish and wildlife resources. In 1982, the Service again participated in the Departmental level review of the project. As a result of views and concerns of the Service, the Department of Interior raised significant issues concerning the need for the project and its environmental acceptability. As you know, these views were raised by Interior during and despite a very sensitive time for environmental agencies attesting to the gravity of the situation at Big River. Our present review reinforces conclusions reached in earlier reviews. The project would have unacceptable adverse impacts on wildlife and fishery resources. The environmental case against the Big River Reservoir has grown stronger during this decade as a result of information on forest-interior species, species with fidelity to natal areas, the failure of most wetland mitigation projects to work and the recognition that landscape features associated with large wetland systems such as Big River cannot be mitigated except by avoidance.

Therefore, we request that you prohibit the use of Big River, Mishnock River, their tributaries and adjacent wetlands as disposal sites for the reasons discussed in this report. Please feel free to contact me with any questions at 603-225-1411 or FTS 834-4411.

Sincerely yours,

Vernon B. Lang

Vernon B. Lang
Acting Supervisor
New England Area

TABLE 1

Birds Nesting on Big River Management Area that Are Closely Associated with Aquatic Habitats

American Black Duck
Barred Owl
Belted Kingfisher
Canada Goose
Common Yellowthroat
Gray Catbird
Green-backed Heron
Louisiana Waterthrush
Mallard
Northern Waterthrush
Red-shouldered Hawk
Red-winged Blackbird
Spotted Sandpiper
Swamp Sparrow
Veery
Virginia Rail
Wood Duck
Yellow Warbler

TABLE 2

Area-Sensitive Birds Nesting on Big River Management Area

Forest-Interior	Interior-Edge
	American Goldfinch
Acadian Flycatcher	American Crow
American Redstart	Black-capped Chickadee
Barred Owl	Blue Jay
Black-and-White Warbler	Blue-gray Gnatcatcher
Black-throated Green Warbler	Common Yellowthroat
Broad-winged Hawk	Downy Woodpecker
Brown Creeper	Eastern Phoebe
Canada Warbler	Eastern Wood-Pewee
Cooper's Hawk	Gray Catbird
Hairy Woodpecker	Great Crested Flycatcher
Hermit Thrush	Northern Cardinal
Louisiana Waterthrush	Northern Flicker
Northern Goshawk	Red-eyed Vireo
Northern Waterthrush	Rose-breasted Grosbeak
Ovenbird	Ruffed Grouse
Red-breasted Nuthatch	Rufous-sided Towhee
Red-shouldered Hawk	Tufted Titmouse
Scarlet Tanager	White-eyed Vireo
Veery	Wood Thrush
White-breasted Nuthatch	Yellow-billed Cuckoo
Worm-eating Warbler	Yellow-throated Vireo

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APPENDIX III

Appendix III: WATER SUPPLY ALTERNATIVES

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The Big River Reservoir, as proposed by the U.S. Army Corps of Engineers and the Rhode Island Water Resources Board, is intended to provide additional public water supply in the greater Providence area.[1] More than 100 documents were examined in the course of this review. I have employed a conventional planning approach using procedures consistent with the Principles and Guidelines published by the U.S. Water Resources Council.

To evaluate the project purpose, it is necessary to first review the projections and assumptions that give rise to the stated needs, then to consider alternative means of satisfying them. The following sections summarize some the early water supply documents and describe and evaluate the need for the proposed project, showing the sensitivity of the Corps' conclusions to certain key assumptions. This is followed by a survey of demand management and supply augmentation alternatives available to the State. It is shown that (1) likely future need is much less than projected by the Corps in 1982; (2) various feasible and cost effective measures are available which would reduce need still further; and (3) a wide range of practicable, cost effective, and environmentally less damaging supply alternatives are available.

Water Supply Studies Before 1980

Early State-wide water resource studies include C.A. Maguire & Assoc. (1952), Metcalf & Eddy (1967), and Report No. 10 of the Rhode Island Statewide Comprehensive Transportation and Land Use Planning Program (1969). All of these studies discuss potential shortfalls in public water supply capacity and mention the Big River Reservoir, among other alternatives, as a possible means of increasing supply.

The 1952 C.A. Maguire & Assoc. study projects water use from public supplies to be 112.83 MGD by the year 1980, based on an assumed population of 950,000. [Actual 1980 population

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[1] The Corps project would also include the purposes of flood control and recreation.

for Rhode Island was 946,154, although total water use for 23 of the 25 largest systems had reached only 104.8 MGD by 1985 (Corps, 1986).] For the year 2001, Maguire projects water withdrawals from public systems of 144.66 MGD, based on a population of 1,070,000. Water use projections are the result of simple per capita calculations, where per capita water use (91 gpcd State-wide in 1950) is assumed to grow linearly to 135 gpcd in 2001.

Maguire concludes that, as of 1950, existing sources are inadequate to meet projected demand. Seven possible surface water developments are evaluated. Of these, the Big River Reservoir is judged most cost-effective on the basis of a total projected cost of $5.87 million, estimated in 1952 dollars. Converting this amount to 1989 dollars gives a project cost of approximately $32 million.

The Metcalf & Eddy study, completed fifteen years after Maguire's analysis, takes a more optimistic view of population growth within the State, projecting 1,209,000 persons by the year 2000, and 1,406,000 by 2020. Water use projections are the result of a simple per capita calculation, as in the Maguire study, but Metcalf & Eddy assume a decreasing rate of growth in the per capita coefficient. Nevertheless, projected 2020 coefficients fall in the range of 150-200 gpcd. The resulting State-wide forecasts for water withdrawals from public systems are 168.03 MGD for 1990 and 242.04 MGD for 2020. Interpolating these projections gives a 2001 estimate of about 195 MGD, substantially in excess of Maguire's projection of 144.66 MGD.

Metcalf & Eddy, like Maguire, finds existing water system capacity inadequate for projected needs (combined dependable yield for all systems is estimated at 150 MGD), recommending the development of additional surface water impoundments. A major component of these recommendations is the construction of the Big River Reservoir, at an estimated 1967 cost of $23.2 million, to include the treatment plant and finished water aqueduct. This cost is equivalent to approximately $92 million, when measured in 1989 dollars.

The report of the State-wide comprehensive planning program, published in 1969, predicts a 1990 population of 1,105,000. Following the practice of Maguire and Metcalf & Eddy, water use is estimated on the basis of a simple per capita relationship, giving a 1990 estimated need of 174 MGD. Per capita use is based on 1965 statistics and is assumed to grow by 1.5 gpcd each year. Possible water use trends after 1990 are discussed, but no projections are provided.

The discussion of water supply alternatives is based on the earlier Metcalf & Eddy study, including the recommendation for the construction of the Big River Reservoir. The State study includes separate analyses of projected demand/supply balances in each of four major areas and 29 individual planning districts. The results indicate that 23 of the 29 districts (and all four of the major areas) will experience supply shortfalls by 1990. The State-wide deficit is projected to be 21.85 MGD. Allowing for a 25 percent margin of safety, this is said to indicate a capacity shortfall of 66.76 MGD. Specific recommendations call for completion of the Big River Reservoir prior to 1980. A revised cost estimate is provided, now $36.7 million measured at 1969 prices ($129 million in 1989 dollars).

DETERMINATION OF NEED

Big River Feasibility Study

The Corps Big River reservoir feasibility study follows the methods of the earlier studies discussed above, and arrives at similar conclusions (Corps, 1981a, 1981b). The Corps report defines a study area consisting of the existing service areas of the Providence Water Supply Board (PWSB), the Bristol County Water Authority (BCWA), and the Kent County Water Authority (KCWA), plus the communities of Foster and Glocester. This area contained 571,187 people in 1980, and is projected to reach a total population of 655,100 in the year 2000, and 736,900 by 2030 (Corps, 1982, p. 2). The number of residents expected to be served by public water systems is slightly smaller, 633,700 in 2000 and 730,800 in 2030. These latter projections represent average annual rates of growth of +0.52 percent for 1980-2000, and +0.48 percent for 2000-2030.

Based on estimated average day water use of 71.8 MGD for the study area in 1975, the Corps forecasts unrestricted year 2000 demands on public systems at 98.6 MGD, and 128.2 MGD for 2030 (Corps, 1981a). Average annual growth rates implied by these water use projections are +1.28 percent for 1975-2000, and +0.88 percent thereafter.

Consideration of the possible implementation of water conservation measures led the Corps to produce alternative forecasts of restricted average day water use as part of the original study, and to further reduce those alternative forecasts in a supplemental study (Corps, 1982). The revised restricted (with water conservation) forecast is 89.8 MGD for 2000 and 114.2 MGD for 2030. These estimates reflect average annual water use growth rates of +0.90 percent for 1975-2000 and +0.80 percent for 2000-2030. In every case, therefore, water use is predicted to grow substantially faster than study area population.

The Corps estimates the capacity of existing sources available to water utilities within the study area at 91.1 MGD (average day yield under drought conditions, as of 1975) (Corps, 1981b, p.A-51). This estimate assumes a dependable yield of 77.0 MGD for the Scituate Reservoir system of the PWSB. Bristol County is assumed to retain its existing surface and ground water systems (3.2 MGD), and Kent County will maintain its current supply capability (estimated by the Corps at 10.9 MGD). The Corps further assumes that the BCWA will develop 3.0 MGD of new ground water capacity, bringing the total future supply to 94.1 MGD (Corps, 1982).

In the absence of water conservation, Corps water use projections indicate that existing capacity will be fully utilized by 1997, and that a deficit of 34.1 MGD will exist by 2030. Implementation of the assumed levels of water conservation would defer the need for new capacity by a full decade to 2007, producing a year 2030 deficit of 20.1 MGD (Corps, 1982, p. 4 and Plate 2).

Water Use Forecast

<u>The Corps Forecast</u>

The Corps forecast future water use by a modified per capita method, based on population and nonindustrial water use data for 1975. Industrial withdrawals from public systems were estimated at 14.21 MGD, based on a 1971 study by the Rhode Island Water Resources Board. This amount was subtracted from 1975 water deliveries prior to calculation of per capita coefficients. Industrial uses were projected separately using a growth factor said to incorporate economic and technological parameters. No details of this method are provided, and no separate results are reported (only combined industrial and residential/commercial water use is stated for future years). Reconstruction of the Corps' calculations, however, indicates that industrial withdrawals are expected to grow from 14.21 MGD (1975) to 17.66 MGD (2000) to 28.12 MGD (2030).

Remaining water use, identified as residential and commercial use, was projected on the basis of a simple per capita calculation. The estimated per capita coefficient for 1975 (calculated separately for each subarea, but averaging 111.3 gpcd over the entire study area) was increased by 0.80 gpcd/year until the year 2000 and by 0.33 gpcd/year thereafter. The slower rate of increase after 2000 is said to reflect an expected increase in public awareness of water conservation. Areas presently without public water service were assigned coefficients of 70 and 80 gpcd for 2000 and

2030, respectively, except for the Village of Glocester, where 85 and 95 gpcd were used (Corps, 1981b, p. A-49).

The initial Corps report adopted population projections developed by the State in 1975, as well as revised projections completed in 1979 (Corps, 1981a). The 1975 projections anticipate State-wide population of 1,173,600 by 2000, while the 1979 revised prediction is for 1,005,600 persons. The later, supplemental analysis incorporates 1980 OBERS projections, which predict a year 2000 State population of 1,086,400 (Corps, 1982).

Projected totals for residential/commercial and industrial water use were combined to give a water use forecast for the study region. The results are equivalent to aggregate per capita use rates of 155.6 gpcd for 2000 and 175.4 gpcd for 2030. After deducting 9.0 and 11.0 percent, respectively, for water conservation the effective aggregate use rates are 141.7 and 156.3 gpcd. The comparable figure for 1975 (based on Corps estimates of residential, commercial and industrial water use) is 123.9 gpcd.

Critique

The water use forecast presented by the Corps is suspect on several grounds. The first concerns the results obtained and their reasonableness in the light of data currently available. The Providence region already experiences nonindustrial per capita water use that is comparatively high by U.S. urban standards. Data for 1981, for example, indicate that per capita residential use, while highly variable, averaged 82 gpcd in a nationwide sample, well below the apparent level in the PWSB area (Boland, 1983, p. 4.16; Corps, 1981b, p. A-21). This discrepancy is due, in part, to an exceptionally low price level existing in the PWSB retail area (Boland, 1988). On this basis, further growth in per capita use appears unlikely.

In fact, no growth in per capita water use is evident in the region. This can be illustrated by considering the PWSB service area, which included 80 percent of the study area population in 1975 and an even greater percentage of the industrial water use. The Corps measured 1975 water use in the PWSB area at 62.4 MGD for an estimated population served of 416,800, giving overall (including industrial) average use of 149.7 gpcd (Corps, 1981b, p. A-21). Testifying before the Rhode Island Public Utility Commission in 1988, PWSB General Manager Mainelli gave 1987 total water use at 30,236,605 hundred cubic feet and total population served at 500,000 (Mainelli, 1988, pp. 1, 2). Mainelli's figures, therefore, place 1987 PWSB per capita use at 123.9 gpcd, more than 17 percent below the level of 12 years earlier. Although actual population served is somewhat uncertain, other estimates available for the year ended June 30, 1986, imply average use rates in the range of 107 to 138 gpcd, all significantly below the Corps 1975 estimate (Chernick, 1988, p. 16; PWSB, 1986, p. 717).

Nevertheless, the Corps projects rapidly rising per capita use for fifty years into the future, even in the presence of water conservation measures. This is contrary to trends observed elsewhere in the U.S., where per capita rates are typically stable or falling, and it is exactly contrary to trends observed in the PWSB area. No discussion or justification for this result appears in the Corps reports.

The second forecast issue concerns the forecast techniques employed, especially with respect to use of the per capita method and the way in which key assumptions were generated. The only water use data analyzed by the Corps are for 1975. No adjustment was made for economic conditions, weather conditions, or for any other factor that may have made 1975 water use data unrepresentative. Also, the population estimate used for 1975 was subsequently shown to be overstated (1980 Census count was less the 1975 estimate in most subareas), yet the basic assumptions were not revised.

The only disaggregation performed was to separate industrial use from other use, and to project industrial use on the basis of a 1971 study. There is no indication that the fact of sharply falling levels of industrial water use, observed throughout the nation after implementation of the Clean Water Act in the late 1970's, had any role in the industrial forecasts. Changes in the composition of industrial activities, in Rhode Island and elsewhere, away from water-using "smokestack" industries and in the direction of more service-oriented, low-water-using activities, are similarly ignored. In fact, the Corps projected industrial water use to grow faster than any other sector of water use through the year 2030.

Non-industrial water use, consisting of residential, commercial, institutional, and public uses, is not disaggregated for forecasting purposes, even though individual sectoral trends are likely to differ. The simple per capita method used precludes any consideration of anticipated changes in housing type, household size, income, water price, water using appliances, commercial and institutional activity types and levels, weather, water conservation practices, and water use restrictions. A number of forecasting methods, available and in common use at the time of this study, are capable of incorporating some or all of these explanatory variables (Boland, 1978; Boland, et al., 1983; and Jones, et al., 1984).

Nevertheless, in a large and complex study area, the Corps elected to use a method which considers only two explanatory variables: population and rising per capita water needs.

Finally, the implementation of water conservation is associated with very modest reductions in forecast water use (9.0 percent in 2000 and 11.0 percent in 2030). The conservation program assumed to produce this result is not described, nor are the methods used to formulate it or the assumptions employed in estimating effectiveness. As discussed below, concerted efforts to achieve water conservation in the Providence area would produce substantially larger reductions.

Existing Supply Capacity

The Corps study defines supply capacity as the sum of the safe yields of existing surface and ground water facilities. Safe yield (or dependable yield) is defined, in turn, as the uniform rate of withdrawal which could be sustained throughout a repetition of the 1965-1966 drought, assuming that 100 percent of usable storage is available at the beginning of the drought period (Corps, 1981b, pp. D-22 to D-23). On this basis, 1975 supply capacity is calculated at 91.1 MGD (Corps, 1981b, p. A-51).

Incorporated in this calculation is a figure of 77 MGD for the dependable yield of the Scituate Reservoir system. This estimate was increased from an earlier Corps estimate of 72 MGD. Yet, in recent testimony before the Rhode Island Public Utility Commission, a witness for the PWSB give the available safe yield of the facility at 80.3 MGD (Archer, p. 10). Another witness argued that certain disputed commitments for future supply to others had been improperly deducted, and that the dependable yield is more accurately stated at 89.3 MGD (Copeland, pp. 7-9).

Similarly, the Corps estimate of the dependable yield of the BCWA system (3.2 MGD) is at the lower bound of the range of opinion. The most recent available study places the combined yield of the surface water and ground water systems at 4.0 MGD, even after allowing for lost reservoir capacity due to siltation (Camp, Dresser & McKee, 1989, p. 2-4).

Sensitivity of Need to Key Assumptions

If Corps estimates of future water use and supply capacity are accepted, existing facilities will be adequate until the year 2007 (Corps, 1982, Plate 2). A supply deficit is projected for later years, growing to a level of 34.1 MGD by 2030. This reflects the following results of the Corps analysis:

Dependable yield --		
Existing sources 91.1 MGD		
New BCWA ground water 3.0 MGD		
Total Supply	94.1 MGD	
Projected water use --		
2030, w/o conservation		128.2 MGD
2030 Surplus (deficit)		(34.1 MGD)

An alternative Corps projection, incorporating an allowance for water conservation, reduced projected water use to 114.2 MGD, giving a year 2030 deficit of 20.1 MGD.

However, these results are highly sensitive to the underlying assumptions. The following adjustments to Corps assumptions appear warrented in this analysis given more current information:

- PWSB estimates that the dependable yield of the Scituate Reservoir is 89.3 MGD, and that 9.0 MGD must be released to the North Branch Pawtuxet River. This leaves an available yield of 80.3 MGD, 3.3 MGD higher than the 77 MGD used by the Corps.

- The Corps assumed that BCWA would shortly develop an additional 3.0 MGD of ground water capacity. To date, no additional wells have been drilled in Bristol County, and there are no current plans to do so.

- The Corps estimated the dependable yield of the BCWA system at 3.2 MGD. In 1989, a consultant for BCWA estimated yield at 4.0 MGD, 0.8 MGD higher than the Corps assumption.

- Per capita use has not increased in the study area since 1975, and it is unlikely to do so in the future. In fact, the PWSB area reports a significant decrease. If per capita use is held constant at 1975 levels (more than 20 percent above the 1986 level reported by PWSB), and if the Corps population projections are accepted, projected residential and commercial water use for 2030 will be 21.5 MGD below the Corps forecast.

- No rationale is offered for the Corps projection of rapidly increasing industrial water use. In fact, industrial water use is decreasing throughout the U.S. If industrial use in the study area is held constant at

1975 levels, the year 2030 projection will be 13.9 MGD below the Corps projection.

The effect of these adjustments can be shown:

Dependable yield --		
Corps estimate	94.1 MGD	
Addtl.Scituate yield	3.3 MGD	
BCWA ground water	(3.0 MGD)	
Addtl.BCWA yield	0.8 MGD	
Total supply		95.2 MGD
Projected water use --		
Corps, 2030	128.2 MGD	
Stable per capita rates	(21.5 MGD)	
Stable industrial use	(13.9 MGD)	
Total water use		92.8 MGD
2030 Surplus (deficit)		2.4 MGD

In the absence of more detailed supply studies or water use forecasts, these adjusted figures are believed to represent reasonable estimates of future water use and water supply. They are conservative estimates, in that dependable yield is calculated at a very high level of reliability (approximately a 1.0 percent level, as discussed below) and no decrease in water use rates is assumed after 1975, despite evidence to the contrary.

ALTERNATIVES

The need for the water supply capacity of the proposed Big River Reservoir, as stated in the feasibility study, has little foundation in fact or analysis. Using modified, but still conservative assumptions regarding supply capability and water use, no new supply is needed before the year 2030. However, even if the Corps' most generous needs assessment were to prove accurate, there exists a wide range of practicable and less environmentally damaging alternatives to Big River. This section reviews the major categories of available alternatives.

Water supply capacity needs can be met in various ways. Given some set of water use forecasts and supply capacity estimates, any predicted shortfall can be reduced or eliminated either by decreasing water use (demand management), by increasing supply (supply management), or by a combination of these strategies.

Demand management consists of various long-term water conservation measures (including changes in pricing policy) as well as temporary, short term water use reduction programs (drought management). These measures, and all of their variants and combinations, comprise the set of alternatives which must be considered in any response to a water supply "need".

Supply management includes increases in the effective yield of existing sources, new surface water sources, new ground water sources, and the reclamation of other waters such as brackish water and mineralized or contaminated ground water.

Demand Management

The water resource planning literature often uses the terms "demand management" and "water conservation" interchangeably. One widely accepted view, which defines water conservation as "any beneficial reduction in water use or in water losses," tends to support this usage (Baumann, et al., 1979, p. 12). Any step taken to reduce water use (conserve water) is a demand management measure, and vice versa.

For purposes of discussion, however, it is helpful to divide demand management measures into several categories. One important distinction can be made according to the time frame of implementation. The term "water conservation" will be applied to actions and policies sustained over a long period of time, in the interest of securing a permanent reduction in water use. These measures are further divided into (1) those implemented solely through pricing policy and (2) other long-term conservation methods. The remaining demand management measures are implemented as needed, for relatively short periods of time. These measures, triggered by temporary supply inadequacy, comprise drought management practices.

Pricing Policy

The amount of water used within any area depends, among other things, on the price at which it is sold. Economists speak of the demand for water as typically inelastic, meaning that the quantity demanded varies less than proportionately with changes in price. In this respect, water is similar to other staple goods which are regarded as necessary to normal everyday life.

A recent review of more than 60 studies of water demand concludes that the long run price elasticity for public water supply is -0.10 or less in the winter, and, in the eastern U.S., in the range of -0.50 to -0.60 in the summer (Boland, et al., 1984). The significance of these findings can be illustrated by considering the impact of the recent rate increase granted to the PWSB.

1988 PWSB Rate Increase

In 1988, the Rhode Island Public Utilities Commission authorized the Board to revise its rates so as to collect an additional $4,237,251, an increase of approximately 37 percent in total revenue (RI PUC, 1988). This increase will reduce water use noticeably and permanently (provided rate level is adjusted periodically to reflect general price inflation). Although data needed for a more exact calculation are not available from the PWSB, the following will illustrate the approximate magnitude of the adjustment.

It is assumed here that the increase is applied uniformly across-the-board (actually, some rate restructuring was done). This results in a 37 percent price increase for those residential customers with water use under the wastewater free allowance (200 gpd/household). Other customers, who must pay an additional $1.05 per hundred cubic feet ($1.05/HCF) for wastewater service, will perceive a smaller percentage increase in the total cost of water use: approximately 8.4 percent. Data provided by the Narragansett Bay Commission indicate that households with water use below 200 gpd accounted for 1,482 MG during calendar year 1987 (Narragansett Bay Commission, 1988). Other water use data are provided in Boland (1988, p. 52). The calculation is shown as Table A2-1.

As shown on Table A2-1, the overall effect of a permanent price increase of 37 percent applied across-the-board is to reduce annual water use by 3.6 percent, compared to use levels in the absence of the rate change. This reduction is a long run estimate. Normally, less than half of such a change will be evident within the first year, with the remainder appearing gradually over the next five to ten years. In the case of Providence, a temporary surcharge (expired July 1, 1989, with provisions for renewal) of $0.085/HCF may accelerate the adjustment process, without necessarily affecting the size of the long-run result (RI PUC, 1988, Order, paragraph 10).

Table A2-1.--Estimated Impact of 1988 PWSB Rate Change

FY 1987 water use before price change --

	households below 200 gpd	all other customers	Totals
Summer	860 MG	12,480 MG	13,340 MG
Winter	622 MG	9,038 MG	9,660 MG
Total	1,482 MG	21,518 MG	23,000 MG

FY 1987 water use after price change --

Residential customers below 200 gpd/household			
Summer	$860 * (1.37)^{-0.6}$ =	712 MG	
Winter	$622 * (1.37)^{-0.1}$ =	603 MG	1,315 MG
All other customers			
Summer	$12,480 * (1.084)^{-0.6}$ =	11,890 MG	
Winter	$9,038 * (1.084)^{-0.1}$ =	8,965 MG	20,855 MG
		Total	22,170 MG (-3.6 %)

The impact of a price change can be further magnified by altering the structure of rates, as well as their level. One alternative is to adopt a summer-winter differential, reflecting the higher cost of service associated with serving summer demands. Since summer demand is also much more elastic than winter use, directing more of the increase to summer prices augments the expected water use reduction. If 100 percent of the increased revenue in the above illustration were obtained from summer rates, for example, the overall water use reduction would be more than 5 percent.

The effect of a permanent 3.6 percent water use reduction in the PWSB area (such reductions are permanent if rate levels thereafter keep pace with general price inflation) is to reduce year 2030 water use for the Big River study area by 2.8 MGD. This comparatively modest water use reduction reflects the very low level of existing PWSB charges, especially when compared to wastewater charges. As water prices increase in the future, a given percentage increase in water price will produce a larger percentage increase in the total cost of water and wastewater service. The result will be increased sensitivity of water use to changes in water prices.

Future Policy Options

Other tariff design possibilities include the adoption of uniform (unblocked) rates, the elimination of preferential rates to industrial customers, changes in the fraction of total revenue recovered through the commodity charge, increasing block rates, summer surcharges, and excess use charges. All of these strategies have the potential of securing further reductions in water use for a given increase in total revenue. Testimony in the 1988 rate case indicates that the PWSB expects to make further changes to its tariff design in the interest of water conservation (Russell, 1988). Also, future increases in wastewater charges levied by the Narragansett Bay Commission, or any reduction in the residential free allowance (now 200 gpd/dwelling unit) would bring about further decreases in water use.

Actual construction and operation of the Big River Reservoir would add a large, though yet undetermined increment to the PWSB revenue requirement. While the magnitude of these changes cannot be estimated at this time (pending further data on total project cost, the share to be borne by the PWSB, and the future rate-making policy of the Board), the result would be an upward adjustment in rate level, with a corresponding decrease in water use.

It can be seen that already-implemented changes in water rate levels and tariff design, coupled with the probability of further changes in the future, will result in steadily decreasing water use levels, compared to levels projected on the basis of pre-1988 rates. Based on actions already taken or planned for the future, ultimate reductions in the range of 5-10 percent appear likely. A mid-range estimate of 7.5 percent reduction through rate redesign, reduced by the 3.6 percent estimated to be already achieved, gives an additional 3.9 percent still likely to occur as a result of rate-making policy initiatives. Assuming, again, that these changes occur only in the PWSB service area, the year 2030 impact is a reduction of 3.0 MGD.

The price effects discussed have the following impact on supply planning:

Dependable yield --

Corps estimate 94.1 MGD	
Addtl.Scituate yield 3.3 MGD	
BCWA ground water	(3.0 MGD)
Addtl.BCWA yield 0.8 MGD	
Total supply	95.2 MGD

Projected water use --

Corps, 2030 128.2 MGD	
Stable per capita rates(21.5 MGD)	
Stable industrial use(13.9 MGD)	
1988 rate change	(2.8 MGD)
Rate re-structuring (3.0 MGD)	
Total water use	87.0 MGD

2030 Surplus (deficit) 8.2 MGD

<u>Other Long-Term Water Conservation</u>

Present Status

The urban portions of the study area are fully metered and some efforts are made to locate and repair distribution leaks. Rhode Island Public Law 89-326, adopted January 1989, provides for the mandatory installation of ultra-low flush toilets (1.6 gallons/flush) in all new construction. Otherwise, there is little water conservation activity in the Providence area at the present time. The Rhode Island Public Utilities Commission found the PWSB to have "no policy or directives" on water conservation, "no public education program," "no program of technical assistance for water use reduction" for any user class, "no staff trained in, experienced with, or devoted to conservation matters" (RI PUC, 1988, p. 33).

Testifying before the Commission in the same docket, Juan Mariscal of the Narragansett Bay Commission (NBC) testified that the NBC has recently spent as much as $75,000 per year on public information largely directed to reducing wastewater flows, but that the PWSB has taken no action on water conservation (Mariscal, 1988).

Some additional efforts have been undertaken in Bristol County, and possibly in one or more of the PWSB wholesale service areas. Certain individual water users have doubtless taken steps to conserve water, despite the very low economic incentive for doing so. However, available evidence, including current water use levels, suggest that few conservation practices are in general use at this time.

Table A2-2 lists the general types of water conservation measures that could be considered for the Big River study area. Among these are measures which seek to influence the

Table A2-2.--Potential Water Conservation Measures

Management measures (to be implemented by water supply agencies or other units of government)
Universal metering
Improved meter maintenance
Distribution pressure regulation
Leak detection and repair
System rehabilitation
Economic incentives (e.g., rebates, credits, subsidies, or penalties for changes in appliances, landscaping, etc.)
Distribution of water conservation kits
Distribution and installation of other water-saving devices
Distribution of leak detection kits
Recycling water treatment plant washwater
Regulations (to be implemented by State or local government)
Plumbing codes for new structures
Retrofitting requirements
Changes in landscape design
Water recycling
Growth controls
Conservation Education (by government, water supply agency, or non-governmental organization)
Direct mail campaign
News media
Personal contact
Special events

Source: Boland, et al., 1982, pp. 14-15.

type of plumbing fixtures installed, either through economic incentive, plumbing codes, or retrofitting requirements. A list of fixtures potentially targeted by such measures is provided as Table A2-3.

Water Conservation Program Formulation

Shortly before the publication of the Big River feasibility study, the Institute for Water Resources of the Corps of Engineers developed and promulgated a standard procedure for formulating and evaluating urban water conservation programs (Baumann, et al., 1980). The procedure consists of two major phases, with a number of specific steps in each. In the first "Measure Specific" phase, a list of all possible water conservation measures is prepared. Each of these measures is subjected to the following tests:

Applicability--does the measure apply to water uses actually present in the service area?
Technical feasibility--can the measure be implemented and will it actually reduce water use?
Social acceptability--will the measure be acceptable to water users?
Implementation conditions--what is required to implement the measure and what will implementation cost?
Effectiveness--what quantitative reduction in water use will occur?
Advantageous effects--what other benefits will accrue, if the measure is implemented (e.g., energy savings)?
Disadvantageous effects--what other costs will appear, if the measure is implemented (e.g., brown lawns and shrubs)?

In the second, "Project Specific" phase, the benefits of water use reduction are calculated by determining foregone supply cost: the amounts that the water supply agency will save, now or in the future if a certain water use reduction can be achieved. Measures which survive the first stage screening are then combined in various ways and evaluated. The final result is the water conservation plan which achieves the largest aggregate reduction in water use while producing benefits at least equal to costs. In most cases, benefits appear principally in the form of foregone water supply costs, while costs are dominated by initial implementation expense.

Big River Reservoir Cost Estimates

Since the primary motivation for water conservation in the eastern U.S. is the avoidance of current or future water supply costs, the expected costs of the Big River project form the basis of any conservation evaluation. Future supply costs will depend upon the actual cost of construction as well as incremental operating, maintenance, and administrative costs.

Table A2-3.--Plumbing Fixtures Considered in Conservation Plans

shallow trap toilet	shower flow-control devices
vacuum toilet	pressure-reducing valves
incinerator toilet	toilet inserts
pressurized flush toilet	faucet aerators
wastewater recycling toilet	faucet flow restrictors
oil flush toilet	spray taps
freeze toilet	pressure balancing mix valves
packaging toilet	hot water pipe insulation
composter toilet	swimming pool covers
dual flush toilet	low water-using dishwashers
micropore toilet	low flush toilets
water recycling system	minimum use showers
low flow showerheads	hose meters
water dams	low water-using clotheswashers
toilet flush adapters	moisture sensors
shower mixing valves	sprinkler timers
air-assisted showerheads	thermostatic mixing valves

Source: Boland, et al., 1982, pp. 14-15.

Two different measures of cost can be calculated. The average cost measure spreads the total cost of the project over all units of water to be produced. Characterizing costs in this way implicitly compares the project to the no-action alternative (Big River is never built). Marginal cost, identified here as incremental cost savings realized by slightly deferring the project, measures the incremental value of the water under the assumption that the project will eventually be built. It compares one development scenario to another. Both cost measures are presented here.

Recent estimates place construction cost at $281,796,000, including the proposed treatment plant and transmission conduit (Keyes Assoc./Metcalf & Eddy, 1988). No data are available for operation and maintenance costs, variable treatment costs, or pumping costs. Unit capital costs can be calculated from the information given, however, if a number of assumptions are made. These are based on the Corps analysis, and are presented here for the sole purpose of estimating costs.

- Incremental costs of water produced at Big River will be at all times higher than for all other sources, including the Scituate reservoir, so that total cost is minimized by using Big River water last.
- Big River water will not be needed before the year 2007, according to the most recent Corps projections.
- Use of Big River water will increase by equal annual increments from 2007 to the year 2030, when it will be used at an average rate of 20.1 MGD (according to Corps projections).
- Water withdrawals from the Big River will continue to increase after 2030 at the same rate until project capacity of 31.9 MGD is reached in 2044.
- Construction will occur during the 2002-2006 time period, with equal cash outlays in each of five years.
- A discount rate of 9.0 percent/year and a planning horizon of 50 years are appropriate.

Construction postponement to 2002 and continued post-2030 growth are assumed in order to provide the lowest possible cost measures. An assumption of immediate construction would increase all costs cited here by a factor of 2.8. Since Rhode Island already owns the land for the proposed reservoir, putting off the construction of the dam will only save money in real dollars. The reason the cost of the reservoir is greater today than estimates 10 and 20 years ago stems from further engineering studies of the necessary costs.

Because of the slow increase in projected utilization of Big River, average cost is found by computing the levelized unit cost of water delivered from the proposed reservoir.

This unit cost should include all incremental operating, treatment, pumping, and maintenance costs plus the capital cost. However, data are only available for capital cost at this time. These data give a levelized unit cost, stated in 1989 dollars, of $9,136.97/MG (6.83/HCF). This cost is the amount which, if collected for each unit of water projected to be delivered by Big River over the planning period, would produce a stream of revenue exactly equal, at present value, to the estimated construction cost.

The average cost can also be stated as a capitalized unit cost. $9,136.97/MG, capitalized over 50 years at 9.0 percent, gives a value of $36.56 million/MGD.

It should be noted that even this partial estimate of average unit cost is equivalent to more than 15 times the current retail price of water in Providence. While it is not known what share of total cost will ultimately be borne by PWSB ratepayers, or what rate-making treatment this increment will receive, a significant impact on rate level can be expected. With annual debt service in the vicinity of $27.5 million ($281 million construction cost, 9 percent interest, 30 year amortization), a local cost share of as little as 50 percent would be sufficient to nearly double the current revenue PWSB revenue requirement (87 percent over the 1989 level). Even if the increase were spread across all water use and all customers, such a rate impact would lower water use in the range of 5-10 MGD (see earlier discussion of price effects).

The marginal cost of the Big River Reservoir is based on the 1989 present value of estimated construction costs. Because of the assumed postponement of construction to 2002, the 1989 present value of construction cost is $77.94 million, stated in 1989 dollars. A permanent reduction in water use equal to 0.8739 MGD would allow this investment to be postponed by one year, for a savings (at present value) of $6.44 million. This translates into a benefit (considering construction costs alone) of $7.364 million for every 1.0 MGD reduction in average water use, even under the implied assumption that the full cost must eventually be borne. Amortizing this amount over a 50 year planning horizon, the marginal capacity cost implied by Big River cost estimates is $1,841/MG ($1.38/HCF). This is more than four times the 1988 retail price of water in the PWSB service area.

Effectiveness of Water Conservation in the Big River Study Area

The water conservation evaluation procedure described above has been applied throughout the U.S., in Federal, state, and local studies. Portions of it are embedded in a widely used water use forecasting model, the IWR-MAIN System (Davis, et al., 1988). Resulting water conservation programs vary substantially from place to place, depending on the projected cost of additional supply as well as other local conditions.

As reported elsewhere in the literature, predicted reductions range from several percent up to and beyond 50 percent (Metcalf & Eddy, 1979a, 1979b). Chernick, in testimony before the Public Utilities Commission, estimated that household water use in the Providence area can be reduced by as much as 140 gpd (about 44 percent) by installation of flow reducers and low flow toilets (Chernick, 1988).

It is difficult to generalize about predictions and measurements of conservation effectiveness for various locations, since they are based on different combinations of measures, and address different water use conditions. One thing can be observed, however: as projected supply cost increases, water conservation benefits are greater and more measures become feasible. High costs, then, lead to high water use reductions.

In the case of Rhode Island, the cost of water conservation measures undertaken as partial alternatives to Big River are properly compared to the anticipated cost of the Big River Reservoir. To the extent that these measures eliminate the need to build the Reservoir, they are cost effective when total implementation and other costs are less than the unit cost of water from the Reservoir. Since the capital component alone of that unit cost is more than $9,000/MG, even very high-cost conservation measures can be considered.

To avoid possible biases in predictions of water use reductions, data should be based on empirical measurements of effectiveness conducted after actual implementation of conservation measures. Among the reliable studies of this type are the Brown and Caldwell study of conservation plumbing fixture performance (1984), a U.S. Department of the Interior-sponsored comparative analysis of four cities (1982), and the Planning and Management Consultants, Ltd., analysis of the Phoenix retrofit program (1988).

In the latter study, Dziegielewski and Opitz report on the impact of an intensive retrofit program implemented in a portion of Phoenix, AZ, during 1985. The program distributed low-flow shower heads and toilet dams to 44,000 residential units in a 37-square mile area. The study, which combined the results of several independent analytical approaches, concludes that installation of the devices resulted in a long-term water use reduction of at least 9.0 gpcd, or 24 gpd/household.

Water conservation kits could be distributed throughout the Big River study area whenever indicated by a potential supply shortage, and maintained through periodic inspection and replacement as long as needed. Using the 9.0 gpcd figure, and assuming 80 percent coverage of the Providence area with water conservation kits in the year 2030 (approximately 585,000 persons), water use would be reduced by 5.3 MGD, for a benefit of $17.5 million/year, or $192 million at present value. The economic benefit, more than $1,000 per installed household (not including energy savings), exceeds the cost of purchasing and distributing the kits by a factor of at least 50.0.

Under these conditions of high supply cost, many other water conservation measures would prove beneficial. For example, substantial subsidies could be paid to encourage the purchase of water-saving appliances (dishwashers, clotheswashers, low-flush toilets) without exceeding the value of the water saved.

Water Conservation Conclusions

There is nothing in the Big River feasibility reports to indicate that any study was conducted of the potential for water conservation in the Providence area. It is clear that the Corps procedure for formulating and evaluating water conservation plans was not followed (Baumann, et al., 1980). The data described in the feasibility reports, the forecasting method employed, and the statements made about water use forecasts and conservation plans are entirely inconsistent with the standard procedure.

Already implemented changes in the State Plumbing Code (revision of June 8, 1989) will reduce water use in new structures by 15-20 gpcd, with an eventual major impact on residential water use. Using the lower estimate, if this fixture turnover is 80 percent complete by 2030, a reduction of 8.8 MGD can be expected. Also, it is certain that water use reductions of 9 gpcd (5.3 MGD for the PWSB) or more could be obtained almost immediately, utilizing only the most cost-effective and non-disruptive techniques available (water conservation kits similar to the Phoenix application). Increased attention to leak detection and repair could bring about further reductions at nominal cost, although no estimates are available.

The impact of water conservation from the new State plumbing code is added to the previous items:

Dependable yield --

Corps estimate 94.1 MGD		
Addtl.Scituate yield	3.3 MGD	
BCWA ground water	(3.0 MGD)	
Addtl.BCWA yield	0.8 MGD	
Total supply		95.2 MGD

Projected water use --

Corps, 2030 128.2 MGD		
Stable per capita rates	(21.5 MGD)	
Stable industrial use	(13.9 MGD)	
1988 rate change	(2.8 MGD)	
Rate re-structuring	(3.0 MGD)	
1989 Plumbing Code	(8.8 MGD)	
Total water use		78.2 MGD

2030 Surplus (deficit) 17.0 MGD

Additional measures could be considered for application in Rhode Island. With prospective water supply costs in excess of $9,000/MG, virtually any measure may prove to be feasible and cost-effective. No water conservation study has been completed for the Providence area, although both the State and the PWSB have initiated work in this area. Based on experience elsewhere, overall water use reductions of 30 gpcd (17.6 MGD for PWSB) or more are within easy reach, and larger reductions are perfectly feasible (Baumann, et al., 1979; Brown & Caldwell, 1984; Hawk Mountain Corporation, 1988; Chernick, 1988; Grisham and Fleming, 1989; Vickers, 1989; Cuthbert, 1989). Reductions calculated above for two specific measures are well within this potential.

Drought Management

A drought is a period of lower than normal precipitation which results in reduced streamflows and ground water levels. Since urban water users irrigate lawns and gardens to supplement rainfall, drought is a time of low supply and high demand. Water supply systems are designed on the basis of anticipated drought conditions. In the case of the Big River Reservoir, project need is calculated on the basis of conditions expected during a repetition of the 1965-66 drought, which is described as having a return probability of 1-2 percent during any given year (Corps, 1981b, p. D-19). It is assumed that supply facilities must be capable of delivering all water demanded during such a drought.

To illustrate the impact of this assumption, the safe yield from the Scituate Reservoir is estimated at 80.3 MGD, with 9 MGD released downstream, for a repetition of the 1965-66 drought. This reflects a total inflow equivalent to approximately 25 inches over the most severe 24 months of drought (Corps, 1981b, Plate D-9). The Corps analysis identifies this condition as a 1.0 percent probability event. By contrast, a 2.0 percent event is associated with 24-month runoff of about 28.5 inches (14 percent more), and a 5.0 percent probability event would result in 24-month runoff of 32.5 inches (an increase of 30 percent over the 1.0 percent event). However, the realizable yield does not continue to increase as inflow rises. PWSB states that the average yield of Scituate (over all years since 1940) is 110.1 MGD, only 23 percent more than the 1.0 percent probability yield. This may reflect lack of storage capacity, increased evaporation rates, or unnecessary spilling, since mean runoff is at least 140 percent greater than the 1.0 percent level (Corps, 1981b, Plate D-6).

The analysis performed in the Corps feasibility report takes no account of the possibility of reducing water use, rather than increasing supply, during drought. In fact, widespread reductions occurred in New England during the 1960's drought. Pawtucket, RI, for example, reported a reduction of 16-18 percent of expected unrestricted demand (Anderson, 1967). Later analysis of the entire region showed restrictions of this kind to be, in most places, relatively low in cost and non-disruptive (Russell, et al., 1970). It is clear that temporary reduction in water use during dry periods is far less costly than constructing supply facilities which are needed only during those times (Boland, et al., 1980).

Accepted procedures are available for formulating and implementing contingent plans, to be activated in the case of anticipated water supply shortage (Dziegielewski, et al., 1983a, 1983b). These plans include the use of short-term water conservation measures, such as sprinkling restrictions, as well as varying degrees of water rationing and water use prohibitions. A drought management program developed for Springfield, IL, includes demand reduction measures expected to yield 6.488 MGD in the year 2000 (24 percent of average day use) during a 1 percent probability drought, at a unit cost of $70/MG saved (Dziegielewski, et al., 1983b, p. 70). This cost can be compared to the unit cost of water from the Big River Reservoir, estimated above in excess of $9,000/MG.

Comparable drought-period water use reductions were estimated for the Washington, DC, area (Boland, et al., 1980). Substantially larger reductions, sometimes 50 percent or more, were actually achieved during 1975-76 drought in Great Britain and the 1976-77 California drought (National Water Council, 1976; Robie, 1978). No drought management plan was located for any community in Rhode Island, and no agency is known to be developing such a plan.

The formulation of a drought management plan for the Providence area would delay the need for supply augmentation, even if all demand and supply projections are accurate and no other demand management measures were implemented. If the design criterion were changed from the 1.0 percent probability drought (such as the 1965-66 event) to some drought with a higher probability of occurrence, the nominal yield of the Scituate system would be revised upward. Water use reductions of about the same magnitude as the increased yield would be required, but only during the most severe droughts. In this way, a contingent drought plan serves to augment reservoir yield.

Although the Corps evidently accepted the State's reliability target, and failed to perform the simulations needed to estimate supply or demand under alternative reliability constraints, statistical analyses of runoff suggest that the yield of the Scituate Reservoir system would increase by roughly 20 percent for a 3.0 percent probability drought with a duration of at least two years (Corps, 1981b, Plate D-9). In order for the system to serve the needs, water use reductions ranging up to 19 percent would be required throughout the study area during all droughts with a probability of 3.0 percent or less; the full 19 percent reduction would be needed in case of a 1.0 percent drought.

If drought management were confined to the PWSB system, the necessary water use reductions would range up to 23 percent.

Reductions of 23 percent are within the capability of conventional drought management plans, and can be implemented with no more than moderate cost and disruption. Furthermore, risks of this type are widely accepted. Many utilities routinely base supply planning on a reliability criterion of 2.0 or 3.0 percent. The Washington Suburban Sanitary Commission, after considering the costs and benefits of a range of alternatives, selected and implemented a reliability level of approximately 5.0 percent (Boland, et al., 1980).

The effect of changing the planning criteria from a 1% to a 3% drought, if implemented for the Scituate supply alone, would be an increase in effective yield of 17.9 MGD, assuming a release of 9 MGD downstream. This would have the following effect on supply planning:

Dependable yield --		
Corps estimate	94.1 MGD	
Addtl.Scituate yield	3.3 MGD	
BCWA ground water	(3.0 MGD)	
Addtl.BCWA yield	0.8 MGD	
Lower Scituate reliab.	17.9 MGD	
Total supply		113.1 MGD
Projected water use --		
Corps, 2030	128.2 MGD	
Stable per capita rates	(21.5 MGD)	
Stable industrial use	(13.9 MGD)	
1988 rate change	(2.8 MGD)	
Rate re-structuring	(3.0 MGD)	
1989 Plumbing Code	(8.8 MGD)	
Total water use		78.2 MGD
2030 Surplus (deficit)		34.9 MGD

Supply Management

Improved Surface Water Yield

In assessing the capability of existing supply works, the Corps appears to have measured the yield of each surface water source on the basis of current operating practices. There is no discussion in the feasibility report of the potential for increasing yield through improved management. Similarly, no consideration is given to the potential for harvesting water from existing structures not now used for water supply.

The Scituate system consists of six reservoirs, five of them eventually draining into the large Scituate impoundment. The upstream reservoirs are apparently operated passively, with no attempt to optimize the yield of the system. It is certain that the use of a simulation-based operating rule for the entire watershed could increase the effective yield; it is possible that it could be increased significantly. Implementation of such a rule would require installation of appropriate gates and controls at several points in the system. Improvements of this kind would have the additional benefit of increasing PWSB's ability to contain possible spills of hazardous materials in the watershed. In the absence of data or studies, no estimate can be made of the increased yield that might be available.

Some additional water supply could be obtained from the South Branch Pawtuxet Basin by utilizing existing impoundments. The Big River watershed, for example, contains at least 9 ponds of significant size, in addition to the Flat River Reservoir which is the terminus of Big River itself. Many of these ponds are located on land that has been acquired by the State. Construction of a diversion weir near the proposed Big River dam site, combined with construction of outlet works on the ponds (possibly including new or raised embankments), would make it possible to harvest stored water from Big River during low flow periods.

The combined yield of all systems could also be increased by diverting water from Big River during moderate-flow periods, permitting the storage at Scituate to be used more efficiently. (Note that a similar benefit is expected from the Big River Reservoir, which will add as much as 4.0 MGD to the effective yield of Scituate [Corps, 1981b, p. D-23].) Also, some water could be withdrawn from the Flat River Reservoir without producing unacceptable changes in water level, provided that attention is given to sanitary waste disposal practices along the highly developed shoreline.

For all of these alternatives, pumping and transmission facilities would be need to transport the water to Scituate for treatment. In the absence of data or a suitable study, no estimate of available yield, feasibility, or cost can be offered. Based on the current projection of Big River Reservoir costs, however, even an alternative used for a few months of the year may be feasible if the construction cost does not exceed $36 million/MGD (not including pumping or other operating cost).

<u>New Ground Water Development</u>

Past water resource studies in Rhode Island show a curious neglect of the State's ground water resources. In 1952, Maguire and Associates noted the existence of significant ground water reserves, but claimed that experience shows that ground water "cannot be depended upon" to provide adequate quantity and quality "over long periods" (Maguire, 1952, p. 177). The study proposed that ground water be considered for future water needs only in Newport County

(Aquidneck Island) and in certain then-rural portions of Kent, Providence, and Washington counties.

Later, Metcalf & Eddy also proposed a small role for ground water, expressing concern about present and future ground water quality, especially in the Blackstone Valley and in the Providence area (Metcalf & Eddy, 1967). While available daily yield from the State's aquifers was estimated at 82.5 MGD, nearly 38 MGD in excess of estimated withdrawals, this resource is recommended for industrial use and for certain rural and semi-rural areas (Metcalf & Eddy, 1967, p. 50). Some possibility of additional ground water yield in the Chepachet Valley is also noted.

These same issues were revisited by Metcalf & Eddy in a 1979 report prepared for the Corps of Engineers as part of the Pawcatuck River and Narragansett Bay Drainage Basins Water and Related Land Resources Study (Metcalf & Eddy, 1979a and 1979b). The study area consisted of 2,636 square miles in Southeastern Massachusetts and Rhode Island, including the study area of the later Big River Reservoir project. In this report, the consultant recommends development of ground water wherever possible, in all parts of the State. Attention to ground water recharge is also suggested, including the possible future siting of wastewater treatment plants where the effluent may assist in maintaining aquifer and surface water levels.

A 1961 study estimates ground water recharge in the Providence-Warwick area at 22-42 MGD in excess of withdrawals (Lang 1961, pp. 13-15). Significant potential yields were observed in most other areas of the State, including the South Branch Pawtuxet basin (20 MGD). Further study was proposed for several areas, including the Big River-Mishnock area, because of indications that larger quantities could be available. Other studies suggest that at least 25 MGD of dependable ground water yield could be developed in the Pawcatuck Basin (Wheeler, 1989).

A summary of the literature, prepared in the Rhode Island Office of the U.S. Geological Survey, indicates that total ground water yield throughout the State is approximately 140 MGD, and that total withdrawals in 1985 were 27 MGD, leaving 113 MGD of potential new supply (Johnston, 1989). The same review notes that, of the 10 MGD formerly withdrawn for industrial uses in the Providence area, only about 2 MGD is now in use. Elsewhere, the Geological Survey reports on the quality of Rhode Island ground water, finding it suitable for human consumption with little or no treatment in most parts of the State (U.S. Geological Survey, 1987). Areas of contamination are found to be "relatively small."

Development of additional ground water resources, is a feasible and effective alternative to the Big River Reservoir. Yields on the order of 10 - 20 MGD (Big River is expected to produce 31.9 MGD [see Corps, 1981b, p. D-23]) are potentially available in the same general area [South Branch Pawtuxet, Potowomut-Wickford (Hunt), and Providence-Warwick area]. Additional ground water is available in other parts of the State, especially in the southern part. Water quality and costs of treatment must be carefully checked in the Providence area. Although transmission and pumping costs would be higher because of distances and spatial dispersion, most well field and treatment costs would be modest. With properly managed withdrawals, disruption of wetlands and downstream flows would be negligible.

New Surface Water Impoundments

State-wide water resource studies have consistently identified at least six potential surface water impoundment sites in addition to the Big River. These include locations elsewhere in the South Branch Pawtuxet basin (Nooseneck River) and at least five sites in the Branch-Blackstone basin, near the State's northern border. Unfortunately, detailed studies of these alternatives are not available. Investigations are necessary to determine which, if any, of these proposals are likely to be cost-effective and/or less environmentally damaging than Big River. Such investigations are beyond the scope of this review.

Unconventional Water Sources

The existing water supply system in the study area is comprised of approximately 88 percent surface water, obtained from a number of large and small impoundments, and 12 percent ground water. Opportunities for further surface water development are, in some cases, blocked by land development and/or jurisdictional boundaries, while some ground water, especially in the locales of highest water use, is potentially contaminated with industrial wastes, or with minerals such as iron and manganese. Yet some of the fastest growing and most densely settled areas of Rhode Island are literally surrounded by water, and ground water is present to some degree in all parts of the State.

The major hydrologic feature of the State is the Narragansett Bay, a large estuary containing water which ranges in salinity from fresh water in the upper reaches to seawater at the mouth. There is no technological barrier to the desalination of brackish water or even seawater; the only impediment is the cost. The same is true for ground water, which can be demineralized and stripped of many possible industrial contaminants by means of advanced processes including membrane filtration techniques.

None of the studies reviewed make reference to the existence of brackish ground water in Rhode Island. If such a resource exists, it can be treated by reverse osmosis at moderate cost. Brackish ground water up to 8,000 mg/l total dissolved solids (TDS) can be treated to drinking water quality in a facility costing not more than $10 million for

10 MGD capacity (Taylor, 1989). Combined with operating costs of about $0.75/1,000 gallons, this gives a unit cost of $1,000/MG, far below the cost of water from Big River.

Seawater ranging up to 25,000 mg/l TDS can be treated to drinking water standards in a reverse osmosis plant costing not more than $2.5 million/MGD (cost estimated by J. Taylor [1989] for a plant capacity of 10 MGD). Operating costs may be as much as $10.00/1,000 gallons. Combined with the capital cost, this would give a unit cost of $10,900/MG (capital costs amortized over 20 years at 9 percent, 80 percent plant availability). Although this cost is high, it is less than 20 percent higher than the capital cost alone of water from the Big River.

Not Abandoning Existing Supplies

Bristol County Alternatives

A series of planning studies for the BCWA and its predecessor, the Bristol Water Company, have considered alternative means of insuring future water supply (Weston & Sampson, 1979; Tri-Town Water Study Committee, 1983; Weston & Sampson, 1988; Camp, Dresser & McKee, 1987 and 1989). BCWA serves the towns of Warren, Barrington, and Bristol, located just southeast of East Providence. The service area is bounded on the west by Narragansett Bay and on the east by Massachusetts. The BCWA supply system consists of two wells (providing about 20 percent of the total) and several surface water impoundments located in Rhode Island and Massachusetts. Dependable yield is calculated at 4.0 MGD, although total withdrawals have been in excess of that amount in recent years (Camp, Dresser & McKee, 1989).

The supply alternatives considered by Bristol County include (1) dredging and diking of existing impoundments, combined with refurbishment of treatment plant and other facilities, (2) development of additional surface water impoundments, (3) additional ground water development, (4) purchase of water from Fall River (MA), (5) purchase of PWSB water through connection in East Providence, and (6) purchase of PWSB water through the proposed Cross-Bay Pipeline (Camp, Dresser & McKee, 1989). These alternatives are contrasted to a demand forecast which calls for water use to increase from 4.26 MGD in 1985 to 6.05 MGD in 2020 (Arthur Young, 1986).

The first five alternatives listed above were ruled out by the BCWA because of perceived difficulty in obtaining necessary permits (1, 2, and 3), inadequate capacity to accommodate 100 percent of BCWA's needs (4 and 5), and environmental impacts (1 and 2) (Camp, Dresser & McKee, 1989). Documents reviewed do not indicate consideration of a mixed strategy, e.g., maintenance of existing capacity with supplemental water purchased from PWSB via East Providence. Other possible supplemental sources are not discussed, including desalination of brackish ground water. As a result of consultant studies and recommendations, BCWA is presently pursuing the Cross-Bay Pipeline as the preferred source for the County's future needs, to replace existing ground and surface water resources (Merrill Lynch, 1986).

Economic considerations evidently provide a strong motivation for BCWA's continuing interest in the Cross-Bay Pipeline. Up to 1988, PWSB sold water to large customers outside the City of Providence for $0.23/HCF (quantities above 4,000 HCF/year). At the same time, BCWA, using a combined increasing/decreasing block tariff, charged retail prices ranging from $1.63 to $4.29/HCF (BCWA, 1988). None of the studies reviewed appear to consider the possibility of large increases in the cost of PWSB water, such as those that would follow the construction of the Big River Reservoir. The expected cost of the pipeline, recently estimated at $40 million, is itself equivalent to approximately $1.25/HCF.

An inexpensive and feasible alternative would be to maintain existing surface and ground water sources at their current capacity, purchasing supplemental water as needed from PWSB through the existing connections in East Providence. This would require upgrading of the Child St. Treatment Plant, as well as strengthening of the distribution system in Bristol County and possibly in East Providence. Provision could also be made for limited dry year or emergency withdrawals by water systems on Aquidneck Island, as discussed below. Combined with appropriate attention to water conservation and drought management, the impact of Bristol County on PWSB's future needs would be minimal.

On the other hand, the proposed abandonment of the existing BCWA supply facilities will probably prove irreversible (with the possible exception of the ground water source). Continuing siltation, land use changes, and new reservoir activities are likely to preclude any future water supply uses of the surface water sources. The total supply capability of Rhode Island would be permanently reduced, therefore, by the yield of these sources, currently about 3.2 MGD. In this connection, State water supply policy states that "existing sources of water should not be abandoned" (RI Division of Planning, 1988, p. 2.6).

Aquidneck Island Alternatives

Similar to Bristol County, the water systems on Aquidneck Island face the rehabilitation and upgrading of facilities which have marginal supply capability. Among the alternatives considered is upgrading the existing connection to the mainland (across the Sakonnet River Bridge) to permit imports from BCWA or from PWSB through the BCWA system (Save the Bay, 1983; Metcalf & Eddy, 1984). Unlike BCWA, the City of Newport apparently does not plan to abandon its existing surface water source.

The cost of Big River water, transmitted to Aquidneck Island via the proposed Cross-Bay Pipeline and the Sakonnet River bridge, would be comparable to the cost of seawater desalination, approximately $10,000-11,000/MG. If brackish ground water (up to 8,000 mg/l TDS) is available on the Island, it could be treated for about one-tenth the cost of seawater. Furthermore, all of the demand management alternatives discussed above are potentially applicable to Aquidneck Island.

The Corps did not include Aquidneck Island demands in its Big River feasibility study. This review suggests that there is no reason to do so now.

Conclusions

PUBLIC WATER SUPPLY

Need

In identifying a need for increased water supply capacity, the Corps relies on forecasts of water use which omit consideration of all factors known to affect water use levels except population and increasing per capita demands. Increases in per capita water use are assumed without investigation of past or current trends in the Providence area, and despite generally stable or declining per capita rates elsewhere in the U.S.

Actual per capita water use in the PWSB service area has fallen by about one-sixth during the period 1975-1987. Nevertheless, even after modification to incorporate an assumed level of water conservation, the Corps forecasts still indicate sharply rising water use over the entire planning period. No justification is provided for these anomalous results.

The Corps measures the supply capability of existing systems in terms of a repetition of the 1965-1966 drought. In doing so, it adopts dependable yield estimates at the lower end of the range of current opinion.

In the absence of water conservation, the feasibility study indicates that water use will exceed the capability of current and anticipated supplies by 34.1 MGD in the year 2030. This is based on a supply of 94.1 MGD and water use of 128.2 MGD. Correction of the Corps estimate to reflect more recent yield data and to exclude anticipated ground water development, gives a supply capability of 95.2 MGD. Further assumptions--(1) per capita use remains stable at 1975 levels (despite recent declines) and (2) industrial water use does not increase--reduce water use to 92.8 MGD in 2030. The result is surplus capacity of 2.4 MGD, even prior to any consideration of demand management measures or supply alternatives.

The studies reviewed, therefore, do not indicate a current need for the Big River Reservoir project.

Alternatives

Even if a need for water supply augmentation is identified at some future time, there exist numerous feasible, cost-effective, environmentally benign alternatives. These include both demand management measures and supply augmentation actions.

Demand Management

Pricing Policy

Rate increases already granted to the PWSB will reduce future water use by approximately 3.6 percent, compared to levels that would have been predicted on the basis of pre-1988 prices. If this rate increase and expected future increases are accompanied by appropriate modifications in tariff design, long term water use reductions in the range of 5-10 percent can be achieved. Taking the mid-point of this range, year 2030 water use is reduced by 2.8 MGD because of the 1988 rate increase, and 3.0 MGD to acknowledge the possibility of later rate re-structuring. Both of these adjustments are based on the PWSB service area alone.

If the Big River Reservoir were built, the PWSB portion of the cost would cause a sharp upward shift in revenue requirement, and therefore in rate level, with a corresponding further drop in water use. No data are available on the size of this impact, however.

Other Long-Term Conservation Measures

There is no evidence that the Corps assumptions of water conservation are based on any systematic consideration of available methods, or that accepted evaluation procedures were followed. In fact, reductions comparable to those assumed by the Corps (9-11 gpcd) can be achieved by implementing a single measure (water conservation kits).

Many other conservation measures are feasible and cost-effective, when compared to the cost of the Big River project. The effect of the already-implemented change in the State Plumbing Code, mandating the use of 1.6-gallon flush toilets in new construction, is expected to be 8.8 MGD by 2030. The immediate effect of 80 percent coverage by water conservation kits is a water use reduction of 5.3 MGD.

Drought Management Plans

Water supply requirements are identified by comparing expected water use to supply capability during some selected drought event. It is the practice of the PWSB, and of the Corps in the feasibility study, to base this calculation on the worst dry period of record, the 1965-66 drought. Planning assumes that facilities must be capable of delivering all water demanded during such a period. A contingent plan for water use reduction in times of drought would substantially reduce the need for water supply augmentation. Although typical drought management measures are highly cost-effective, their application has not been considered as an alternative to construction of the Big River Reservoir.

Changing the design criterion for the Scituate system from a 1 percent drought to a 3 percent drought would require drought management program capable of reducing water use up to 23 percent during a 1 percent event (assuming the drought management occurs in the PWSB area only). This would increase the effective yield of Scituate by roughly 20 percent. Even if implemented for the Scituate system alone, this single step would increase available supply by 17.9 MGD.

The effect updating assumptions regarding need, and of incorporated selected demand management calculations, is to increase supply to 113.1 MGD, and to reduce year 2030 water use to 78.2 MGD. Surplus capacity in 2030 is, therefore, 34.1 MGD.

Supply Management

Opportunities for increasing the yield of the Scituate system by improved management have not been investigated. There are a range of possibilities for harvesting water from the Big River watershed, using existing impoundments after some upgrading of outlet works. None of these alternatives appear to have been examined, and no data or costs are available.

The Big River feasibility study includes no serious consideration of ground water as an alternative to surface water impoundments. Yet the U.S. Geological Survey estimates that more than 100 MGD of potentially developable ground water exists throughout the State, with the possibility of additional resources in areas such as Mishnock Swamp. Ground water quality is generally good, except in specific areas where contamination has occurred, or may occur in the future. In most cases, ground water can be developed inexpensively and requires little treatment.

Bristol County and Aquidneck Island

The principal motivation for BCWA's support of the Cross-Bay Pipeline appears to be economic: the price of water purchased from PWSB ranges from 5 to 14 percent of current retail prices in Bristol County. A practicable, low-cost, and environmentally benign alternative would be to retain existing ground and surface water surfaces (upgrading the Child St. Treatment Plant), implement appropriate conservation and drought management programs, and purchase any needed supplemental water from PWSB through the existing connections in East Providence.

Similarly, Aquidneck Island has a number of supply alternatives available (including refurbishment and preservation of existing sources), as well as significant potential for demand management. In the event that supplemental supplies are needed on Aquidneck Island, they can be obtained through existing connections from PWSB via Bristol

County. If local systems are properly managed, neither Bristol County nor Aquidneck Island will place large demands on the PWSB system.

Failure to exploit these opportunities will result in abandonment of the existing ground and surface water sources. In the case of surface water, such abandonment is likely to be irreversible, with a consequent permanent loss of water supply capacity for the State as a whole.

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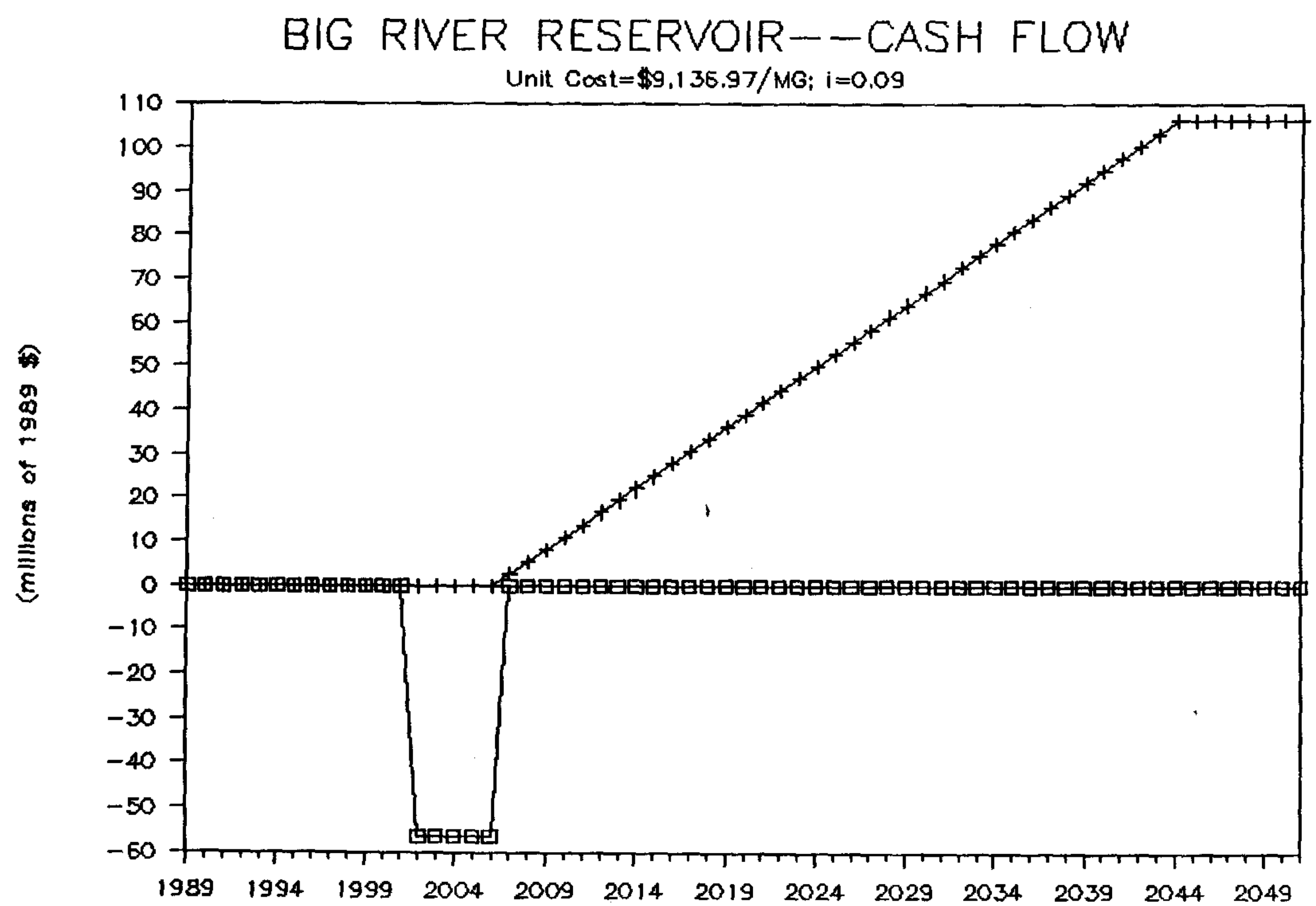
BIG RIVER RESERVOIR--CASH FLOW
Unit Cost=$9,136.97/MG; i=0.09
(millions of 1989 $)
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
1989
1994
1999
2004
2009
2014
2019
2024
2029
2034
2039
2044
2049

BIG RIVER RESERVOIR

Calculation of levelized unit cost disc.rate 0.09

Year	Constr. Outlay ($ mil)	1989 Present Value	Water Sales (MGD)	(MG/yr)	P.V. Water Sales
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					
1998					
1999					
2000					
2001					
2002	56.3592	18.3832			
2003	56.3592	16.8653			
2004	56.3592	15.4727			
2005	56.3592	14.1952			
2006	56.3592	13.0231			
2007			0.8375	305.69	64.8038
2008			1.6750	611.38	118.9061
2009			2.5125	917.06	163.6323
2010			3.3500	1,222.75	200.1618
2011			4.1875	1,528.44	229.5434
2012			5.0250	1,834.13	252.7083
2013			5.8625	2,139.81	270.4829
2014			6.7000	2,445.50	283.5993
2015			7.5375	2,751.19	292.7057
2016			8.3750	3,056.88	298.3749
2017			9.2125	3,362.56	301.1122
2018			10.0500	3,668.25	301.3634
2019			10.8875	3,973.94	299.5202
2020			11.7250	4,279.63	295.9268
2021			12.5625	4,585.31	290.8848
2022			13.4000	4,891.00	284.6579
2023			14.2375	5,196.69	277.4762
2024			15.0750	5,502.38	269.5397
2025			15.9125	5,808.06	261.0221
2026			16.7500	6,113.75	252.0735
2027			17.5875	6,419.44	242.8231
2028			18.4250	6,725.13	233.3818
2029			19.2625	7,030.81	223.8441
2030			20.1000	7,336.50	214.2903

BIG RIVER RESERVOIR

Calculation of levelized unit cost disc.rate 0.09

Year	Constr. Outlay ($ mil)	1989 Present Value	Water Sales (MGD)	Water Sales (MG/yr)	P.V. Water Sales
2031			20.9375	7,642.19	204.7881
2032			21.7750	7,947.87	195.3942
2033			22.6125	8,253.56	186.1554
2034			23.4500	8,559.25	177.1101
2035			24.2875	8,864.94	168.2894
2036			25.1250	9,170.62	159.7179
2037			25.9625	9,476.31	151.4145
2038			26.8000	9,782.00	143.3934
2039			27.6375	10,087.69	135.6647
2040			28.4750	10,393.37	128.2346
2041			29.3125	10,699.06	121.1066
2042			30.1500	11,004.75	114.2815
2043			30.9875	11,310.44	107.7578
2044			31.9000	11,643.50	101.7715
2045			31.9000	11,643.50	93.3683
2046			31.9000	11,643.50	85.6590
2047			31.9000	11,643.50	78.5863
2048			31.9000	11,643.50	72.0975
2049			31.9000	11,643.50	66.1445
2050			31.9000	11,643.50	60.6830
2051			31.9000	11,643.50	55.6725
Totals	281.7960	77.9395		308,046.31	8,530.1253
	Levelized Unit Cost ($/MG)			=	9,136.97