UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107

SUBJECT: Recommended Section 404(c) Determination for the Ware Creek, James City County, Virginia Project

DATE: 1988

FROM: Stanley L. Laskowski
Acting Regional Administrator (3RA00)

TO: Rebecca W. Hanmer
Acting Assistant Administrator for Water (WH-556)

I am forwarding to you the Regional Recommended Determination pursuant to Section 404(c) of the Clean Water Act regarding the proposed construction of the Ware Creek Reservoir. This project would involve filling and inundating approximately 425 acres of diverse wetlands and 792 acres of upland forest thus destroying extensive wildlife habitat. The proposed mitigation plan would attempt to recreate approximately 167 acres of wetlands, with the possibility of another 128 acres created by additional mitigative effects.

After consideration of the entire record in this case, I have determined that filling and inundating the subject waters, including wetlands, will have an unacceptable adverse effect on wildlife, fishing areas, and recreational areas. Therefore, I am recommending that action be taken by EPA under Section 404(c) of the Clean Water Act (CWA) to prohibit specification or use for the subject waters of the United States, including wetlands, as a disposal site for dredged or fill material in association with the construction of any dam, lake, or reservoir.

The Administrative Record for this Determination is being forwarded to the Office of Wetland Protection under separate cover. A copy of this recommended Section 404(c) package is being provided to the Office of the Administrator.

Attachments

Recommended 404(c)
DETERMINATION TO PROHIBIT, OR DENY THE SPECIFICATION, OR THE USE FOR SPECIFICATION, OF AN AREA AS A DISPOSAL SITE: WARE CREEK, JAMES CITY COUNTY, VIRGINIA

I. SUMMARY

On November 18 1988, EPA Region III gave notice in the Federal Register (53 Fed. Reg. 46656-46659) of its "Proposed Determination to Prohibit, or Deny the Specification, or the use for Specification, of an Area as a Disposal Site: Ware Creek, James City County, Virginia. The area in question includes those areas in the Ware Creek basin which would be affected by a dam located approximately 1,000 feet downstream from the confluence of Ware Creek and France Swamp (Figures 1 and 2).

The announcement also indicated that a public hearing would be held concerning this action. The public hearing was subsequently announced in the Federal Register on December 9, 1988, (Fed. Reg. 49789-49790) and held in the James City County Center on January 18, 1989. Mr. Greene Jones, Director, Environmental Services Division, presided as hearing officer at that hearing.

I have considered the administrative record in this case, including comments received before, during and subsequent to the public hearing from federal, state, regional and local agencies; public interest groups, affected property owners and the general public. Based upon these comments, my conclusion is that the construction of a dam on Ware Creek would continue to have unacceptable adverse effects on wildlife, fishing areas and recreational areas. Furthermore, the EPA believes that several promising environmentally superior, economically feasible alternatives should be more thoroughly investigated.

Pursuant to 40 CFR Part 231.5, I therefore recommend that EPA prohibit, or deny the specification, or the use for specification, of portions of the Ware Creek floodplain, as an area for disposal of dredged or fill material for the purpose of creating an impoundment for water supply purposes.

II. LEGAL BACKGROUND AND AUTHORITY

Section 301(a) of the Clean Water Act, 33 U.S.C. §1311(a), prohibits the discharge of pollutants, including dredged and fill material, into waters of the United States (including wetlands) except as in compliance with, among other things, Section 404 of the CWA, 33 U.S.C. §1344. Section 404 of the CWA authorizes the Secretary of the Army, acting through the Chief of Engineers, to authorize the discharge of dredged or fill material at specified sites through the application of environmental guidelines developed by EPA in conjunction with the Secretary under

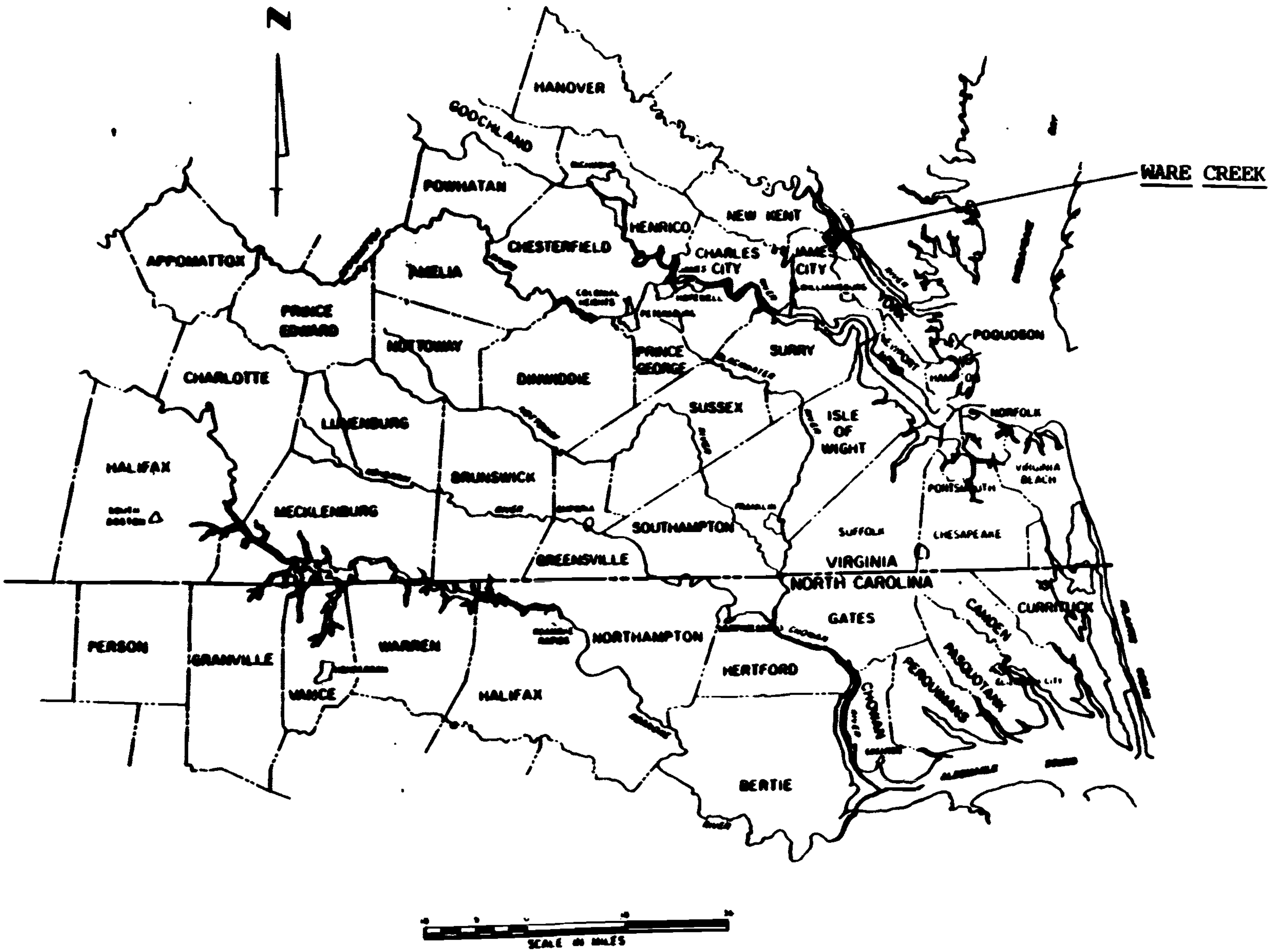


Figure 1. Location of Ware Creek

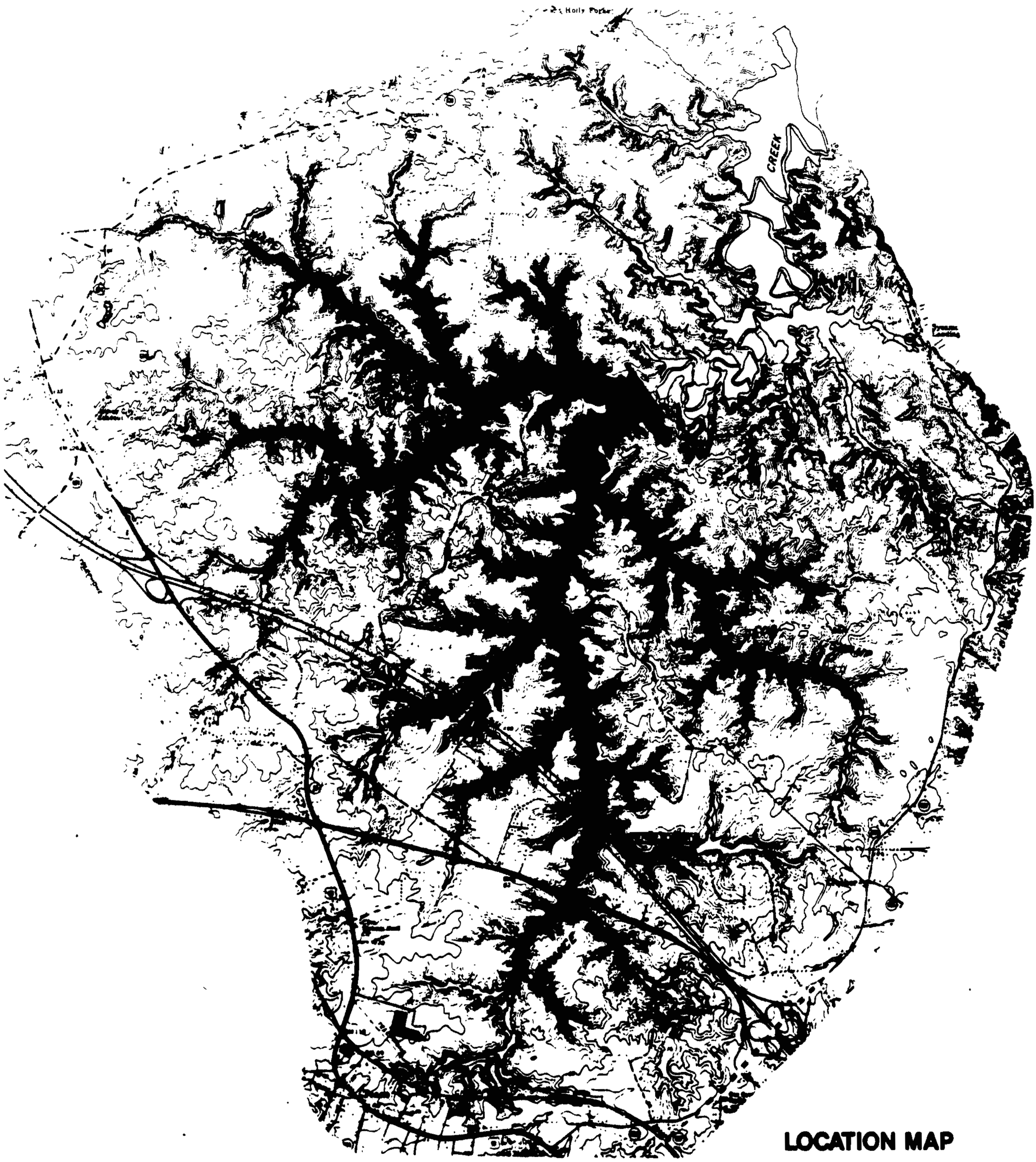


Figure 2. Location and Lake Area of the Proposed Ware Creek Reservoir (Site V)

Section 404(b) of the CWA, 33 U.S.C. §1344(b), or where warranted by economics of anchorage and navigation, except as provided by Section 404(c) of the CWA, 33 U.S.C. §1344(c). Section 404(c) of the CWA states that the Administrator of the U.S. EPA is authorized to prohibit the specification of any defined area as a disposal site and he is authorized to deny or restrict the use of any defined area for specification as a disposal site, whenever he determines, after notice and oportunity for public hearing, that the discharge of such materials into such area will have an "unacceptable adverse effect" on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas.

These regulations define " unacceptable adverse effect" in Section 231.2(e) as:

> Impact on aquatic or wetland ecosystem which is likely to result in significant degradation of municipal water supplies (including surface or ground water) or significant loss of or damage to fisheries, shellfishing, or wildlife habitat or recreation areas. In evaluating the unacceptability of such impacts, consideration should be given to the relevant portions of the section 404(b)(1) guidelines (40 CFR Part 230).

The preamble to 40 CFR Part 231 explains that one of the basic functions of Section 404(c) is to enforce the application of the Section 404(b)(1) Guidelines. Those portions of the Guidelines relating to significant degradation of waters of the United States (40 CFR 230.10(c)), as well as consideration of cumulative impacts (40 CFR 230.11(g)), are of particular importance to EPA were used in the evaluation of the unacceptability of environmental impacts in this case.

Section 230.10(c) of the Guidelines requires that no discharge of dredged or fill material shall be permitted that contributes to the significant degradation of waters of the United States. Section 230.10(d) requires that no discharge of dredged or fill material shall be permitted unless appropriate steps have been taken which will minimize potential adverse impacts.

Within the decision-making process, Section 230.11(g)(2) requires that the permitting authority collect, analyze, consider, and document information relevant to cumulative impacts resulting from the subject action. Thus, it is appropriate under Section 404(c) to take into account whether significant degradation of waters of the United States will occur as a result of individual and/or cumulative fill activities and whether appropriate steps have been taken to minimize adverse impacts.

Sections 230.10(a) and 230.10(b) of the guidelines address alternative availability and project impact minimization respectively. EPA considered these issues during project evaluation.

The Administrator has delegated the authority to make a final decision under Section 404(c) to the Assistant Administrator for Water, who is EPA's National Clean Water Act Section 404 program manager. The authority may be used either to veto a permit which the Corps has determined it would issue or to withdraw an issued permit. Under the Section 404(c) authority, the Assistant Administrator may prohibit all discharges of dredged or fill material in a defined area or may impose some partial prohibition, such as a restriction on discharges from a particular type of activity. This proposed Section 404(c) determination is a prohibition or denial of specification or the use for specification of Ware Creek as a disposal site for dam and subsequent lake and reservoir construction.

The procedures for implementation of Section 404(c) are set forth in the Code of Federal Regulations, 40 CFR Part 231. Pursuant to those procedures, if the Regional Administrator has reason to believe that use of a site for the discharge of dredged or fill material may have an unacceptable adverse effect on applicable resources, he may begin the 404(c) process by notifying the Corps of Engineers and the applicant that he intends to issue a proposed determination. Unless within 15 days the applicant or the Corps has demonstrated to the satisfaction of the Regional Administrator that no unacceptable adverse effects will occur, or that corrective action will be taken to prevent an unacceptable adverse effect satisfactory to the Regional Administrator, the Regional Administrator will publish a notice in the Federal Register of his proposed determination, soliciting public comment and offering an opportunity for a public hearing.

Subsequent to the public hearing and the close of the comment period, the Regional Administrator will decide whether to withdraw his proposed determination or prepare a recommended determination. A decision to withdraw may be reviewed at the discretion of the Assistant Administrator for Water at EPA Headquarters. If the Regional Administrator prepares a recommended determination, he will then forward it with the complete administrative record compiled in the Region, to the Assistant Administrator for Water at EPA Headquarters. She will review all pertinent information and issue a final decision affirming, modifying, or rescinding the recommended determination. In accordance with the regulations at 40 CFR §231.6, the U.S. Army Chief of Engineers and the applicant will be provided with another opportunity for consultation with the Assistant Administrator for Water before the final determination is made. This document constitutes the recommended determination and is being submitted in that context.

III. PROJECT DESCRIPTION

James City County proposes to discharge dredged and/or fill material into Ware Creek and its adjacent wetlands in order to construct an earthen dam to impound water for a water supply reservoir. The impoundment structure is to be located approximately one thousand feet downstream of the confluence of Ware Creek and a tributary (France Swamp). The proposed lake will be located along the border of James City and New Kent Counties (Figure 1). The dam will measure 1,450 feet in length with a crest elevation of +48 feet mean sea level (msl). The reservoir is designed for a normal pool elevation of +35 feet msl. with an average depth of 16 feet. It will store 6,355 million gallons of water and provide a safe yield of 9.4 million gallons per day (mgd). Construction of the 1,217 acre lake, will result in the inundation and/or clearing of 1,325 acres of land.

IV. PROJECT HISTORY

A. Ware Creek Reservoir

During the first half of 1981 a series of meetings were held between representatives of James City County, and Federal and State agencies to evaluate proposals to impound Ware Creek for a water supply reservoir. Since the proposed plan would have significant environmental impacts and because a Clean Water Act Section 404 permit issued for the project would constitute a major Federal action, all of the Federal agencies involved concluded that an Environmental Impact Statement (EIS) would be required in accordance with the National Environmental Policy Act (NEPA, 40 CFR Part 1500). In a letter dated May 12, 1981, sent to the U.S. Army Corps of Engineers, EPA anticipated that the environmental impacts of the proposal would be significant and unacceptable. It further recommended that all viable alternatives be investigated including the study of regionally oriented solutions to plan for projected overall water supply needs.

After considerable consultation, field evaluation and study, a Draft Environmental Impact Statement (DEIS) was prepared and released by the Norfolk District, Corps of Engineers (Corps) in July 1985. The EPA reviewed the DEIS document and rated it EU-3 (Environmentally Unsatisfactory, Inadequate Information). Comments by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) parallel those of EPA. The primary basis for the EU-3 rating of the DEIS was that EPA believed that the adverse environmental impacts associated with the proposed project were severe and had not been adequately minimized, and that the full range of feasible water supply alternatives had not been adequately investigated or fully discussed in the document.

The Corps of Engineers unilaterally determined that the preparation of a supplemental DEIS was not necessary. In proceeding with final EIS (FEIS) preparation, the Corps enlisted three Federal Agencies; EPA, USFWS, NMFS to serve as cooperating agencies to address questions which were raised during the DEIS review. Considerable effort was subsequently expended to inventory and classify the biological communities of the proposed reservoir basin, to evaluate the current habitat value and potential impacts through the Habitat Evaluation Procedures (HEP), and to investigate mitigative measures and alternatives to the proposed plan.

In September, 1987, the Corps of Engineers issued the FEIS. The recommended alternative remained essentially the same although measures to mitigate the environmental impacts were expanded. The environmental conditions and impacts were described in more detail and several alternatives were discussed more fully. On November 23, 1987, EPA issued comments regarding the FEIS to the U.S. Army Corp of Engineers. EPA found that the FEIS preferred alternative, the construction of the Ware Creek impoundment, was environmentally unsatisfactory, that mitigative measures were inadequate and that alernatives had not been adequately addressed. Those comments also stated that EPA was considering the CWA Section 404(c) option. EPA recommended to the Corps that the Ware Creek permit be denied and that all concerned Federal, State and regional parties work together toward a viable, environmentally satisfactory comprehensive water-supply solution.

On July 11, 1988, the Corps issued a Notice of Intent to Issue a Permit for the proposed Ware Creek reservoir. In response to that notice, EPA informed Colonel Joseph J. Thomas the Corps Norfolk District Engineer on August 5, 1988, that it was initiating a 404(c) action. The action began with a 15 day period, during which the District Engineer was given an opportunity to submit information which demonstrated to the satisfaction of the Regional Administrator that no unacceptable adverse effects would occur. The District Engineer responded to the Regional Administrator but did not demonstrate that corrective action to prevent an unacceptable adverse effect would occur. On November 18, 1988, EPA published a notice in the Federal Register (53 Fed.Reg. 46656-46659) to inform the public of the preliminary decision to exercise 404(c) authority (i.e. proposed determination) with regard to the Ware Creek impoundment, and to solicit comments from interested parties. A public hearing was subsequently announced in the Federal Register (53 Fed. Reg. 49789-49790) and was held at the James City County Center on January 18, 1989. Numerous speakers, including James City County, and other public officials, the Virginia Water Control Board, USFWS, affected property owners, environmental groups and other interested parties were provided a forum in which to express their views. A complete transcript of the public hearing proceedings is contained in the Administrative record. EPA received a large number of written coments in response to the Region's proposed Section 404(c) determination during the public comment period both before and after the public hearing. EPA received a total of 27 letters in support of the proposed Regional action while 53 letters and signatures were received opposing the proposed Regional action. A profile of the responses follows:

	Support §404(c)	Oppose §404(c)
Governmental Agencies		
Federal	4	
State		6
Local		11
Intergovernmental Agencies		7
Corporations		8
Professionals (lawyers, engineers)		5
Public Interest Groups		
Environmental	10	1
Business		2
Private Citizens	13	13

Comments were received before, during, and after the public hearing, from proponents and opponents of the proposed 404(c) determination. After careful review of the comments, EPA Region III continued to believe that earlier Agency determinations were justified and that a recommended determination to prohibit or deny project construction to EPA Headquarters was warranted.

B. Regional Water Supply Issues

For some time there have been ongoing efforts to develop regional solutions to the long-term water supply needs of the northside of Hampton Roads, including James City County. The Corps of Engineers gathered the requisite data together in Draft and Final Feasibility Reports and Environmental Impact Statements (EIS) entitled Water Supply Study Hampton Roads, Virginia in May and December of 1984 respectively. Three action alternatives were identified in the water supply study as the most feasible to serve the long-term water needs for Northside, Hampton Roads. The preferred alternative was a withdrawal from the James River, upstream of Richmond and a pipeline to carry the water to the existing water supply system operated by Newport News. Two secondary alternatives, withdrawal from the Pamunkey River with storage in a Black Creek reservoir and withdrawal from the Chickahominy River with storage in a Ware Creek reservoir, were considered to be less feasible - primarily because of the significance of the environmental impacts.

In a July 16, 1984, review letter, EPA concurred with the Corps' conclusions. EPA took a preliminary position concerning the two secondary alternatives in that the proposals for the Black Creek or Ware Creek impoundments would probably result in recommendations for a CWA Section 404 permit denial. The Ware Creek proposal for this report was for a somewhat larger impoundment with greater environmental impacts. Nevertheless, the type and order of ecological damage was similar to the County oriented water supply impoundment which is currently proposed by James City County.

During this decade, Southeastern Virginia has been the focal point for several other water supply proposals. Gloucester County proposed a water supply impoundment on Beaverdam Swamp to meet long-term water supply projections. In a similar fashion, Hanover County proposed a withdrawal from the Pamunkey River, with storage in a proposed impoundment on Crump Creek. The City of Suffolk proposed an impoundment on Crump's Mill Pond as an interim solution to meet water demand until the Lake Gaston pipeline, the Corps' recommended Southside Hampton Roads long-term solution, was completed.

Faced with this plethora of individual public works initiatives to meet localized water requirements, the federal regulatory community endeavored to broaden the range of alternatives analysis and revisit regional solutions. The Corps of Engineers convened a meeting with Federal, state and local officials to gauge the scope of future water supply proposals and the feasibility of comprehensive solutions which could include cooperation on an intergovernmental or regional level. Although unsuccessful in reaching a consensus, the meeting did indicate the importance of the issue and the deleterious ramifications of continued locally-oriented solutions.

At the same time the environmental evaluation of the Beaverdam Swamp reservoir proposal was proceeding in accordance with the National Environmental Policy Act (NEPA) and Section 404. At the conclusion of the NEPA process the proposed reservoir was found by EPA to have severe environmental impacts. Feasible alternatives (e.g. reverse osmosis treatment of available groundwater) were identified. In an effort to demonstrate the viability of a treated groundwater source, EPA funded a feasibility study of reverse osmosis. The conclusion of the report (EPA, 1987) was that reverse osmosis of groundwater was competitive with a conventional reservoir and treatment facility and the potential and realized environmental costs of a conventional reservoir were much greater. Gloucester County proceeded with reservoir construction, which the Corps of Engineers had permitted.

The reverse osmosis report did, however, provide sufficient information to encourage the City of Suffolk to fund a pilot groundwater treatment facility and, eventually, a full scale facility now under construction. Therefore the Crump's Mill Pond impoundment project was discontinued.

V. NATURAL RESOURCE FUNCTIONS AND VALUES

A. Introduction

The criteria upon which this 404(c) action is based include unacceptable impacts to wildlife, fisheries areas and recreation areas. The relevant functions and values of the wetlands and adjacent habitats are attributable to both the structure of the communities and the ecosystem processes which occur within, and are exported from, the Ware Creek watershed. In recognition of this fact the discussion of the 404(c) criteria will address ecological parameters such as primary productivity and pattern diversity which are critical components of the value of the Ware Creek basin.

Portions of the final analysis of the Ware Creek impoundment have been provided by expert consultants contracted by the EPA. The four reports which are appended to this recommended determination have been reviewed by EPA staff. The EPA staff concur fully with the findings which are provided in these reports and therefore incorporate their findings as part of the recommended determination.

B. Project Site

Ware Creek is located approximately five miles downstream of the confluence of the Pamunkey River and Mattaponi River, which form the York River at the turn of West Point. Ware Creek serves as a tributary of the York River, flowing eastward into the river and forming a portion of the New Kent-James City County border (Figure 2).

The Ware Creek watershed is approximately 14,600 acres in size and contains a mix of land uses and habitat types. The primary upland habitat types are hardwood forest (5,808 acres), mixed pine-hardwood forest (3,914 acres) and mixed agricultural residential (3,706 acres). Dominant upland hardwood trees include various species of oaks (Quercus spp.), hickories (Carya spp.), American beech (Fagus grandifolia), black gum (Nyssa sylvatica), red maple (Acer rubrum), sweetgum (Liquidambar styraciflua) and tulip poplar (Liriodendron tulipifera). The understory and shrub layers are characterized by sassafrass (Sassafrass albidum), flowering dogwood (Cornus florida) serviceberry (Amelanchier sp.), blueberry (Vaccinium spp.), huckleberry (Gaylussacia spp.) and mountain laurel (Kalmia latifolia). Conifer trees distributed throughout the predominantly hardwood and mixed pine-hardwood forests include lobolly pine (Pinus taeda) shortleaf pine (P. echinata) and Virginia pine (P. virginiana).

There are approximately 986 acres of vegetated wetlands and 184 acres of open water habitat within the Ware Creek watershed. (Figure 3). The mixture of habitat types results in a complex mosaic of interspersed wetland communities and adjacent uplands. A total of 44 wetland community types have been identified. (COE, 1987:3-24). At the juncture of Ware Creek and the York River the wetlands are estuarine, intertidal and comprise a mixture of smooth cordgrass (Spartina alterniflora), big cordgrass (S. cynosuroides) and black needlerush (Juncus roemerianus). As one proceeds upstream, the influence of the tides diminishes and the salinities decrease. In this vicinity the marshes are dominated by mixtures of wild rice (Zizania aquatica), cattails (Typha spp.), arrowarum (Peltandra virginica), pickerel weed (Pontederia cordata), bulrushes (Scirpus spp.) and rushes (Juncus spp.).

Beaver have had a profound impact within the nontidal freshwater portions of Ware Creek and its tributaries. The result has been a complex mixture of forested, scrub/shrub and herbaceous wetlands dominated by sycamore (Platanus americana), green ash (Fraxinus pennsylvania), sweet gum, red maple, black gum, holly, river birch (Betula nigra), willow (Salix spp.), blueberry, alder, buttonbush (Cephalanthus occidentalis), viburnums (Viburnum spp.), spicebush (Lindera benzoin), ferns (Osmunda spp.; Woodwardia spp.; Onoclea sensibilis), rice cutgrass (Leersia oryzoides), wild rice, bulrushes, rushes, sedges (Carex spp.), cattails, burreeds (Sparganium spp.) and smartweeds (Polygonum spp.).

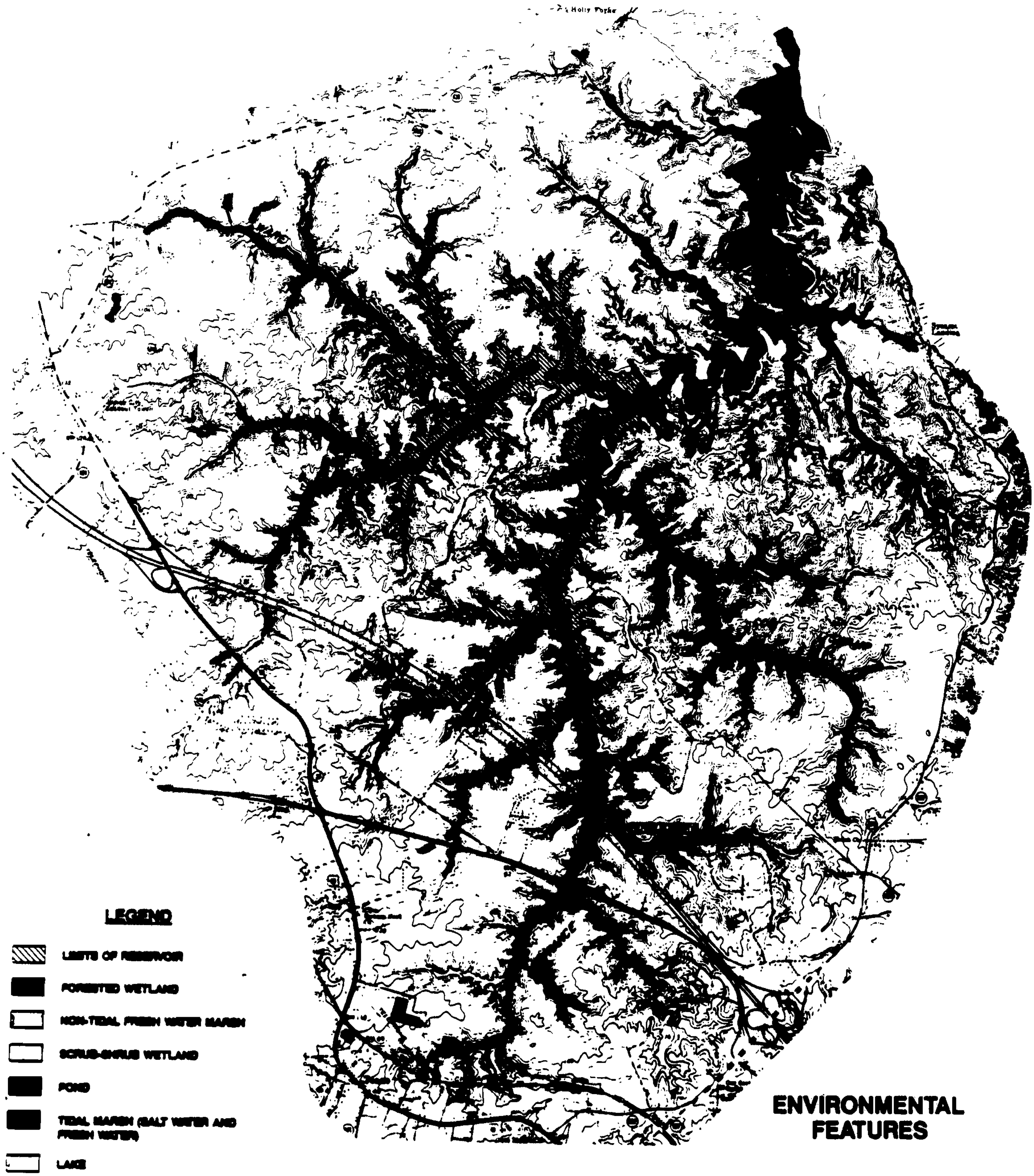


Figure 3. Dominant Wetland Cover Types
Ware Creek Watershed

In addition to beaver, the wetlands are utilized by a variety of migrating and resident songbirds, migratory waterfowl, game birds (e.g. woodcock - Philohela minor), wading birds and river otter (see Appendix A Tables 1-4).

Of particular note is the location of a great blue heron rookery (Ardea herodias - a USFWS species of special concern) within the France Swamp tributary of Ware Creek, and the sighting of bald eagles (Haliaeetus leucocephalus - an endangered species) in and around the Ware Creek basin.

The adjacent uplands provide adequate food and shelter to support game species such as white-tailed deer, grey squirrel and turkey (Meleagris gallopavo) as well as a variety of non-game vertebrates.

Game fish found in the aquatic portions of the watershed include largemouth bass (Micropteris salmoides) and sunfish (Lepomis spp.) in freshwater areas and white perch (Roccus americana) in estuarine reaches. Although Ware Creek is not used by anadromous fish species to any great extent, the organic material which is produced, processed and exported from Ware Creek wetlands creates a direct ecosystem linkage to the downstream wetlands, the York River system and the Chesapeake Bay.

C. Wildlife Support Function

The wetlands and deepwater habitat of the Ware Creek watershed comprise only eight percent of the total watershed area, yet the bottomland communities, and the immediately adjacent uplands are the focal point for the resource values attributable to wildlife and fisheries. Evidence of actual and potential recreational use of these resources serves to emphasize their importance to society.

The linear progression of wetland community types begins at the mouth of Ware Creek. Proceeding upstream, Hershner and Perry (1987) denote four separate herbaceous wetland communities which are influenced by the tides and salinity. Earlier inventory work by Doumlele (1979) and Moore (1980) identified comparable assemblages in the tidal portion of Ware Creek. The bulk of these communities are ranked by Silberhorn et al. (1974) in a group which contains the most environmentally valuable tidal wetlands in Virginia. The balance of the Ware Creek intertidal communities are classified in the second of five groups and are of only "slightly less value than Group One marshes". In aggregate these Ware Creek wetlands annually produce three to ten tons of plant material, much of which is available to the marine environment, waterfowl (ducks, geese, rails) and small mammals.

The proposed dam site is located within the uppermost of the intertidal marsh communities previously noted. Proceeding farther upstream, woody vegetation predominates in a mosaic of palustrine, freshwater wetland communities. There has been considerable beaver activity which has had a profound impact on the nature and distribution of most of the forty-four separate wetland community types found within the Ware Creek impoundment area.

Wharton et al. (1982: 95-98), in a review of energy flow in riverine systems notes that both detrital and grazing pathways are within the wetland system and provide linkage to terrestrial and aquatic wildlife habitats involved. Furthermore, there are significant differences between dry systems (during wetland drydown) and wet systems (during floodplain inundation and in pools). The detrital pathways during wet periods serve the primary export functions linking the riverine system to receiving waterbodies. Exported plant material, and the enriching bacterial and fungal biomass derived from it, form the particulate organic matter which drives the system. Wharton et al. (1982: 98) noted that higher floodplain tree diversity insures that wildlife food is available over a longer time span because the vegetation of different tree species are broken down at various rates. The Ware Creek wetlands provide the ecosystem support function at a rate which is far greater than the aerial extent of those communities, as do comparable systems cited in the literature.

Primary productivity is a measure of the energy fixed through photosynthetic activity in the form of biomass. This plant material forms the foundation for the food chain which support wildlife populations. Ecol Sciences (1989) compiled primary production values for the various undeveloped (i.e. not agricultural, residential or commercial) acreage within the Ware Creek watershed. Table 1 indicates that the wetlands are generating over 14% of the primary production while comprising only 9% of the area.

Table 1: Proportion Of Primary Production And Area Of Major Undeveloped Habitats In The Ware Creek Watershed

HABITAT	PERCENTAGE AREA	PRIMARY PRODUCTION
Upland	89.67%	84.73%
Wetland	9.09	14.21
Lacustrine Open Water	.61	.21
Estuarine Open Water	.62	.83

The biomass generated by the Ware Creek wetlands is reflected in the food provided and the structure of the system satisfying various wildlife life cycle requirements. The value of this system is evidenced by the 168 species of fish, amphibians, reptiles, birds and mammals listed by USFWS (1989) which have been as observed, collected or likely to occur in such habitat (Appendix A).

It has been noted by USFWS (1989) that much of the forested portion of the Ware Creek wetlands fit the criteria for Zone IV and Zone V bottomland hardwoods cited in Wharton et al. (1982). As Table 2 demonstrates, such wetland communities in the landscape perform a variety of ecosystem support functions.

Table 2: Some environmental factors affecting the fauna of the bottomland hardwoods (and the ecosystem in general), and their relative importance in each bottomland hardwood zone. Importance: 0 negligible or none, 1 low, 2 moderate, 3 high.
(Adapted From Wharton et al. 1981)

	Zone	
Factors	IV	V
Retardation of "side flooding" from tributary streams (damming effect)	2	3
Organic matter production	3	2
Detritus source for feeding downstream life by annual inundation (includes coastal estuary)	2	1
Detritus source for feeding downstream life on 5-7 year pulse cycle (includes coastal estuary)	2	3
Diversity of oak species (acorns for food) (excluding _Quercus_ _palustris_, _bicolor_, _macrocarpa_, _imbricaria_)	3	3
A mix of white oaks (bear each year) and red oaks (bear every second year)	2	2
Availability of non-coniferous nut-bearing trees other than oaks (hickories, pecan, beech)	2	3
Diversity of berries and soft fruits in high canopy (sugarberry, tupelo, black gum, persimmon, etc.)	2	3

Table 2: Continued

Factors	Zone IV	Zone V
Availability of berries and soft fruits in subcanopy and shrub zone (decidous holly, haws (<u>Crataegus</u>), mulberry, paw paw, Elliott's bluberry, American holly, swamp palm, tall gallberry, etc.)	3	3
Availability of berries and soft fruits of vines (grapes, poison ivy, supplejack (<u>Berchemia</u>), etc.)	3	3
Availability of herbs as browse for birds and mammals (cane, greenbrier, jewelweed, sedges, etc.)	2	3
Availability of small terrestrial fauna (insects, snails, earthworms, etc.)	2	3
Availability of aquatic macroinvertebrates	3	0
Availability of Chimney-building floodplain crayfish	3	1
Forage for adult fish (when flooded)	3	2
Refuge for young fish (when flooded)	3	3
Diversity of forest strata (for bird guilds, etc.)	2	3
Availability of ground-level hibernation sites (stump-holes, logs, leaf base of swamp palm, crayfish burrows)	3	3
Availability of aboreal hibernacula (tree cavity sites in old growth forest)	3	3
Presence of rare and endangered species (e.g., Swainson's and Bachman's warblers, ivorybilled and red-cockaded woodpecker)	2	2
Diversity of amphibians and reptiles	2	3
Diversity of small mammals	2	3
Breeding bird diversity and density of individuals	3	3
Refuge for "terrestrial" fauna from high water	0	3

Wharton et al. (1982) cites Kennedy (1977) who noted that more birds preferred Zone IV and Zone V hardwoods than the other southeastern bottomland dominant types studied, and that game birds such as wild turkey were known to nest and feed in the Zone IV bottoms. In Florida, the Florida Game and Freshwater Fish Commission (1978) found that eastern wild turkey population densities were 250% greater in bottomland hardwoods than in uplands (Wharton et al., 1982).

Field evidence of wildlife use verifies the support function of the Ware Creek ecosystem. USFWS (1989) notes that the size of the heron rookery located in France Swamp has ranged from 45 to 88 nesting pairs since 1982. The rookery supported 67 breeding pairs in 1988. In addition, they state that red-headed woodpeckers, a species of local significance to birdwatchers, are common in Ware Creek because they favor the open stands of timber found in these bottomlands.

The value of the Ware Creek system to migratory waterfowl is particularly important to USFWS (1989). Natural tree cavity nest sites, combined with a wood duck nest box program have resulted in an enhanced resource for wood duck reproduction. Roosts containing as many as 500 birds have been observed in Ware Creek. With regard to other duck species, several hundred ducks of several species were observed at the confluence of Ware Creek and France Swamp in March 1987, and December 1988. An estimated 250-300 mallards and black ducks were observed during the latter occasion. A supplemental feeding program may have had some impact on the waterfowl numbers, but in the absence of such a program 63 ducks (56 black ducks and 7 mallards) were observed near the proposed dam site in mid-November 1983 and 115 ducks (40 black ducks and 75 mallards) were observed in the same general vicinity in mid-January 1984. In sum, the USFWS (1989) considers the Ware Creek wetlands as good quality habitat for dabbling ducks (especially black ducks) and the overall quality for wood ducks is excellent. Given that the North American Waterfowl Management Plan recommends the provision of an additional 50,000 acres of black duck migration and wintering habitat along the east coast, the potential jeopardy of 75 acres of such habitat is crucial.

Other wildlife activity has been noted within the Ware Creek basin. A bald eagle has been observed in the watershed. Although the closest nesting pair is located within the next watershed, upstream along the York River (Goddins Pond), the resources within Ware Creek are no doubt used by these raptors.

Fresh scat and other signs of river otter were observed near the confluence of France and Cow Swamps. River otters are relatively rare or absent in many portions of their former range with coastal plain swamps remaining as a last refuge. The USFWS (1989) cites Linzey (1979) who considers the Virginia river otter's status as an endangered species, yet they are afforded no additional protection other than that of a furbearer species.

The use of Ware Creek by wildlife (e.g. ducks, otters, eagles, etc.) is important. Nevertheless, the physical structure (e.g. foliage height diversity, juxtaposition and interspersion of varied habitats), and the biomass production which is created, serve to support a valuable series of biological communities. These communities, in conjunction with the remaining comparable systems, serve as a crucial foundation for the ecology of the York River, the Chesapeake Bay and adjacent uplands.

D. Fisheries Support Function

At this time, Ware Creek has not been found to directly support an anadromous fishery. Nevertheless, significant fishery resources have been identified within the watershed. Within the impoundment site proper, fish surveys have identified 23 species of fish which use the upstream wetland communities. These include migratory estuarine fish (spot, white perch) and forage fish (mummichogs and sheepshead minnows). The fish fauna of Ware Creek have been characterized by James City County as "abundant and diverse" (USFWS, 1989). The intertidal emergent wetlands which form the most downstream wetland continuum are cited by Silberhorn et al., (1974) as nursery areas for fish.

Without additional detailed study, the exact contribution of the Ware Creek watershed to downstream fisheries is difficult to quantify. Nevertheless, a substantial portion of the annual 128,584 metric tons of primary production is in all likelihood, transported to downstream waters to support the estuarine ecosystem. Ecol Sciences (1989) also notes that the contribution of Ware Creek to estuarine invertebrates and fishes is enhanced by its "exceptional benefit of position" - discharging to an estuarine region (i.e. lower York River) that serves a nursery function where larvae and juveniles of the migratory fish that enter the York River system grow and develop (Van Engel and Joseph, 1986 cited in USFWS, 1989).

E. Recreation

The recreational benefits which Ware Creek provides may be divided into several categories. On-site recreational opportunities include consumptive (hunting, fishing and trapping) and non-consumptive (hiking and bird watching) opportunities. Off-site recreational opportunities are attributable to Ware Creek to the extent that the production exported from the watershed supports wildlife and fishery populations which provide recreational opportunities elsewhere. For example, of the wood duck broods which fledge from Ware Creek and the black and mallard ducks which winter there, some proportion are utilized in recreation (hunting and birdwatching) elsewhere. The same is true for the warblers and other songbirds which rely upon Ware Creek as a stop on the migratory route between wintering and breeding habitats.

On-site hunting opportunities are the most tangible data available concerning recreational use of the watershed. The Chesapeake Corporation, a major landowner, currently leases a portion of their upland property for deer, turkey and squirrel hunting to four hunt clubs, (1986 acreages): Toana Hunt Club (2,205); Grove Kennel (1,301); Cedar Point (437) and an unnamed club with no available figure of leased acres (USFWS, 1989). The demonstration of a market for leased hunting acreage in the watershed indicates that there is sufficient recreational benefit and harvest opportunity to justify lease expenditures. Given the previously cited wildlife productivity values of the adjacent wetlands, the Ware Creek wetland productivity and added habitat diversity support a portion of the recreation on the leased land.

The Chesapeake Corporation has constructed 32 waterfowl blinds along Ware Creek (4 of which are located above the proposed dam site) to provide waterfowl hunting opportunities for invited corporate guests. Given the high quality of the wintering waterfowl habitat in the lower Ware Creek, particularly the fresh water intertidal marsh, and the numbers of ducks which have been sighted in the area, these blinds have, in all likelihood, provided high quality recreational opportunities. An additional 100 wood ducks were harvested on various beaver ponds in the upper Ware Creek basin during the fall 1988 hunting season (USFWS, 1989).

Access to the Ware Creek watershed is restricted by the current landowners, therefore unpermitted recreational opportunities, particularly on-site non-consumptive uses, are limited. Nevertheless, as the two counties become more developed, the importance of Ware Creek to support potential recreational opportunities, both on-site and off-site, will increase.

VI. ADVERSE ENVIRONMENTAL IMPACTS

Construction of the proposed Ware Creek impoundment will result in the inundation of 425 acres of wetlands and 792 acres of primarily forested upland. The range of impacts however, is not restricted to the limits of the reservoir boundary. The project will affect ecological processes both upstream and downstream of the reservoir and will contribute to ongoing cumulative effects on the regional ecology. Due to the variety of impacts, the assessment of environmental change has been studied from several perspectives.

A. Watershed Impacts

1) Habitat Evaluation Procedures (HEP)

Habitat Evaluation Procedures (USFWS, 1980) were applied during the preparation of the FEIS to determine the effect of the proposed project on existing wildlife and fishery habitat values. The following summary of the HEP results is excerpted from Appendix A of the FEIS (USFWS, 1987).

Species-specific Habitat Suitability Index (HSI) models are used in HEP to assess the habitat quality for a particular species based upon selected habitat characteristics. The HSI can range from 0.0 (unsuitable habitat) to 1.0 (optimal habitat). A measure of the habitat value is derived by multiplying the HSI by the number of acres of habitat to arrive at Habitat Units (HU's). An HU is, in effect, a combination of habitat quality and quantity with each HU serving as the equivalent of one acre of optimal habitat.

Impact asessment with HEP requires the establishment of baseline HSI's which, when multiplied by the area of available habitat, yield the total HU's for each modelled species under pre-project conditions. Changes in habitat value over the course of the defined assessment period may result from changes in habitat areas or HSI values and yield altered HU's. The average number of HU's over the course of the assessment period are expressed in terms of Average Annual Habitat Units (AAHU's). The net impact of a project is thereby calculated by projecting the available AAHU'S under a "no-project" and " project" scenario and assessing the difference as a net gain or loss in habitat value.

The Ware Creek HEP analysis was designed to assess cover-type habitat values rather than species-specific habitat values. The species were selected to represent the range of existing cover-types and to reflect the change in cover-type values which would be expected over the assessment period. The species selected included the: pileated woodpecker (Dryocopus pileatus), gray squirrel, American woodcock, beaver, wood duck (Aix sponsa) -brood habitat only, yellow warbler (Dendroica petechia), redwinged blackbird (Agelaius phoeniceus), large-mouth bass (Micropterus salmoides) and juvenile spot (Leiostomus xanthurus).

The cover types which were assessed included the undeveloped portion of the Ware Creek watershed as well as Cranston's Pond, which is part of James City County's proposed mitigation plan on Yarmouth Creek. The assessment of covertype changes over the Target Year 10, 25 and 50 year periods include the direct impacts of the project alternatives combined with expected successional patterns, timber harvests compatible with maximization of real estate values, and commercial and residential development in accordance with accepted planning principles (see USFWS, 1987 for more detail).

The net changes in land use over the 50 year assessment period are depicted for the "No Project" (Figure 4); "Site V" (Figure 5); and "Three-Dam" (Figure 6); alternatives.

With the "No Project" Alternative (Figure 4), most cover-types are assumed to have reached a state of dynamic equilibrium. By target year 25 however, approximately 40% of the upland mixed pine-hardwood forest and 28% of the upland hardwood forest will have been converted to residential, commercial or industrial uses. This land use pattern was derived from data gathered by USFWS staff and primarily follows established transportation and utility corridors. As a result, development tends to be concentrated near existing infrastructure and is primarily located in the peripheral parts of the Ware Creek watershed.

Figure 4. Land Use Trends - No Project Alternative

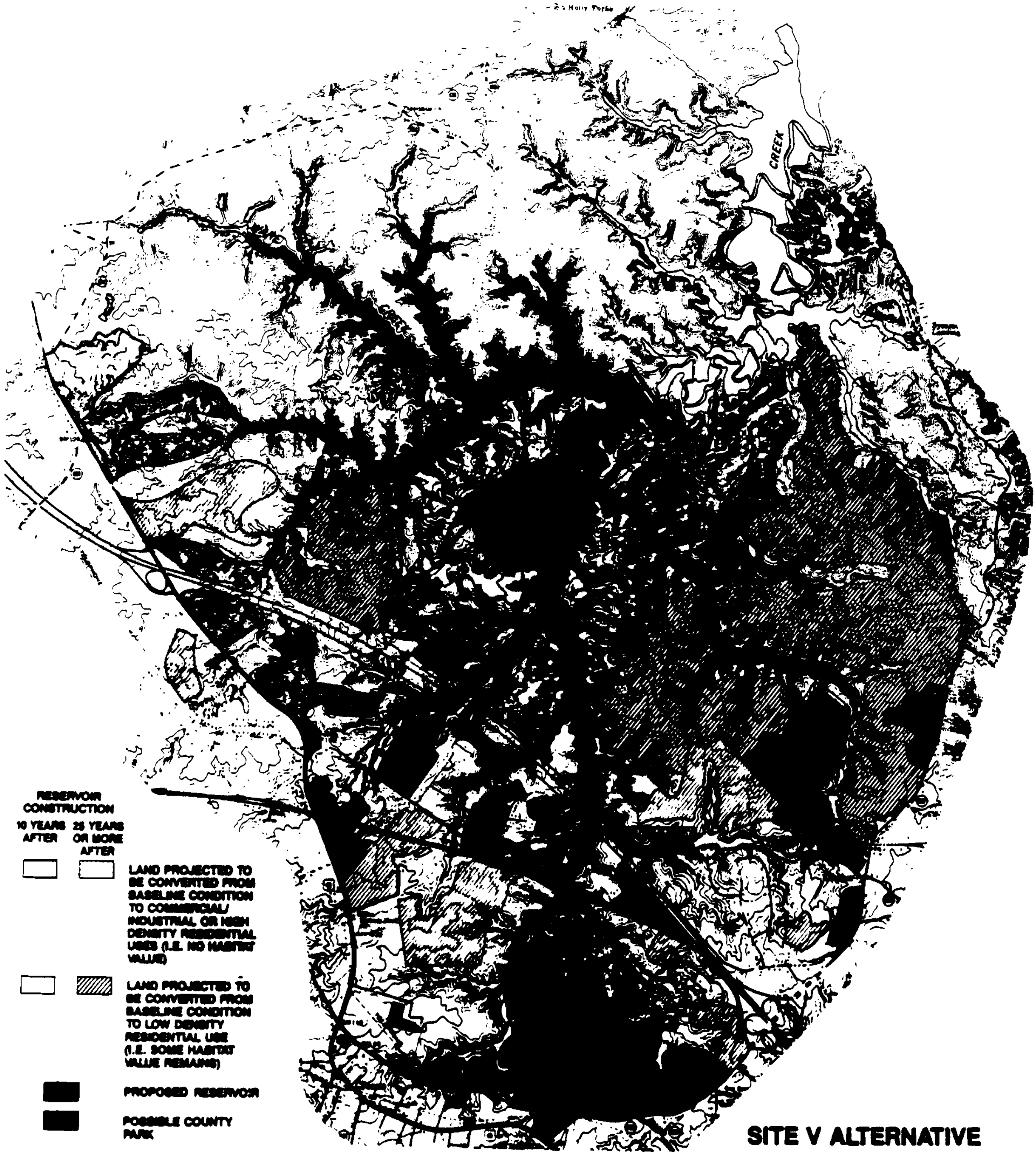


Figure 5. Land Use Trends - Site V Alternative

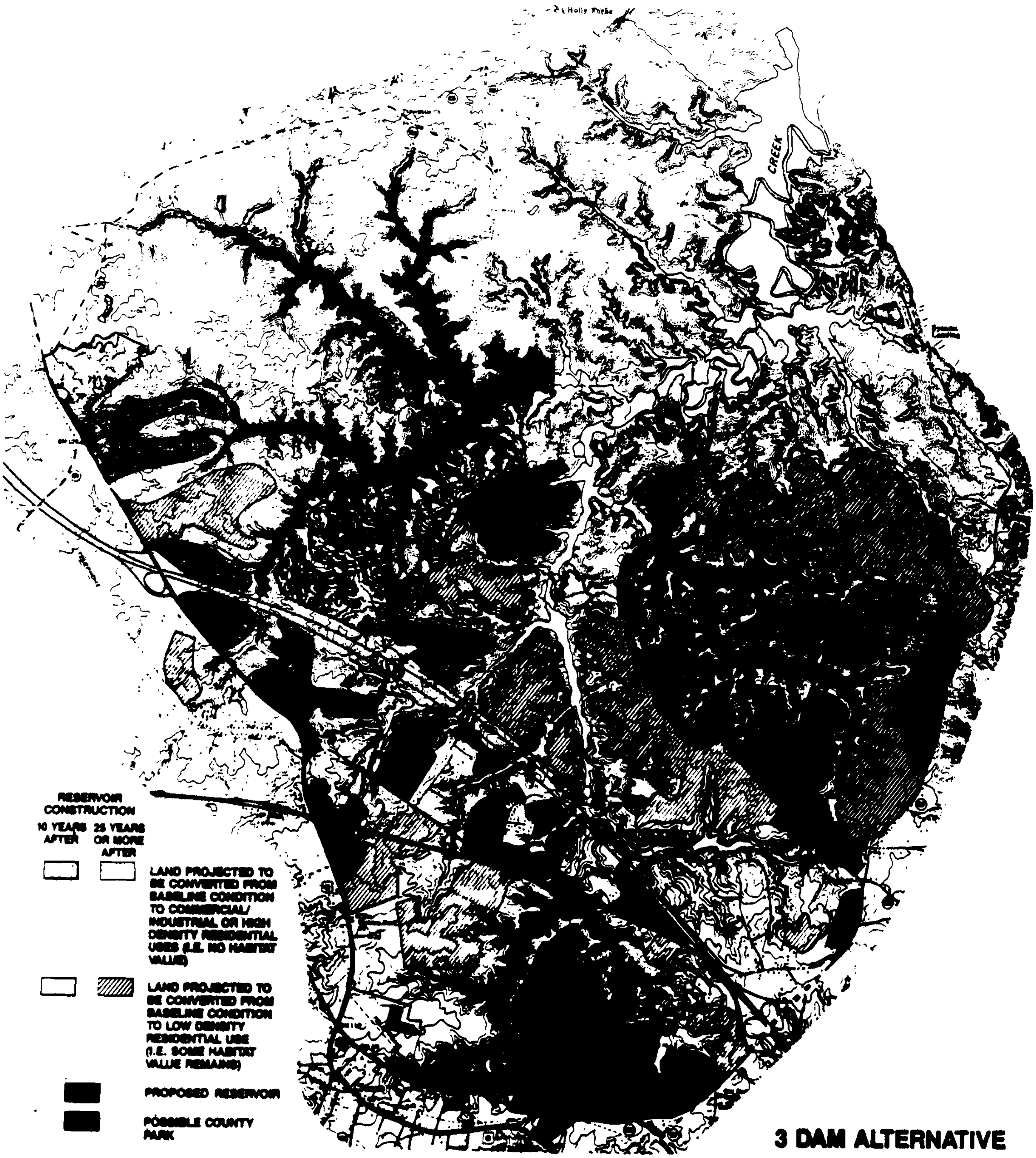


Figure 6. Land Use Trends -
3 Dam Alternative

The "Site-V" scenario (Figure 5) incorporates the habitat changes caused by the impoundment inundation and the mitigation activities (i.e. breaching Cranston's Pond, construction of headwater and borrow-pit wetlands).

High-density residential, commercial and industrial development generally follows the "No Action" Alternative. However, a large scale residential development, oriented toward the Ware Creek reservoir, will result in significant cover-type modifications within the interior of the watershed. Essentially the increased marketability of lakeside real estate provides the capital necessary to extend utility services to the watershed interior.

The "Three-Dam" Alternative (Figure 6) is an intermediate scenario, in which three smaller impoundments are constructed to partially meet the design yield of the larger impoundment while reducing the inundation impacts proportionally. Although no mitigation plan has been proposed for this alternative, it has been assumed that mitigation comparable to Site V would be implemented. The impacts, as expected, are intermediate to the other two scenarios. The central reach of Ware Creek-France Swamp is preserved and the only central portions of the watershed subject to residential development are oriented around the constructed reservoirs.

Figure 7 and Table 3 depict the change in cover-type habitat values expressed as a percent change from the No Action condition AAHU totals for the Site V and Three Dam Alternatives. Assuming complete success of all mitigation activities and some retention of habitat value in low density residential areas, construction of the Site V will result in the eventual loss of 296 acres of vegetated wetland and estuarine open water habitats and 1,072 acres of undeveloped upland forest over and above expected losses under the No Action Alternative. The Three-Dam Alternative option will result in comparable losses of 145 acres and 446 acres respectively. The comparison of changes in cover-type acreage, for the three alternatives is depicted in Figure 8. In all cases, undeveloped cover-types decrease to the greatest extent under the Site V Alternative.

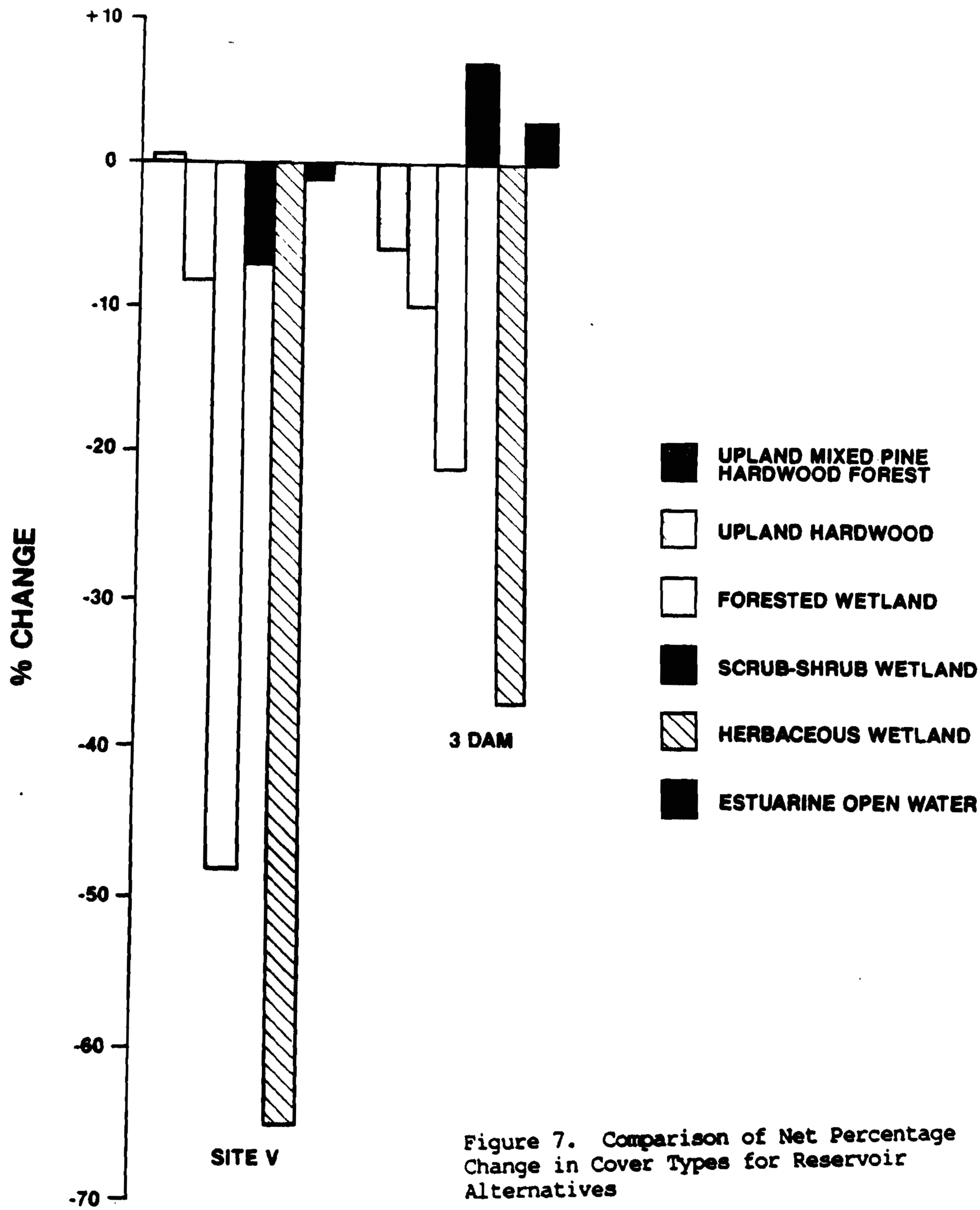


Figure 7. Comparison of Net Percentage Change in Cover Types for Reservoir Alternatives

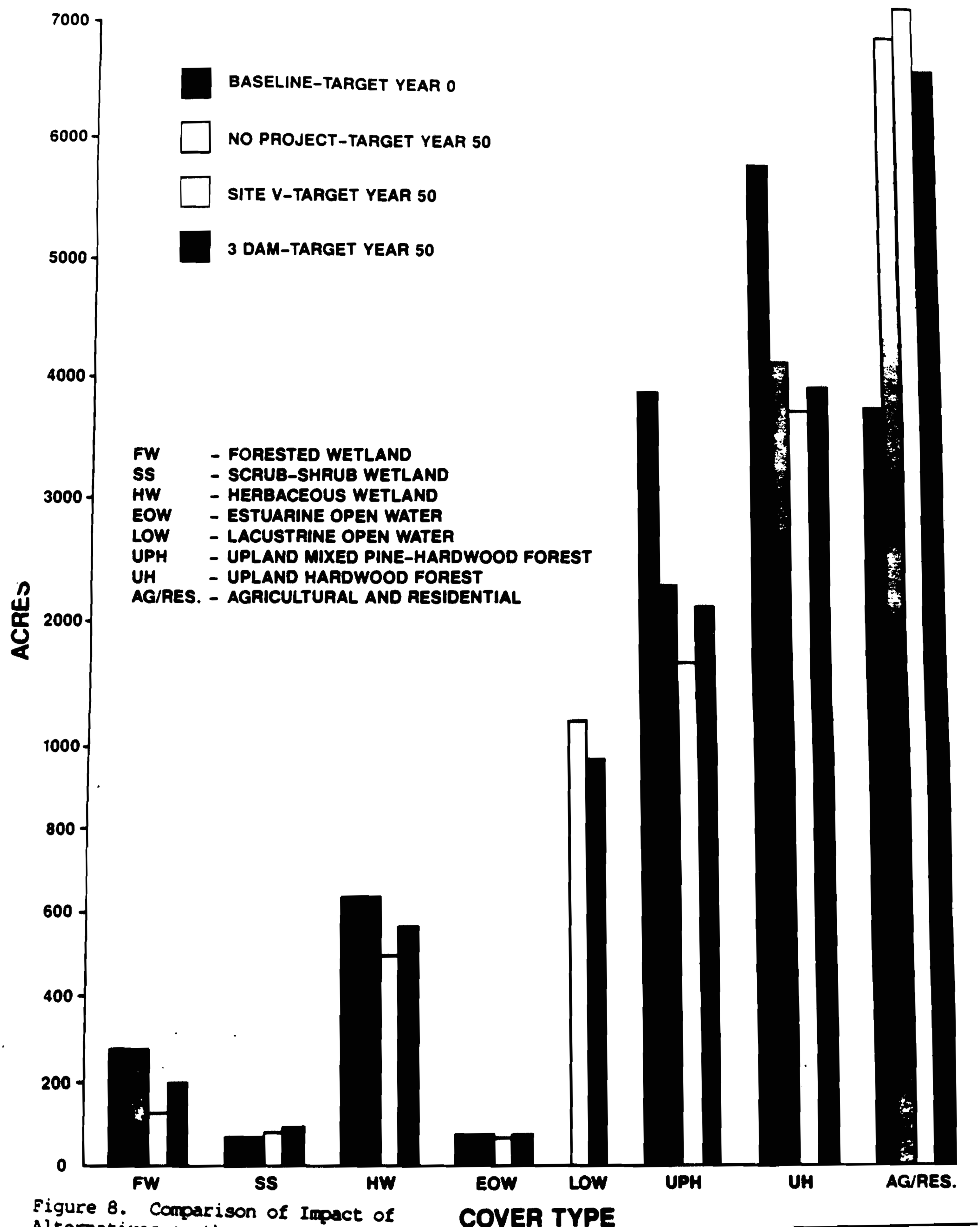


Figure 8. Comparison of Impact of
Alternatives ...

TABLE 3: Long Term Habitat Value Impacts: No Project vs Site V and Three-Dam Alternatives (from USFWS, 1987).

Evaluation Element	Percentage Change In Habitat Values Site V	Three-Dam
Upland Pine-Hardwood Forest and Low Density Residential	+0.4%	- 6.5%
Upland Hardwood Forest and Low Density Residential	7.1%	- 10.0%
Forested Wetland	-48.4%	-20.9%
Scrub/Shrub Wetland	- 6.6%	- 6.8%
Herbaceous Wetland	-64.4%	-37.6%
Lacustrine Open-water	+1,298.4%	+990.7%
Estuarine Open-water	- 1.4%	+3.1%

2) Standard Ecological Measurement Parameters.

In an effort to evaluate the significance of the Ware Creek impoundment from a different perspective, orthodox ecological methods were applied to measure the ecological attributes of the existing system and the anticipated system which will result from dam construction. Much of the analysis is derived from Ecol Sciences (1989) whose full report is appended to this recommended determination.

a) Primary productivity

The high productivity of wetland systems is one of the best documented and most often cited values of wetland ecosystems. Since primary production serves as the foundation for supporting higher topic levels, much of the fish and wildlife support values of wetlands may be attributable to this aspect of wetland ecology. As Table 4 depicts, the palustrine and estuarine wetland systems are generally the most productive found within the existing Ware Creek Basin. Lacustrine open water is by contrast, the least productive.

TABLE 4: Approximation of Primary Production Rates in Ware Creek Watershed (From Ecol Sciences, 1989)

Cover Type	Mean NPP (metric tons/ha/yr)
Upland mixed pine-hardwood forest (UPH)	12.7
Upland hardwood forest (UH)	10.2
Forested wetland (FW)	10.5
Scrub-shrub wetland (SS)	27.4
Herbaceous wetland (HW)	21.0
Lacustrine openwater (LOW)	4.4
Estuarine openwater (EOW)	16.0

Source: Richardson, 1979

Multiplying the anticipated cover type acreage of the Site V scenario, (and assuming optimal conditions), results in the following comparison of primary production (Table 5):

TABLE 5: Estimated Annual Primary Production (PP) Ware Creek Without and With Reservoir (From Ecol Sciences, 1989)

Cover Type	Est. PP mt/yr	
	No. Project	Alt. V
Upland mixed pine-hardwood forest (UPH)	49702	48532
Upland hardwood forest (UH)	59246	51662
Forested Wetland (FW)	2895	1300
Scrub-shrub wetland (SS)	2011	1425
Herbaceous wetland (HW)	13367	10607
Lacustrine open water (LOW)	293	5399
Estuarine open water (EOW)	1072	1026
TOTAL	128584	119950

Source: Acreages from pp. 12 and 20 Appendix A, FEIS; PP rates from Richardson, 1979

The net loss of 8,634 metric tonnes per annum yields a 6.7% loss in watershed productivity. Unfortunately, the operation of the water supply reservoir will result in further losses in watershed productivity and ecosystem support.

Ecol Sciences (1989) describes the planned water withdrawal from an ecological perspective as a cropping of water and water-borne conticuents. In other words, the nutrients and plankton which would normally be recycled within the watershed or exported downstream will end up on the filters of a water treatment facility (and probably into a solid waste landfill).

Therefore, the 76% acreage reduction in watershed downstream releases (diverted for water supply) can be conservatively estimated to result in a 76% reduction of effective lake productivity. This additional reduction of 4,103 metric tonnes of primary production raises the total amount of annual productivity lost to the existing system to 12,737 metric tonnes - a 9.9% reduction. This is still a very conservative estimate which we believe substantially underestimates the lost productivity. The reasons for this are the following:

Since the lake will serve as a conduit for much of the total watershed release of productivity the "cropping" will remove substantial material which was produced outside of the lacustrine environment.

"Cropped" products will also include secondary productivity such as zooplankton and ichthyplankton which represent significant plant biomass which has already been converted to animal biomass.

All mitigation is assumed to perform instantaneously and at 100% efficiency as compared to natural systems - this is an overly optimistic assumption.

A constant lake level is assumed. This is a water supply reservoir with planned and extensive fluctuations. This reduces the total lake hypervolume available for productivity; reduces the available light as an energy source (i.e. increased turbidity due to erosion at exposed lake margins) and removes potential littoral zone productivity contributions.

b) <u>Secondary productivity</u>

The material which is exported from highly productive ecosystems becomes available for the support of downstream fish and wildlife ecosystems, thereby subsidizing biomass accumulation in the receiving systems. Construction of the Ware Creek reservoir will discontinue this material transport process, trapping much of the detritus in the benthic region of the reservoir or diverting it with water withdrawals. Despite the fact that Richardson's Millpond conceivably traps 18% of the currently exported detritus, the reservoir will theoretically trap 50% entire of the watershed detrital export, a decrease of almost 280%

c) Habitat complexity

Ecol Sciences (1989) notes that the Ware Creek wetlands which will be inundated are comprised of approximately 66 mapped subareas of at least two dozen different vegetative community types. This highly complex community mosaic will be replaced by a relatively monotonic lake environment. Diversity indices have been derived from probability and/or information theory and have become standard tools for comparing the complexity (i.e. information content) of two or more ecological systems. In most cases, increased complexity results in a greater number of ecological niches, more complex food webs, increased fish and wildlife community diversity and resilience. Numbers of individuals per taxon or occasionally, acres per cover or habitat type, are used to compile the indices. In this case Ecol Sciences (1989) applied Brillouin's H index for totally censused collections (Pielou, 1975) to compare habitat complexity between baseline and post-impoundment conditions. As Table 6 indicates, the loss in gross habitat diversity ranges from 9.5-12.8% over the 50-year assessment period.

TABLE 6: Brillouin's Index
Ware Creek Without or With Reservoir
(From Ecol Sciences, 1989)

"Scenario"	H diversity	H evenness	% Loss
No Action (TY+1)	1.696	0.7305	-----
Alt. V (TY+1	1.479	0.6370	-12.8
Alt. V (TY+10)	1.535	0.6610	- 9.5
Alt. V (TY+25)	1.527	0.6576	-10.0
Alt. V (TY+50)	1.527	0.6576	-10.0

Ecol Sciences (1989) notes that these data are the result of summed averages of the habitat types, thereby yielding a very conservative comparison. The finer details of subunit interaction and the subtler aspects of ecological diversity are lost when each separate cover type is lumped over the entire community. When Brillouin's Index is calculated with the use of the subunit acreages, the watershed's 66 areas yield an H diversity index value of 5.3588 and an evenness value of 0.8866. By contrast, the watershed with the impoundment has an H index value of 1.4658 and in evenness value of 0.3392 because the impoundment has only 20 mapped areas. The difficulty in discriminating separate mapped areas for the mitigation proposals could lead to somewhat higher indices under separate interpretations. However the greater contrast between before- and after-impoundment habitat diversity using a subarea database would continue to be marked.

Subtle, but ecologically meaningful, features of naturally evolved and integrated systems are a primary reason why ... "mitigation by accounting"- (-i.e., counting acres lost and acres gained) fails to acknowledge fully the favorable geometry of the system such as the complex mosaic of discrete wetland habitat types juxtaposed with aquatic and terrestial habitats along a gradual gradient of change from headwaters to the confluence with the York River (Ecol Sciences, 1989).

3) Special Features

a) Natural reserve assessment

Gosselink and Lee (1987) have established fundamental concepts for the management of bottomland hardwood forests as natural reserves. Ecol Sciences (1989) cites several of these principle concepts as applicable in the case of the existing Ware Creek watershed:

> Reserve Area. Species richness increases with area: large reserves are better than small ones.
>
> Reserve Fragmentation. For a given total area, one large reserve will support more native species than two or more smaller ones. Further, the invasion of opportunistic species that could displace native biota is reduced.
>
> Reserve Patch Proximity. For a given area, disjunct patches that are close together will support more species than patches far apart. Proximity increases immigration rates among patches, thus buffering the total system against local extinctions (Ehrlich and Holm, 1963). Proximity tends to increase with an increasing number of patches (and hence, decreasing patch size).
>
> Continuity and Contiguity. Disjunct reserves connected by strips of protected habitat are preferable to isolated reserves, Riparian habitats are natural corridors in the landscape. Reserves that are bordered by similar habitats support more native species than reserves bordered by dissimilar habitats. Similar habitats provide a gradual ecotone that is not as inhospitable to most species as an abrupt edge.
>
> Reserve Shape. All other things being equal, a circular-shaped reserve is preferable to a linear one. This is because the circular reserve area maximizes dispersal distances within the reserve, and minimizes the edge relative to the interior.

This reasoning is based on the fact that the Ware Creek watershed is "a large, unfragmented mosaic of habitat patches with high continuity and contiguity and gradual edges, and provides exceptional habitat for wildlife". Ecol Sciences (1989: 22) goes on to conclude:

"If one were to identify potential reserve areas on the west bank of the lower York River, the Ware Creek system would surely be one of the premier candidates (if not the best candidate)."

b) Oligothaline and tidal freshwater wetlands

In addition to the ecosystem impacts previously described, the reservoir is predicted to have a profound impact on the continuum of tidally influenced emergent wetlands located in the lower reaches of Ware Creek. The most diverse and most vulnerable communities are the oligothaline and tidal freshwater wetlands described by Hershner and Perry (1987). The diversion of up to 76% of the natural freshwater discharge of Ware Creek will result in significant changes in downstream salinities. Hershner and Perry (1987) conclude that the tidal freshwater marshes remaining after dam construction will be totally eliminated by the salinity change. The oligothaline marsh will be reduced considerably in areal extent. The balance of the tidal freshwater marsh located upstream will be excavated for the impoundment structure or inundated by the reservoir. The tidal freshwater marsh characterized by wild rice and other favored waterfowl food, is prime waterfowl wintering habitat. The USFWS (1979) notes that the loss of 75 acres of such habitat in an area of international significance to waterfowl (i.e. Middle-Upper Atlantic Coast) is contrary to the recommendation of the North American Waterfowl Management Plan to provide 50,000 additional acres of black duck migration and wintering habitat along the east coast of the United States.

c) Blue heron rookery

The blue heron rookery located in France Swamp is a relatively uncommon natural resource feature which will be destroyed by reservoir construction. The elimination of the nesting trees will probably cause the nesting pairs which use this site to relocate to other colony sites, concentrating the regional heron population in fewer locations and therby increasing the probability of catastrophic losses due to further habitat disturbance or disease. Although there have been location shifts within the France Swamp rookery over time, it is conceivable that France Swamp meets some, as yet unquantified, habitat requirement of the breeding population. Given the lack of information, designing mitigation features to offset this loss is not possible to any acceptable degree of confidence (USFWS, 1989).

B. Cumulative Impacts

Of the original 215 million acres of wetlands which existed in the conterminus United States in presettlement times, only 99 million acres (46%) remained by the mid-1970's. During the time period from the mid-1950's to the mid-1970's annual loss rates averaged 458,000 acres (Tiner, 1984). Current annual loss rates are estimated in the range of 300,000-400,000 acres.

Comparable rates of loss have characterized wetland trends in Virginia. From 1956-1977, over 63,000 acres of coastal and inland vegetated wetlands were lost. The losses of inland vegetated wetlands was greatest in the region surrounding James City County where 14% of these wetlands were destroyed - fully 80% of the total loss of the State's inland vegetated wetlands. Twenty-five percent of the loss of inland vegetated wetlands was directly attributable to pond, lake or reservoir construction. During the same time period, ponds and lakes/reservoirs increased from all land use types within the state by 35,000 and 520,000 acres respectively (Tiner and Finn, 1986).

Roelle et al. (1987) and Gosselink and Lee (1987) have assessed the primary development impacts on bottomland hardwoods throughout the southeastern United States. The conclusion is that, in terms of areal extent, intensity and permanence of impacts, impoundments have the most profound effect (Figure 9).

Wetland trends within the lower York River watershed display cause and effect relationships comparable to regional, state and national trends. The wetlands and selected deepwater habitats, of at least ten acres in size, were identified and measured throughout the watershed (Gannett-Fleming, 1989a). The total acreage of wetland and lacustrine habitats within this area is 15,829.7 acres - approximately 8.7% of the watershed. Vegetated inland wetlands however comprise only 4,110.8 acres - 26% of the total wetland/lacustrine resource and only 2.26% of the watershed area.

Twenty existing impoundments distributed throughout the watershed (Figure 10) have cut off substantial inland watershed areas from the original connection with the York River. A total of 1,106.4 acres of inland vegetated wetlands have been cut-off by this process - 26.9% of the total inland vegetated wetland resource of the Lower York River (Table 7). Construction of the Ware Creek reservoir will inundate or cut off an additional 264.3 acres resulting in a total of 1,370.7 acres - a full third of the vegetated inland wetlands which contributed productivity and provided habitat corridors for downstream systems. An additional 46.7 acres of estuarine emergent wetlands (i.e. the valuable tidal freshwater wetlands) will be lost due to filling and inundation.

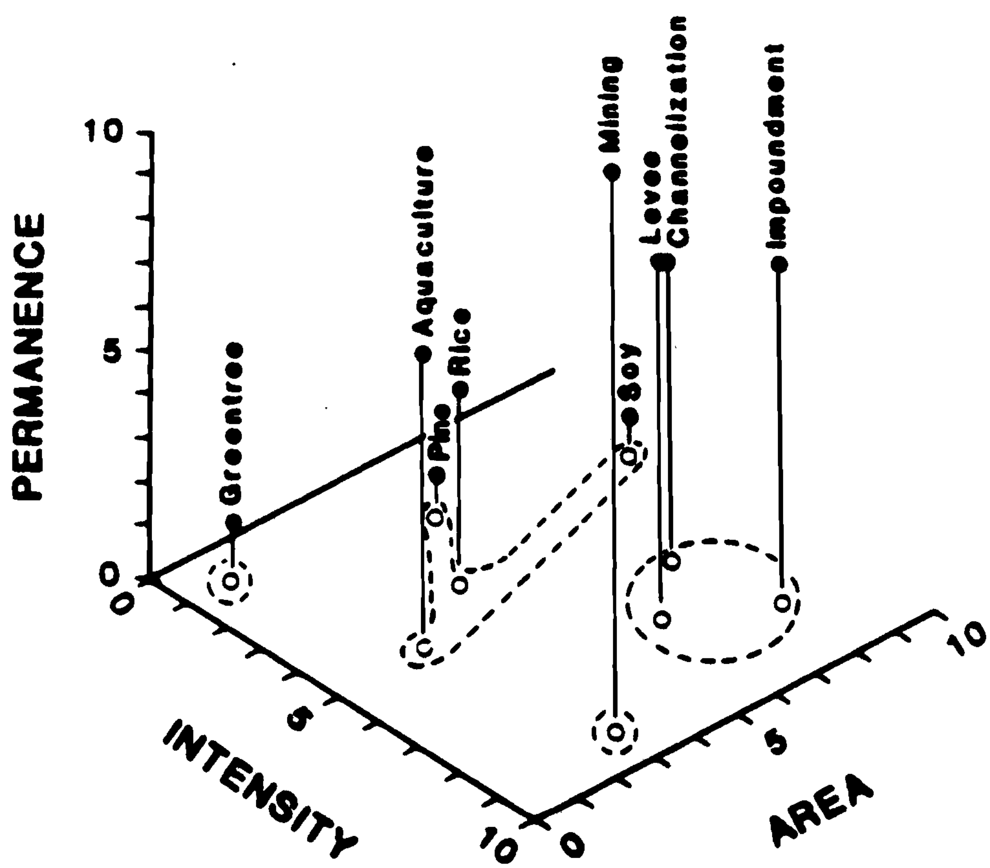


Figure 9. Ordination of Development Impacts Upon Bottomland Hardwoods (from Gosselink and Lee, 1987 and Roelle et al., 1987)

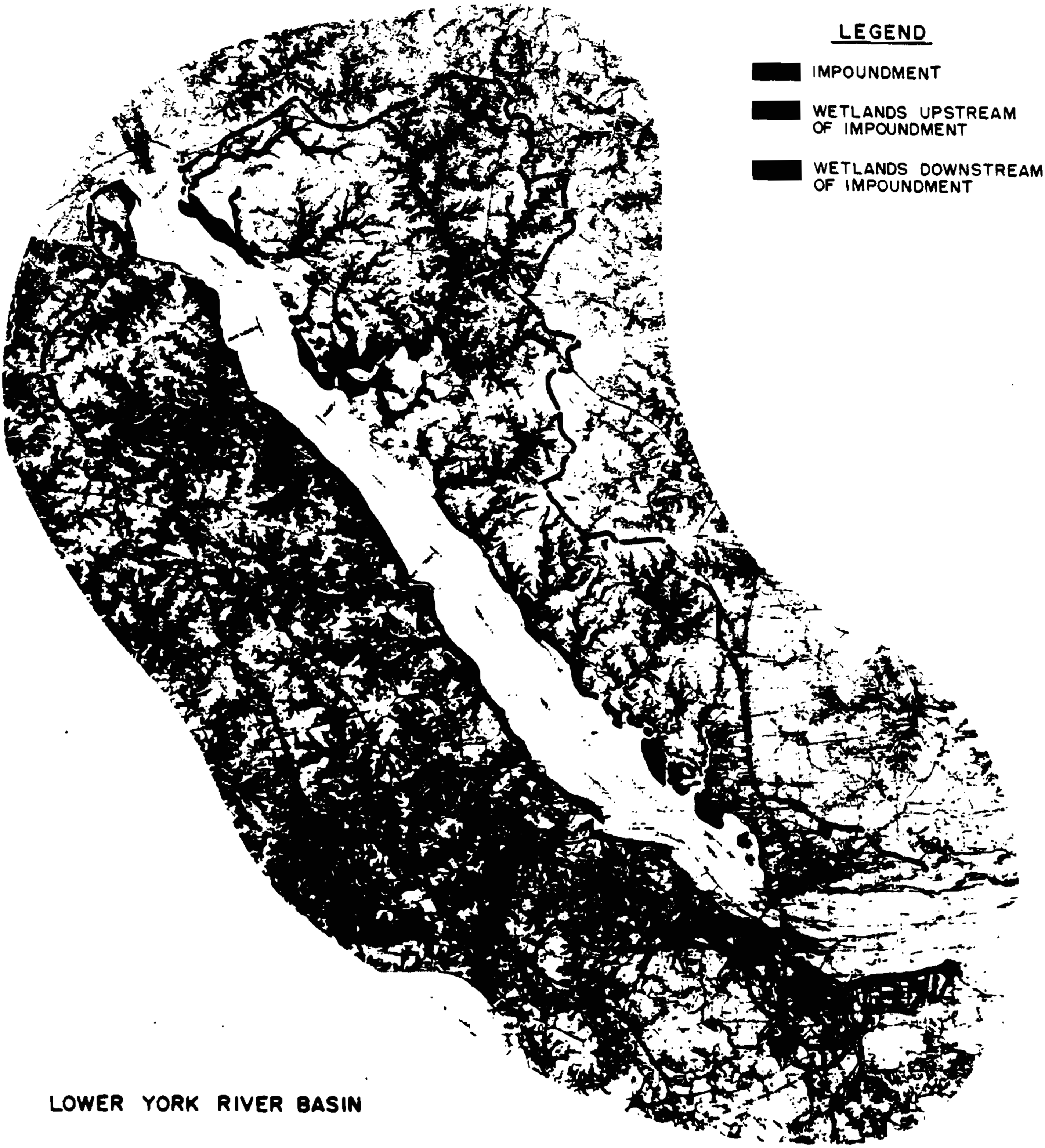
INVENTORY OF WETLANDS

LOWER YORK RIVER BASIN

SOURCE · NATIONAL WETLAND INVENTORY MAPS

Figure 9a Wetland Resources - Lower York River

IMPACTS OF IMPOUNDMENTS



SOURCE: NATIONAL WETLAND INVENTORY MAPS

FIGURE 10

CUMULATIVE IMPOUNDMENT IMPACTS -

Table 7: Disruption of Watershed Ecological Processes by Impoundments - Lower York River Watershed (From Gannet-Fleming, 1989a)

Wetland Type	Total Watershed Acreage	Current-ly Cut-off	Percent of Total	Additi-onal Ware Creek Impact	Total	Percent of Total
PFO	3,390.6	619.7	18.3%	248.9	868.6	25.6%
PEM	621.0	457.6	73.7%	*	457.6	73.7%
PSS	99.2	29.1	29.3%	15.4	44.5	44.9%
TOTAL	4,110.8	1,106.4	26.9%	264.3	1,370.7	33.3

* 46.7 acres of EEM (freshwater intertidal wetlands) will be destroyed

Applying a reasonable estimate that 33% of the existing lake basins were once wetlands, the 1,422.5 acres of laustrine open water habitat may have resulted in the inundation of an additional 474 acres of wetlands. Under this scenario, the original unrestricted vegetated inland wetland resource base comprised 4,585 acres. Through disconnection and destruction, 1,580 acres (34%) have been lost and the additional losses attributable to the Ware Creek impoundment would increase the loss to 1845 acres (40%).

The unhinging of 34% or 40% of a critical ecosystem resource can be reasonably construed as a significant impact. Given current environmental conditions, further losses would be unacceptable from an ecological perspective. This sub-section of the Chesapeake Bay is a microcosm of Bay area problems which have comparable, significant long-term ramifications. In the Chesapeake Bay Low Freshwater Inflow Study (COE, 1984b), the water-supply demands in the Bay were projected to increase from 4370 mgd (1965) to 5990 mgd (2020) with an increase in consumptive losses of 2060 mgd. These diversions are anticipated to cause 50-85% reductions in oligohaline and tidal freshwater marshes, soft clams and preferred harvest species of waterfowl and fish. Monetary commercial fishing losses attributable to the reductions in freshwater inflow averaged $25-30 million annually. During drought years it was estimated that damages could vary from $70-80 million. It should also be noted that current concerns regarding global warming and sea level rise were not factored into the evaluation.

A comparison between Figure 9a and Figure 10 reveals that most of the significant drainages within the prescribed lower York River watershed have been affected by impoundments. In this context, Ecol Sciences (1989) notes that these watersheds:

"... are being dammed in temporal and spatial succession; barring a change in this trend, it is possible that the only free-flowing watersheds to the York River in this vicinity could be those too small to impound."

The commentary continues:

"As each new impoundment goes in place, watersheds that were considered poor(er) alternatives in the past become, by default, preferred alternatives for dam locations (as was apparently the historical circumstance with the Ware Creek). Environmental impact assessments would consider the need for additional water supplies, and argue that the proximal impacts of another new impoundment were tolerable. From a cumulative impact assessment perspective, this type of development sequence invites long-term problems and long-range significant adverse impacts on local and regional ecosystems."

Coincidentally the same point was made during the January 10, 1989, public hearing. Mr. Paul S. Baker remarked:

"I found there was mention of a Ware Creek reservoir in a 1974 draft Environmental Impact Statement in connection with Newport News Little Creek reservoir dated August 1974 prepared by the Norfolk District Corps of Engineers, in the section on alternatives to proposed action. 6.4 Ware Creek. I'm quoting, "A dam in the Ware Creek drainage basin was not acceptable because of the large amount of land that would be inundated in storing 6.2 billion gallons of water, amount of tidal marsh which would be impacted, and distance from existing raw water transmission mains" etcetera".

Figure 11 graphically depicts the long-term sequence of events that has led to resource allocation for water supply in the Ware Creek vicinity. Diascund Reservoir in the 1960's was followed by the Little Creek Reservoir in the 1970's which in turn is followed by the Ware Creek Reservoir for the 1980's. The "domino effect" alluded to by Ecol Sciences and Mr. Baker can be tangibly appreciated in this illustration.

Despite the presence of three impoundments in the Ware Creek watershed, the balance of the system remains as the largest linear tract of headwater-to-confluence wetlands in the western half of the lower York River watershed and the second largest in the entire prescribed watershed. Though valuable in and of itself, the relative value of the existing Ware Creek watershed is enhanced because of the societal impacts which have already affected the ecosystem substantially:

MAJOR WATER SUPPLY
IMPOUNDMENTS IN THE
WARE CREEK VICINITY

FIGURE 11

LOCATION OF DIASCUND, LITTLE CREEK

20 impoundments constructed
1,106 acres (26.9%) of inland vegetated wetlands disconnected from downstream ecosystem processes
474 acres (estimated) inland vegetated wetlands inundated

Construction of the Ware Creek impoundment will add another obstruction and destroy or disconnect an additional 311 wetland acres - exacerbating environmental damage in an area which has exceeded the "significance" threshold long ago.

A poor assessment of cumulative impacts was one of several observations made by the U.S. Government Accounting Office (1988: 28-33) in a review of the Corps of Engineers administration of the Section 404 program. This reflects difficulties with the present environmental review process which were cited by Roots (1986: 151-152):

> "Present structures for environmental assessment and review are part of a system intended to preserve and perpetuate the very economic practices and values...that have given rise to the environmental problems we are trying to correct. The assessment of cumulative effects directly challenges these entrenched practices, jurisdictions, and value systems, and so will not easily be accommodated within established mechanisms...one of the commonly shared concerns was that structural and conceptual changes were needed in the processes..., if cumulative assessments were to be dealt with adequately."

Following up, Gosselink and Lee (1987) identified a series of unique attributes concerning cumulative impacts assessment which must be dealt with. In the discussion of Scientific/Technical Issues the following points were made.

With regard to <u>Ecological Complexity</u> they state:

> "Ecosystems and landscapes are exceedingly complex. If traditional approaches to impact assessment are used to assess cumulative impacts the complexity will soon become unmanageable. Because cumulative impacts are landscape level processes, the challenge is to identify "valued ecosystem components" around which the assessment can be built."

They go on to say:

> "...we should not expect standards and techniques developed for individual permit application to be adequate for cumulative impact assessment. We should be considering the architectural design of the landscape and testing the strength of the whole ecosystem "wall", not the quality of the individual "bricks" from which it is built."

Concerning Incremental Environmental Change they note that this

> "...issue captures the fundamental difference between traditional permit-level regulation and cumulative impact assessment. Usually on the scale of cumulative impacts (for example, watersheds, regions) permit-level activities are not measurable. That is not to say that the impact is not real, but only that the incremental change in the resource caused by one proposed action is below the level of detection with the analytical techniques available. In statistical jargon the incremental change is within the error term of the estimate. On the other hand, when one hundred or one thousand individual permits are granted in the management unit, the total impact can be serious, Under these circumstances the techniques used for individual permit review cannot find the impact of the proposed activity significant, and denial of the permit request is difficult even though it is clear that the impact of many such requests could be devastating to the environment. From this observation it is hard to escape the conclusion that if cumulative impacts are to be regulated, individual permit requests will have to be handled within a context of preplanning that involves a prior setting of limits for development."

Remarking on the Importance of Pattern in the Landscape:

> "It is not enough to know the total area impacted by a human activity in a management unit. The pattern in the landscape of that impact is also important. For example 50,000 ha of forest in a single block might support some far-ranging mammals that could not be supported on 50 separate 1000 ha tracts, and water quality is likely to be preserved better in the face of clearing if buffer strips are maintained along stream edges, instead of permitting clearing to the stream bank. Relevant aspects of pattern are patch size, patch continuity (whether patches of similar habitat are linked with corridors), and contiguity (which defines the spatial relationship of different habitat types). Orians (1986) stated:

"Perhaps the most important single problem in biological conservation relates to our ability to preserve species in the face of habitat fragmentation. There is considerable debate about the details of the consequences of fragmentation ... and how best to respond to those effects when designing the sizes and shapes of reserves. There is, however, nearly universal agreement that the cumulative effects of fragmentation are important."

"In effect, the scope of cumulative impact assessment is to design reserves, not in the sense of wholly dedicated natural areas, but in the sense of conserved or reserved environmental resources. Pattern and fragmentation are properties of the whole landscape and cannot be addressed at the permit level, except in the context of decisions made about the whole management unit."

With regard to the Boundary Problem, Gosselink and Lee (1987) separate the issue into spatial and conceptual components:

" Spatial boundaries. Cumulative impacts occur at a number of scales. For example, water quality impacts may be important as a small watershed problem, or by aggregation of a number of small watersheds, they may be treated at the level of major watersheds. The scale may range from a few thousand hectares to the watershed of the Mississippi River, which covers nearly one half of the United States. Other cumulative issues are not bounded by watersheds; it might be more appropriate to speak of wolf-sheds or bear-sheds when considering the cumulative effect of forest clearing on large mammals. For migrant waterfowl the appropriate scale is continental. And for practical reasons the scale selected might be circumscribed by political boundaries. The choice of scale is important because it influences the outcome of a cumulative impact assessment. From an environmental point of view a variable scale is desireable, but whether this is practical for regulatory purposes is unclear."

> Conceptual Boundaries. "concerns the need to consider cumulative impacts at a landscape level of resolution. But if cumulative impacts are to be considered at a landscape scale, what tools are available to compare landscapes? What does a healthy, functioning landscape look like? To answer these questions it is imperative to identify a minimum set of predictors or indicator functions to characterize the "health" of the landscape (Lee et al. 1986). This set of indicators must provide a reliable picture of the landscape in a parsimonious manner; that is, it must be fairly simple to use and not too time-consuming."

Time Scales were found to ...

> "become especially important when the focus of regulatory activity is shifted from the permit scale to the cumulative scale. Generally speaking, the time frame of human endeavours (COE projects, farmland clearing, economic forecasting) is no longer than one human generation - 20 to 50 years. In contrast most natural ecosystems, especially forested ones, develop on a scale an order of magnitude longer. A southern bottomland forest - which by forest standards is extremely fast growing - takes at least 100 years to achieve some maturity, and probably could not be called a climax system in under 200 to 500 years. Biological landscape patterns reflect the underlying hydrologic and geomorphic processes, which, in geologically active sedimentary environments of river systems, have developed over thousands of years. Major man-made hydrologic modifications are essentially irreversible in human time scales, and their effects can be major and pervasive in bottomland forests."

It is our opinion that the review of this project adequately reflects these principles.

C. Mitigation

Actions to minimize the environmental effects of permit proposals generally follow the sequence: avoid, minimize and restore, in decreasing order of preference. In the case at hand, EPA has determined that the existing Ware Creek ecosystem cannot be adequately mitigated. Nevertheless, James City County has profferred a mitigation plan (Reed and Associates, 1986) which includes wetland creation, wetland enhancement, the reestablishment of an historical anadromous fishery stream and, more recently, proposals for large scale preservation.

James City County is to be commended for the extensive and innovative approaches that have been applied in an effort to minimize the disruption which is inherent in the construction of a 1200-acre water supply impoundment. Primary features of the County plan include:

1. Breaching of Cranston's Pond, thereby reestablishing an historic anadromous fishery and the linkage of the several hundred acres of inland wetlands with the Chickahominy River.

2. Restoring 37 acres of vegetated wetlands on the former Cranston's Pond bottom.

3. Creation of approximately 130 acres of wetlands in the Ware Creek watershed.

4. Dedication of a total of $1.15 million directly to acquire and preserve wetlands and adjacent upland habitat in Yarmouth Creek and Powhatan Creek.

The plan has been praised by some as the most comprehensive mitigation proposal put forth in the region. This is, in all probability, true. Unfortunately, the plan does not approach an adequate replacement of a diverse system such as Ware Creek. Furthermore, the mitigation plan compares well with other plans primarily because of the generally poor record of success which wetland mitigation generally has (see Larson and Neill, 1986; Reimold and Cobler, 1986; and Houck, 1978).

In evaluating the net environmental impact of the project proposal, sponsors tend to place the best light on impact minimization efforts while depicting the existing system in a worst case (i.e. least valuable) context (Dames and Moore, 1989; James City County, 1989).

A response to the primary arguments has been submited by Bell (1989) and is appended to the recommended determination (Appendix E). To reiterate earlier comments however, mitigation by accounting (i.e. counting acres) misses the point that the existing Ware Creek watershed is a complex, diverse system which has developed over time under the prevailing environmental conditions. The fauna and flora which survive are adapted to the fluxes and pulses which may appear disruptive and chaotic to some. Watershed "creation" has a mixed history at best, which calls into question the 100% success implied by mitigation proponents. Lake environments are characteristically less productive that most wetlands, or upland forests for that matter (Richardson, 1979). Furthermore, a large segment of the proposed headwater wetland will be isolated by a widely fluctuating lake margin which is designed primarily to meet water supply criteria rather than the stability of ecosystem processes. In addition, the headwater wetlands will be inundated if the reservoir surface elevation is ever raised to address the greater storage volumes which are necessary for a legitimate regional water supply facility. No mention has been made about that scenario, or the need for mitigation of the mitigation acres.

VII. Alternatives

In evaluating the unacceptability of impacts to aquatic or wetland ecosystems, consideration is given to the relevant portions of the Section 404(b)(1) guidelines (40 C.F.R. Part 230). This includes examination of practicable alternatives to the proposed discharge [§230.5(c)]; determinations of cumulative impacts [§230.11(g)], etc. With regard to the feasibility of alternatives, several alternatives to a Ware Creek reservoir have been discussed and evaluated over the course of the past decade.

A. Regionally - Oriented Alternatives

A compelling avenue for alternative analysis has been the evaluation of a range of regional water supply plans. Such an approach would meet the needs of James City County within the context of a larger solution to a major regional resource problem. The preferred regional alternative to the Northside Hampton Roads study (COE, 1984a) shows promise, but unfortunately several parts of the formula have not been quantified. This solution - a pipeline from the James River with an intake above Richmond - was thought to be able to supply 40 mgd to the Northside Hampton Roads with the least environmental damage. A critical datum - the minimum in-stream flow requirements of the James River is currently subject to intense debate. Unfortunately, a funding source for the necessary studies to settle the issue has not been found. Furthermore, state agencies have not demonstrated leadership in developing a concensus for regional approaches. An additional complication is that potential water users in the vicinity of Richmond have not yet revealed their own plans for the balance of the available yield of the James River. Public statements from this quarter have generally been to support the water supply proposals of downstream users which do not impinge on the James River watershed.

EPA has reviewed the issues raised concerning regional public water supplies for Southeast Virginia. We recognize the local and statewide jurisdictional and authority issues, and the information gaps that currently constrain the full coordination, study and implementation of a regional solution. EPA believes that because of the high value of Southeastern, Virginia, and Chesapeake Bay resources, alternatives that may hold serious promise should not be dismissed based upon information gaps and difficulties of regional cooperation. Instead, efforts should be pursued to obtain necessary data and remove institutional barriors to sound water management.

B. Groundwater

Groundwater is currently an important source of drinking and process water for many users in the Northside Hampton Roads. Given the range of aquifers from which to draw, the varying water quality, etc., several studies have been initiated to study the feasibility of using groundwater for either local or regional supplies. To complement studies which concerned the supply aspects of the issue, EPA funded a feasibility study for the reverse osmosis treatment of brackish groundwater (EPA, 1987).

This study was initially funded to investigate alternatives to the impoundment and wetland destruction of Beaverdam Swamp in Gloucester County, Virginia. The results of the study demonstrated the technical and economic feasibility of reverse osmosis but also have had impacts beyond the original intent. Results of the study provided encouragement to the City of Suffolk to fund their own demonstration of the utility of reverse osmosis and electrodialysis reversal (Thompson, 1988). The results apparently exceeded expectations and a full scale treatment facility, based on the electrodialysis reversal process, is underway. The conclusions of the reverse osmosis study, combined with the pilot demonstration by Suffolk, reinforced EPA's opinion that conventional or unconventional treatment of groundwater is a viable option for James City County as either a local option (to replace the yield at a Ware Creek reservoir) or as part of a comprehensive regional plan.

A regional groundwater study recently released by the U.S. Geological Survey (USGS, 1989) was reviewed to determine if EPA's contentions concerning groundwater alternatives were still valid. Project proponents believe that sufficient groundwater does not exist to serve future James City County needs. EPA's review of the report, however, indicates that appropriate application of at least one of the projection scenarios would have yields which could fulfill some of the additional water supply needs of James City County. With sound water supply management most of James City County's needs could likely be met. Unfortunately, lack of state regulation provides no assurance that other users would not interfere with the effective use of groundwater by James City County. The USGS report states that:

> "Because numerous users already withdraw groundwater, it is far more likely that water-level declines will result in unacceptable interference among groundwater users before dewatering of the aquifers is a concern. From a water management perspective, this means water-level declines will limit the yields from aquifers before available recharge is depleted unless existing users lower screen intakes."

Furthermore, the contents of the USGS report indicated that to optimize the yield of the York-James Peninsula groundwater system, it would be necessary to develop a regional approach so that each new well's location, spacing, pumping rate, aquifer selection and screening, and other factors could be part of an overall regional management plan. (Gannett-Fleming, 1989b - Appendix D).

The Virginia Groundwater Act of 1973, provides for the establishment of Groundwater Management Areas by the State Water Control Board. (SWCB). Establishment of such an Area on the York-James Peninsula could potentially provide a greater degree of protection of existing wells and future groundwater users. Unfortunately, as of yet no Area has been so designated for the Peninsula (Gannett-Fleming, 1989b).

C. Conservation

The Southern Environmental Law Center (SELC, 1989) and the Chesapeake Bay Foundation (CBF, 1989) have both taken EPA somewhat to task for not placing greater emphasis on conservation in developing comprehensive water supply solutions. This point is well taken. In a monograph submitted as comment for the proposed determination, the SELC (1989) draws comparisons between the potential for water conservation and the realized efficiency gains which were made during the energy supply crises of the 1970's.

> "[I]n the typical plan, water use is projected as a need, or requirement, independent of water supply constraints. The implicit assumption is that water supplies are unlimited or costless. This means not only that the demand projections are suspect but also that inadequate consideration is given to the economics of reallocating existing supplies or to reduction in use. Conservation in use and possible reallocation among uses should be explicitly considered in conjunction with the alternatives of new development and supply augmentation. New development cannot be justified on economic grounds unless incremental (marginal) values in use are equalized among competing uses and are sufficient to justify the incremental costs of the new investment. Demand projections for metropolitan water services have generally failed to do this." (Millman, 1978)

Similarly:

> "[Water] [w]ithdrawals have been projected to grow roughly in step with population and economic growth, and projected levels of water use have acquired the status of requirements, of virtual necessities to be provided regardless of cost. Despite evidence to the contrary, the quantity of water demanded by offstream users has generally been assumed to be insensitive to the costs. Consequently, public concern about water adequacy is translated into support for large, capital-intensive projects, and planners tend to focus on structural solutions." (Fredrick, 1986)

In a further review of these water supply studies (Northside Hampton Roads; SWCB - James Water Supply Plan; James City County's 1983 projections), the SELC finds that they underestimate water conservation opportunities and overstate water supply deficits for three reasons: (1) They underestimate the opportunities for ongoing water demand reductions through the use of water saving fixtures, replacement cost water pricing and public education; (2) They set as their target the elimination of all water use restrictions during the most severe droughts; (3) They dismiss conservation as an "alternative" to supply projects because standing alone it cannot eliminate projected water deficits.

Although the calculations which SELC arrives at in their study may be debated, the fundamental fact is that many of the proposals put forth yield incremental reductions in demand by factors of 18% (e.g. imposition of 25% rationing during severe drought) to 20% (e.g. statewide imposition of conservation eriented building codes). If even a portion of these demands reductions are feasible, the positive implications for the environment and government economy are substantial through the avoidance of unnecessary public works projects. The SELC (1989: 51) postulates that: "reasonable conservation measures could reduce projected water deficits for Northside and Southside Hampton Roads by 17 MGD and 24 MGD, respectively. This would eliminate the need for almost two Ware Creek reservoir equivalents on the Northside alone."

D. Three-Dam Alternative

One structural alternative to the proposed Ware Creek project has been discussed in some detail. This proposal involves the construction of three small impoundments in the Upper Ware Creek Watershed. Despite the fact that this approach would greatly reduce the environmental impacts with a proportional reduction in yield, we believe that James City County never seriously considered this option as a viable alternative. The lack of planning for mitigation under this scenario would seem to bear that observation out. SELC (1989: 53) postulates that even a Three Dam option can be used imaginatively as part of a comprehensive, regional solution:

> "For example, James River withdrawals of 20 MGD plus 6 MGD from the three-dam alternative on Ware Creek and 4 MGD of groundwater would reduce the Corps' projected 2030 deficit to only 10 MGD without any additional ongoing conservation beyond what the Corps is projecting."

EPA has considered the position of both James City County and project opponents relative to the three dam option. We believe that this option continues to present serious environmental consequences. However, in the context of impact minimization the three dam option should have received more attention.

E. Conclusions

James City County (1989) and others have critized EPA for, in their opinion, holding the County hostage in a vain attempt to achieve regional cooperation. It is true that EPA has made efforts to foster such a dialogue (see Water Supply Symposium Synopsis - EPA, 1989). A different point of view is offered by the Southern Environmental Law Center. As SELC (1989: 55) notes ....

> "...impediments appear to be blocking regional solutions to the Northside's supply deficit now. The Water Control Board has noted that jurisdictional conflicts may block the utilization of withdrawals from the James or the

- Pamunkey. The Board chose not to recommend preferred water supply alternatives for the lower York-James peninsula because of the jurisdictional conflicts. One reason for James City County's decision to build a Ware Creek reservoir is dissatisfaction with its supply arrangement with Newport News:

> Under this agreement James City County must finance the design and construction of new water facilities and then dedicate them to Newport News; yet the County receives no guarantee of future services, no considerations for reduced water rates and no representation in the formation of water policies.

As on the Southside, inadequate information exists regarding groundwater availability. James City County may have chosen not to rely on groundwater in part because Newport News is also looking to utilize the resource. In today's institutional situation, EPA is concerned that municipalities will pursue water self-sufficiency by building locally oriented reservoirs, resulting in unnecessary environmental damage.

The primary motivation for EPA has been the impacts of the Ware Creek project on the Ware Creek and Chesapeake Bay ecosystems and the witnessing of a spiral of environmental degradation, arising from water supply projects, which is growing higher (greater damage) and tighter (shortened time frames) over time. Single impoundments such as Diasund and Little Creek spaced at ten year intervals are now replaced by clusters of proposals (Beaverdam Swamp - Ware Creek - Crump Creek) compressed into a relatively short time span. Impoundments sized at 500-1,000 acres resulting in 200-300 acre losses to the wetland resource are now replaced by Ware Creek - sized impacts (1,200 acre lake - 425 wetland acres lost) in which many ecological benefits not tied to acreage are also lost. Projecting to the relatively near future, the 10,000 acre Lake Genito on the Appromattox River implies another quantum leap in the scale of environmental damage.

The EPA is compelled to act given the anticipated environmental losses from reservoir construction and the anticipated devastation arising from accumulated freshwater diversions from the Chesapeake Bay (COE, 1984b). As has been said before, the threshold delimiting "unacceptable" environmental losses has been passed - individually and cumulatively.

VIII. Recommended Determination

After consideration of the entire record in this case, my conclusion is that filling and inundating the subject water, including wetlands would have an unacceptable adverse effect on wildlife, fishing areas and recreational areas.

Therefore, I am recommending that action be taken by EPA under Section 404(c) of the Clean Water Act (CWA) to prohibit specification or use of the subject waters, including wetlands, as a disposal site for dredged or fill material in association with the construction of any dam, lake or reservoir.

Stanley L. Laskowski
Acting, Regional Administrator

2-17-89
Date

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APPENDIX A

Table 1. Fish species collected from Ware Creek stream habitats upstream of the proposed Site V dam (Ayers et al. 1980, J.R. Reed and Associates, Inc. 1982)

Longnose gar	*Lepisosteus osseus*
American eel	*Anguilla rostrata*
Gizzard shad	*Dorosoma cepedianum*
Redfin pickerel	*Esox americanus americanus*
Golden shiner	*Notemigonus crysoleucas*
Creek chubsucker	*Erimyzon oblongus*
White catfish	*Ictalurus catus*
Yellow bullhead	*Ictalurus natalis*
Brown bullhead	*Ictalurus nebulosus*
Pirate perch	*Aphredoderus sayanus*
Sheepshead minnow	*Cyprinodon variegatus*
Mummichog	*Fundulus heteroclitus*
Mosquitofish	*Gambusia affinis*
Tidewater silverside	*Menidia beryllina*
White perch	*Morone americana*
Bluespotted sunfish	*Enneacanthus gloriosus*
Pumpkinseed	*Lepomis gibbosus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Largemouth bass	*Micropterus salmoides*
Johnny darter[1]	*Etheostoma nigrum*
Yellow perch	*Perca flavescens*
Spot	*Leiostomus xanthurus*

[1] Probable misidentification. The tessellated darter (*etheostoma olmstedi*) is a similar species that is much more likely to be found on the Virginia coastal plain.

Table 2. Amphibians and reptiles that occur, or are likely to occur, in the wetland communities of Ware Creek (Schwab) 1988, VDGIF 1989).

Red-spotted newt	Notophthalmus viridescens viridescens
Spotted salamander	Ambystoma maculatum
Fowler's toad	Bufo woodhousei fowleri
Northern cricket frog	Acris crepitans
Gray treefrog	Hyla crysoscelis
Green treefrog	Hyla cinerea
Spring peeper	Hyla crucifer
Eastern spadefoot toad	Scaphiopus holbrooki holbrooki
Bullfrog	Rana catesbeiana
Green frog	Rana clamitans melanota
Pickerel frog	Rana palustris
Southern leopard frog	Rana sphenocephala
Eastern painted turtle	Chrysemys picta picta
Redbelly turtle	Pseudemys rubriventris
Eastern box turtle	Terrapene carolina carolina
Five-lined skink	Eumeces fasciatus
Broad-headed skink	Eumeces laticeps
Eastern worm snake	Carphophis amoenus amoenus
Rough greensnake	Opheodrys aestivus
Black rat snake	Elaphe obsoleta obsoleta

Appendix A

Table 3. Birds that occur, or are likely to occur, in the wetland communities of Ware Creek (USFWS undated, Rhodes 1988, VDGIF 1989).[1]

Pied-billed grebe	Sora
Great blue heron	American coot
Great egret	Killdeer
Green-backed heron	Greater yellowlegs
Wood duck	Solitary sandpiper
Green-winged teal	Spotted sandpiper
American black duck	Least sandpiper
Mallard	Common snipe
Northern pintail	American woodcock
Blue-winged teal	Black-billed cuckoo
Northern shoveler	Yellow-billed cuckoo
Gadwall	Eastern screech-owl
American widgeon	Great horned owl
Canvasback	Barred owl
Redhead	Ruby-throated hummingbird
Ring-necked duck	Belted kingfisher
Lesser scaup	Red-headed woodpecker
Common goldeneye	Red-bellied woodpecker
Bufflehead	Downy woodpecker
Hooded merganser	Hairy woodpecker
Ruddy duck	Northern flicker
Osprey	Pileated woodpecker
Bald eagle	Eastern wood-pewee
Sharp-shinned hawk	Acadian flycatcher
Cooper's hawk	Eastern phoebe
Red-shouldered hawk	Great crested flycatcher
Red-tailed hawk	Eastern kingbird
Wild turkey	Purple martin

[1] Common names derived from the " Thirty-fourth Supplement to the American Ornithologists' Union Check-list of North American Birds," Supplement to the Auk, Vol. 99(3), July 1982. Scientific names are not included because accepted common names accurately identify species in this taxonomic group.

Appendix A

Table 3, Continued

Tree swallow
Blue jay
American crow
Fish crow
Carolina chickadee
Tufted titmouse
Red-breasted nuthatch
Brown creeper
Carolina wren
House wren
Winter wren
Marsh wren
Golden-crowned kinglet
Ruby-crowned kinglet
Blue-gray gnatcatcher
American robin
Gray catbird
Northern mockingbird
Brown thrasher
European starling
Red-eyed vireo
Northern parula
Chestnut-sided warbler
Cape May warbler
Black-throated blue warbler
Yellow-rumped warbler
Black-throated green warbler
Yellow-throated warbler
Palm warbler
Blackpoll warbler
Cerulean warbler
Black-and-white warbler
American redstart
Prothonotary warbler
Northern waterthrush
Louisiana waterthrush
Kentucky warbler
Common yellowthroat
Hooded warbler
Northern cardinal
Indigo bunting
Rufous-sided towhee
Song sparrow
Swamp sparrow
White-throated sparrow
Dark-eyed junco
Bobolink
Red-winged blackbird
Rusty blackbird
Common grackle
American goldfinch

Table 4. Mammals that occur, or are likely to occur, in the wetland communities of Ware Creek (Jackson et al. 1976, VDGIF 1989).

Virginia opossum	Didelphis virginiana
Southeastern shrew	Sorex longirostris
Hoary bat	Lasiurus cinereus
Gray fox	Urocyon cinereoargenteus
Raccoon	Procyon lotor
Long-tailed weasel	Mustela frenata
Mink	Mustela vison
River otter	Lutra canadensis
White-tailed deer	Odocoileus virginianus
Gray squirrel	Sciurus carolinensis
Beaver	Castor canadensis
Marsh rice rat	Oryzomys palustris
White-footed mouse	Peromyscus leucopus
Meadow vole	Microtus pennsylvanicus
Meadow jumping mouse	Zapus hudsonius

REVIEW OF ENVIRONMENTAL ISSUES RELATED TO CONSTRUCTION AND OPERATION OF THE WARE CREEK RESERVOIR, JAMES CITY COUNTY, VIRGINIA

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Region III
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I. BACKGROUND INFORMATION

A. Scope of Review

James City County proposes to construct and operate a water supply reservoir on Ware Creek to meet projected water needs. The reservoir would have a surface area of 1,217 acres and provide a maximum safe yield of 9.4 million gallons per day (MGD). The reservoir would inpound a major portion of the Ware Creek watershed, inundating 425 acres of wetlands (381 acres of vegetated wetlands) and 792 acres of uplands (primarily hardwood and mixed pine-hardwood forest).

The proposed project has been subject to Federal study since 1981, and Draft (DEIS) and Final (FEIS) Environmental Impact Statements have been submitted by the County. The U.S. Army Corps of Engineers, Norfolk District, issued on 11 July 1988 a notice of intent to issue a permit for the applicant's preferred alternative - construction of the 1,217 acre reservoir on Ware Creek.

The United States Environmental Protection Agency (EPA) has reason to believe that the proposed discharge of dredged and/or fill material into Ware Creek will have unacceptable adverse effects on wildlife or recreational area. Furthermore, the EPA has reason to believe that alternatives are available to James City County that are feasible and that can meet projected water supply needs at less environmental cost.

This report reviews potential environmental impacts that could result to the Ware Creek ecosystem and to larger ecosystems of which it is an integral part. Where existing data permit, the magnitude of such impacts is quantified using generally accepted ecological methods.

The principal concerns addressed in this review are:

- What are the existing ecological values of the Ware Creek ecosystem, particularly the wetlands, and to what degree would they be adversely affected by implementation of the proposed reservoir project?

- To what degree do the mitigative measures proposed replace the wetland ecosystem functions and values lost by project implementation?

- Based on the findings of the inquiries above, will the project result in significant adverse impacts to the local and regional ecosystem?

The criterion for rating an environmental impact as "significant" will be, in this review, a finding that a measureable property of the existing ecosystem is reduced by 10 percent or more. Although less pronounced changes in properties may indeed be significant to the biota of the ecosystems (or the converse), an 10 percent change should be detectable by quantitative sampling, and thus be apparent to the human evaluators of the ecosystems.

The format of this review includes pertinent background information on the project (Section I), including a summary description of the affected environment, a summary description of the proposed action, and a recapitulation of major persistent issues about the action. Section II presents detailed discussions of ecosystem values and of estimated changes, while Section III contains a summary of findings from this review.

B. Description of Ware Creek Watershed

B.1. General Features

The Ware Creek watershed in James City County, Virginia is a dendritic drainage area of 10,838 acres. This coastal plain creek is tributary to the York River. The watershed has several deeply-incised subdivisions that all drain to a single tidewater confluence with the York. Although many level upland areas have been logged and replanted in conifers, an ongoing process, the watershed is largely undeveloped.

Ware Creek is the largest of several similar watersheds along the lower reaches of the York River. Most of these other watersheds have been modified by development and/or impoundment for water supply to eastern municipalities.

B.2. Structural Components

The Ware Creek ecosystem includes several major community types within its drainage area, giving the system high structural complexity. The upland areas are covered with pine/hardwood and hardwood forest, while wetter areas include palustrine forested, shrub/scrub, and herbaceous wetland communities.

The valley floor of the watershed is composed of poorly drained, highly compressible alluvial materials, and these "bottomland" wetlands support a variety of hydrophytic species of trees, shrubs, and grasses. Open freshwater areas are found in the lower reaches of the branch swamps and in beaver dams scattered throughout the watershed. Estuarine emergent and open water habitats characterize the confluence of Ware Creek with the York River.

A quantification of the undeveloped Ware Creek watershed acreages by vegetative community type is shown below. These acreages, summed by cover type, are taken from the FEIS at pages 2-14 (para. 2.38) and 3-5 (par. 3.30 and 3.22).

Ware Creek Watershed
Acreages by Cover Type

Cover Type	Acres
Upland mixed pine-hardwood forest (UPH)	3913.0
Upland hardwood forest (UH)	5808.0
Forested wetland (FW)	275.7
Scrub-shrub wetland (SS)	71.8
Herbaceous wetland (HW)	636.5
Palustrine open water (POW)	83.1
Lacustrine open water (LOW)	34.0
Estuarine open water (EOW)	67.0
TOTAL	10889.1

Source: Final Environmental Impact Statement; James City County's Water Supply Reservoir on Ware Creek.

Due to the dendritic, heavily-incised nature of the watershed, the major vegetative community types occur in a relatively predictable sequence related to topography. The flat uplands are now largely coniferous and hardwood forests (with many of the original hardwoods having been harvested from such accessible areas), the steep slopes from the flat uplands to the bottom lands are still dominated by deciduous hardwoods, and the bottomlands are covered with a complex array of wetlands habitats ranging from open water to palustrine forest.

Local variations in topography promote the intercalation of such discrete habitat types, and the activities of beavers add an additional small-scale influence. As a result of the watershed hydrological processes, the Ware Creek ecosystem is a highly complex mosaic of closely interconnected wetland habitats. The high ecological value of such a spatial arrangement of habitats will be considered in a later section (Chapter II, Section A.3).

B.3. Functional Values

Temperate wetlands are almost universally acknowledged as extremely valuable ecosystems. The production of plant biomass in such an ecosystem is higher than any other natural area in the temperate zone, and much of this biomass is exported to neighboring aquatic ecosystems, where it provides energy to run detrital food webs. Wetland areas offer a wide variety of secure habitats for many plants, invertebrates, amphibians and reptiles, and birds and mannals. Threatened and endangered species (Federal and/or State designation) are often found in these habitats. Because of the relatively low level of human disturbance in such areas, wildlife species intolerant of human activities may use these areas as refuges.

The natural functions of wetlands also serve very important "services" to the human population. Wetlands have a high capacity for detaining storm water runoff, reducing erosion and trapping sediment, buffering nutrient fluxes through these systems, and reducing flood damages.

Wetlands also serve the human population by serving as natural laboratories and educational facilities, offering insights into the functioning of these systems to scientists and laypersons. Aesthetically, they offer a diversity of vistas of natural communities. The abundance of wildlife in these areas attracts hunters, where such activities are permitted.

B.4. Exceptional Features

The list of positive values of wetlands ecosystem summarized above applies broadly to almost all wetlands in the nation. To leave the Ware Creek description at that point would be to do injustice to the watershed's exceptional features; attributes of the existing system that have evolved over long periods of time, and whose re-creation or replacement by mitigative efforts is speculative. Some of the exceptional features of the site are:

- <u>The blue heron rookery</u>. Great blue herons, colonial-nesting wading birds, maintain a rookery in France Swamp. Since 1982, the size of this colony has varied from 45 to 88 nesting pairs. The blue herons build nests in large trees in the bottomlands of Ware Creek, and would be displaced by the flooding of such habitats. Great blue herons are a species of "special concern" to the U.S. Fish and Wildlife Service.

- <u>The oligohaline and tidal freshwater plant communities in the reaches just below the proposed dam site</u>. Portions of Ware Creek support a plant community that includes such plants as wild rice, pickerelweed, giant bulrush, and arrow arum (tidal freshwater dominants) and big cordgrass, saltmarsh cordgrass, and water dock (oligohaline dominants). The reduced downstream flows resulting from the damming of the watershed would result in higher salinities in reaches currently supporting such vegetation. The predicted salinity changes would result in "the loss of the tidal freshwater vegetation of Ware Creek and a great reduction or elimination of the oligohaline assemblage" (Herschner and Perry, 1987). The loss of the wild rice community would be of particular significance because the seed heads of this species provide a food source of great value to waterfowl.

- <u>The exceptional waterfowl habitat offered by the tidal freshwater marsh areas</u>. The tidal freshwater marsh areas of the Ware Creek ecosystem are valuable feeding and overwintering areas for waterfowl, particularly black ducks (USFWS, 1989). Existing hydrological and vegetative community attributes of the watershed are the reasons for this value. The North American Waterfowl Management Plan has identified the Middle-Upper Atlantic Coast region, which encompasses Ware Creek, as an area of international significance to waterfowl, and has recommended that additional acreages of black duck migration and wintering habitat along the East Coast be provided. The loss of 75 acres of tidal freshwater marsh of high value to black ducks and other waterfowl is contrary to that recommendation and inconsistent with the waterfowl management plan cited.

- <u>The exceptional habitat diversity of the watershed</u>. The summations of wetlands acreages presented in the FEIS do not adequately portray the complexity of the spatial arrangement of the wetland habitats. For example, the forested wetlands (PFO type) in the watershed sum to 275.7 acres; what is not emphasized is that this lump sum is composed of 51 small areas (all mapped, and ranging from 0.7 to 34.1 acres in area) that are nested among shrub-scrub wetlands, emergent wetlands, and forested uplands. Similar, though smaller sets of subareas are found for the other wetland categories. Such heterogeneity of habitat distribution in one continuous tract is not common, and represents a system of exceptional value to wildlife (Gosselink and Lee, 1987). These features have led the U.S. Fish and Wildlife Service to characterize the Ware Creek system as "unique and irreplaceable" in its comments on the permit action, and to identify Ware Creek as a Priority Wetland pursuant to the provisions of the Emergency Wetlands Resources Act.

- The contribution of the watershed to the Chesapeake Bay ecosystem. Coastal plain drainage systems such as Ware Creek export a significant portion of their high productivity to the Chesapeake Bay estuarine system. The exported organic material forms a substrate for bacterial growth, thus enriching the nutritive value of such plant detritus. A wide variety of filter-feeding and mucoid-feeding invertebrates utilize this food source, and themselves are eaten by higher-level consumers. Casting this contribution in the gross perspective of all inland wetlands, as is stated in Dames & Moore (1989) that "it [Ware Creek] amounts to 0.05 percent of Virginia's inland wetlands, and 0.04 percent of the inland vegetated wetlands surrounding Chesapeake Bay ..." fails to acknowledge any exceptional benefit of position - the Ware Creek watershed discharges to an estuarine region that serves a nursery function for estuarine invertebrates and fishes. Certainly, in the reach of the York River receiving the discharges from Ware Creek, the net benefit is greater than 0.05 percent.

The Ware Creek bottomlands are acknowledged as a valuable wetlands ecosystem by all parties contributing technical evaluations of the project and its impacts; that conclusion appears to be a common starting point in all assessments. Within that general category of "valuable wetland ecosystem", there are discernible differences expressed by evaluators in just how valuable the resource is perceived to be. Differences in that latter perception seem to be expressed as degrees of confidence in the proposed mitigation efforts. The exceptional features of the Ware Creek system itemized above are a long-term evolutionary response to the specific hydrological characteristics of the watershed, and the re-creation or replacement of such exceptional features is an effort with a high degree of uncertainty.

C. Description of Proposed Action

The following descriptions of the project are brief recapitulations of major project features, extracted from FEIS summaries. Their brevity is not intended to misrepresent the extensive planning efforts that have gone into the project as currently configured.

C.1. Proposed Facility

James City County proposes to develop a surface water reservoir to meet future water supply needs. A dam is proposed to be constructed on a northwest-southeast axis across Ware Creek approximately 1,000 feet downstream from the confluence of Ware Creek and Frances Swamp. The dam, 1,450 feet long, 300 feet wide at the base, and 48 feet high, will create a 1,217-acre surface impoundment extending to the peripery of the dendritic watershed. The maximum safe yield of the reservoir will be 9.4 MGD, based on a storage of 6, 355 million gallons at a normal pool elevation of 35 feet above mean sea level. A water purification facility will also be constructed, and 26,400 linear feet of transmission pipelines will be laid to connect the facility to existing transmission mains.

C.2. Unavoidable Adverse Impacts

As set forth in the FEIS (p. 4-25), the County's proposed facility would flood approximately 425 acres of wetlands and 792 acres of upland forest. The blue heron rookery in France Swamp would be destroyed. Operation of the reservoir at full capacity would reduce downstream flow below the proposed damsite by an average of 76%, causing a long-term change in species composition in the downstream vegetative communities.

C.3. Proposed Mitigation Efforts

The proposed mitigation plan would attempt to recreate at least 167 acres of wetlands, with another 128 acres of wetlands possibly created by additional mitigative efforts. An existing dam at Cranston's Pond in the James River watershed will be breached, opening this watershed to possible anadromous fish use, and, if successful, converting 37 acres of open water habitat to wetlands. Opportunity for the blue herons to resettle within the watershed will be provided, although prospects of such are highly uncertain. A minimum water release of 0.4 MGD is proposed proposed to maintain a flow in Ware Creek below the dam.

D. Persistent Major Issues

D.1. General Concerns

Concerns have been raised by the reviewing resource agencies about the magnitude of net adverse impacts attributable to implementation of the project. Proximal concerns are that the proposed discharge of dredged and/or fill material into Ware Creek will have unacceptable adverse effects on wildlife or recreational areas. On a broader scale, several resource agencies consider that reasonable and economically feasible alternatives are available to the County that will meet projected future water supply needs at a smaller environmental cost.

D.2. Specific Concerns

Specific concerns include the net loss of wetland acreage and the overall adequacy of the fragmented array of wetlands mitigation areas in replacing the functions of the Ware Creek ecoystem. Functions that may be irreparably damaged and not fully replaced include the export of detritus to the estuary, the wildlife value of the watershed, and the recreational/educational opportunities offered by the existing natural system.

D.3. Methodology of This Review

This technical review considers in further detail the ecological values of the existing Ware Creek ecosystem with those of the proposed impounded system. This comparison provides the basis for assessing the magnitude of adverse environmental impacts. In the context of the following discussions, a 10% negative change in an ecosystem attribute will be interpreted as a significant adverse impact; a change of 10% should be detectable by sampling with a moderate expenditure of effort.

II. ASSESSMENT OF POTENTIAL IMPACTS

A. Value of Ware Creek Watershed and Estimation of Changes in Values Resulting From the Proposed Action

In their natural condition, wetlands provide a variety of benefits to resident and migratory wildlife, adjacent ecosystems, and to the human residents using surrounding upland areas. Among the major categories of wetland benefits are (Tiner, 1987):

- High Aquatic Productivity
- High Quality Fish and Wildlife Habitat
- Water Quality Improvement
- Flood Damage Protection and Erosion Control
- Quality Recreational and Aesthetic Experiences

These broad categories of benefits derive from the inherent properties of wetlands, where water and nutrients are generally available, where variations in the degree of inundation promote the growth of a variety of vegetative communities, and where excess primary productivity is often exported to adjacent aquatic ecosystems. The diagnostic features of wetlands - water at or near the surface, hydric soils, and a preponderance of hydrophytic vegetation - are largely controlled by the local hydrological regime. Alteration of this hydrological regime is likely to alter, and possibly destroy, the structure and functions of an existing wetland ecosystem.

A variety of analytical techniques have been proposed to quantity (generally by comparison) the values of wetland functions. The USEPA (1984) has reviewed many of these wetland evaluation methodologies. The Ware Creek wetlands complex has been evaluated using the USFWS HEP system (one of those reviewed by EPA), and the results of this analysis are summarized in Appendix A of the FEIS. There are, however, some additional areas in assessment of potential impacts of the proposed Ware Creek impoundment that can be evaluated using orthodox ecological methods.

In the following sections, several of the values of the Ware Creek wetlands complex are analysed, both in terms of existing conditions and in terms of conditions expected to prevail were the impoundment to be constructed.

A.1. Primary Productivity

Primary production is the creation of organic molecules from inorganic carbon dioxide by photosynthetic organisms (plants). This primary production is the base of almost all food chains and food webs; consumers of various animal taxa use this primary production as an energy source. Primary production can be estimated by a variety of analytical means, including measuring carbon dioxide uptake, monitoring tracer materials, and weighing plant tissue.

Wetland ecosystems, including freshwater and estuarine systems such as found in the Ware Creek watershed, are thoroughly documented in the scientific literature as being among the most productive types of ecosystems on the planet (Odum, 1979). Production of organic material in such ecosystems ranges from 8 to 40 metric tons per hectare per annum (Richardson, 1979). These primary production rate estimates are about 50 percent greater than typical upland vegetative communities and 300 percent greater than temperate lakes (Colinvaux, 1973).

Although the precise determination of the overall primary productivity of the Ware Creek ecosystem would require that much more detailed data be gathered for analysis, an approximation of the primary productivity under existing conditions and future scenarios can be made using literature values for average primary production rates in a variety of wetland, upland, and open water community types. The elements of this approximation are shown in the following tables. The first table cites mean net primary production (NPP) rates that have been derived for major vegetative communities.

Approximation of Primary Production Rates in Ware Creek Watershed

Cover Type	Mean NPP (metric tons/ha/yr)
Upland mixed pine-hardwood forest (UPH)	12.7
Upland hardwood forest (UH)	10.2
Forested wetland (FW)	10.5
Scrub-shrub wetland (SS)	27.4
Herbaceous wetland (HW)	21.0
Lacustrine open water (LOW)	4.4
Estuarine open water (EOW)	16.0

Source: Richardson, 1979.

Note that the various vegetative communities found in the Ware Creek watershed have estimated net primary production rates that differ substantially. The wetlands communities generally match or exceed the primary production of upland forested systems, while lacustrine open water (lake) production rates are the lowest of any of the habitat or cover types in the watershed (due principally to nutrient limitations in these lacustrine systems).

The acreages of each cover type in the existing watershed and under the various Target Year scenarios with the project are found in the FEIS - Appendix A. The "No Project" acreages are listed on p. 14; the Site V alternative acreages are listed on p. 20. The acreage comparisons for Target Year 1 are shown below. Target Year 1 is used here because succeeding years have non-zero acreage values for low-density development, and comparable NPP estimates of such land uses are not immediately available.

Ware Creek Acreages
Target Year 1

Cover Type	Acres	
	No. Project	Alt. V
Upland Pine/Hardwood (UPH)	3913.5	3821.4
Upland Hardwood (UH)	5808.4	5054.9
Forested wetland (FW)	275.7	123.8
Scrub-shrub wetland (SS)	73.4	52.0
Herbaceous wetland (HW)	636.5	505.1
Lacustrine open water (LOW)	66.5	1227.0
Estuarine open water (EOW)	67.0	64.1
TOTAL	10841.0	10858.3

Source: Final Environmental Impact Statement; James City County's Water Supply Reservoir on Ware Creek.

The acreages listed above include, according to the FEIS text, the acreages in Cranston's Pond as well as in the Ware Creek watershed. Thus, calculations comparing the productivity of the two scenarious are reflective of project planning with respect to overall mitigation.

Use of the acreage estimates of the several vegetative communities as listed in the Ware Creek EIS to weight the primary production rates shown earlier yields the following estimated annual primary production in the Ware Creek watershed. The first column in the table below lists estimates for the unaltered system at Target Year 1; the second column lists estimates for the system at Target Year 1 after impoundment under Alternative V of the FEIS. As noted above, the acreage multipliers include all of the mitigation acreages (including Cranston's Pond); further, this analysis assumes that the mitigation acreages have primary production rates equal to their undisturbed natural counterparts, and that the reservoir remains at normal pool elevation at all times. With those assumptions, the annual primary production estimates are given in metric tonnes per year.

Estimated Annual Primary Production
Ware Creek Without and With Reservoir

Cover Type	Est. PP mt / yr No. Project	Est. PP mt / yr Alt. V
Upland mixed pine-hardwood forest (UPH)	49702	48532
Upland hardwood forest (UH)	59246	51662
Forested wetland (FW)	2895	1300
Scrub-shrub wetland (SS)	2011	1425
Herbaceous wetland (HW)	13367	10607
Lacustrine open water (LOW)	293	5399
Estuarine open water (EOW)	1072	1026
TOTAL	128584	119950

Source: Acreages from pp. 12 and 20 of Appendix A, FEIS; PP rates from Richardson, 1979.

It is worth noting that a variety of analyses using different primary production estimates could be run on these scenarios. The outcome - that overall primary production is reduced - is inevitable because the common finding in comparative studies is that lakes are less productive per unit area than are wetlands and swamps. The change from the "No Project" to the "Alternative V" scenario exchanges wetlands acreage for lake acreage with no significant change in total acreages; thus, the reduction in primary production is an inevitable consequence of the action.

Given the boundary conditions stated above, these calculations show that net primary production in the impounded watershed is only reduced by about 7%, a value just under the rule-of-thumb criterion adopted here of 10% for a significant adverse change in an ecosystem attribute. It is clear, however, that the source and nature of the primary production is significantly changed, with a larger proportion of plant production occurring in the lacustrine system.

It is further evident that at least one of the boundary conditions listed above (a static water level) will not hold under actual operation and that there are other operational features of the reservoir affecting the proportion of primary production that is actually made available to the lacustrine or estuarine ecosystems. The FEIS notes that the reservoir (operating at full capacity) will reduce downstream flows by 76% (FEIS, p. 4-25). Water that would ordinarily flow from the wetlands system to the York River estuary would be withdrawn for domestic use.

This volume of water withdrawn from the reservoir can be viewed from an ecosystems perspective as a cropping of water and water-borne constituents - nutrients, phytoplankton, zooplankton, and ichthyoplankton - that will end up on the filters of the water purification facility rather than in the waters of the downstream ecosystems. Thus, in the absence of any definition of this effect in the FEIS, it is reasonable to reduce the lacustrine productivity estimate above by 76%. With this correction to the primary production estimates made, the overall productivity of the watershed is reduced by approximately 10%, a significant adverse impact by the 10% standard used here.

Another feature of the proposed reservoir bearing on primary production estimates is that the water level of the impoundment is expected to fluctuate with withdrawals (FEIS, p. 4-5). In three of five years, the level is anticipated to drop by 5 feet (from normal pool elevation of 35 ft to 30 ft to 30 ft), exposing 242 acres and reducing the surface area of the impoundment by about 20%. Thus, water withdrawals will have a significant impact on the surface area attribute of the reservoir and on the primary production in the epilimnion of the water body. The drawdown, most likely occurring in the fall, would coincide with one of the two annual plankton blooms seen in most dimictic temperate lakes.

The frequent severe drawdowns will further reduce the overall primary production of the lacustrine system by inhibiting growth of macrophytes in the littoral (near-shore) zone due to exposure and dessication. Nearby impoundments, Little Creek and Diascound reservoirs, show littoral zones that lack development of aquatic vegetation. In fact, from the air, the bare sands of the littoral zones outline the margins of these reservoirs in a bright white band.

The fluctuating levels of the reservoir may affect primary productivity in more ways than simply reducing the area available for photosysthesis. The unvegetated littoral zone will be subject to wave action, resulting in the sorting of shoreline sediments and resuspension of silts and clays. These suspended particles will reduce light penetration and may reduce photosynthetic rates in phytoplankton populations near the lake margins. Even in Richardson's Millpond, a small impoundment in the watershed, littoral zone sediments show undulating patterns, indicating that sorting of sediments continues even in that static-level impoundment.

A.2. Secondary Production

Primary production can follow several pathways in the trophic web of the system: plant biomass can be grazed directly by consumers, organic material enriched by bacterial colonization can be consumed by detritivores, some detrital material can be laid down in peat deposits, and some material can be exported in particulate and dissolved forms to downstream ecosystems. The conversion of organic material produced from photosynthesis to animal biomass can be termed secondary production.

The material exported from highly productive ecosystems (termed allochthonous material) is available to support consumption (respiration) in the downstream ecosystems. This exported material enables such downstream receiving systems to support a consumer biomass in excess of the biomass that could be maintained by in situ (autochthonous) primary production; in essence, the watershed subsidizes the estuary in terms of food.

An important conclusion from this is that the structure of ecosystems receiving organic material exported from wetlands is dependent on such allochthonous material. Small streams may receive 50-90% of the organic "food" for consumers from the upstream areas of their watersheds (Merritt and Lawson, 1978).

A further pertinent consideration is that much of the freshwater wetlands production is cycled annually (due to the death and decomposition of herbaceous plants), and constitutes a source of organic carbon that is easily assimilable for detritivores (de la Cruz, 1979). Forest ecosystems, on the other hand, tend to produce large amounts of woody biomass that persists, both as adult individuals and as dead trees, for longer periods of time. Thus, the rate at which primary productivity is made available to consumers differs between wetlands and uplands; in this perspective, favoring the wetlands.

Impoundment of the Ware Creek system will prevent much of the excess primary production from being exported to downstream ecosystems. The lake will serve to trap much of the detritus in the reservoir, where it may precipitate to the benthic region of the reservoir, or be extracted with water supply withdrawals. This trapping/extracting will reduce the amount of material exported to downstream areas.

Some evaluators of the mitigation plan (J.R. Reed & Associates, 1987; Dames & Moore, 1989) have noted that a portion of the Ware Creek watershed is already impounded at Richardson's Millpond, thus reducing the export of detritus under existing conditions. Assuming that Richardson's Millpond receives drainage from 260 of the 810 wetland acres above the dam site of the watershed, and that the pond has a 50% efficiency in trapping suspended solids (an conservative efficiency based on the performance of wet detention ponds in "polishing" stormwater), approximately 16 % of the detritus exported from existing wetlands could be trapped at the millpond.

Applying the same analysis to the proposed impoundment, which would receive drainage from all 810 acres of these wetlands and would remove suspended solids with at least the same efficiency, approximately 50% of the detritus exported from the watershed could be trapped at the lake, and much of this could be run through the water treatment facility with water supply withdrawals. This is a significant (200%) reduction in the amount of detritus exported from the watershed even when the existing effects of the millpond are included.

A.3. General and Specialized Habitats

The Ware Creek watershed is a very complex ecosystem, with a variety of habitat types and vegetative communities extending in dentritic fashion throughout the watershed area. The dendritic nature, continuity, and contiguity of bottomland habitats provides a system capable of supporting a high diversity of wildlife species, and very likely makes selection of optimal habitat conditions and movement between habitats an easy task for resident wildlife.

The 1,217-acre impoundment will cover approximately 425 acres of wetlands in the Ware Creek watershed. These wetlands have been classified by Corps, FWS, and EPA personnel in 1985 and 1986 (Fig. 3.3 of FEIS). The 425 acres of wetlands to be covered by the impoundment include approximately 66 mapped subareas encompassing at least two dozen different vegetative community types. In its most fundamental impact, the proposed project will replace an exceedingly complex mosaic of wetland habitats with a relatively monotonic lake habitat.

The complexitity of the existing system, and the significant loss of complexity that will result from impoundment of Ware Cree, has been demonstrated by one quantitative technique - the HEP analyses detailed in Appendix A of the Ware Creek FEIS. In those analyses, selected species are used as "proxies" to represent particular suites of habitat characteristics; decline in the quality and/or quality of a habitat type can be reflected in a decline in the HEP output values for the selected wildlife species.

In HEP studies, potential habitat losses can be quantified in terms of acreage and in terms of annual average habitat units (AAHU's); in both analyses conducted for the Ware Creek system, there are significant losses of important categories (herbaceous and forested types) of wetland habitats. The results of the HEP analyses will be discussed further in the section on wildlife (Sec. A.4).

The loss of habitat complexity can be further demonstrated by applying another common ecological assessment technique - the diversity index - to the Ware Creek habitat data. Diversity indices, derived from probability and/or information theory, can be used to compare the complexity (i.e., information content) of two or more systems. Commonly used formulations include the Shannon-Weaver H' index, Simpson's index, and Brillouin's H index for totally censused collections (Pielou, 1975).

Rather than using numbers of individuals per taxon, as is the most common application of these indices, the number of acres per habitat type can be used, and the diversity computations performed as usual. When this is done, the computed diversity index characterizes the diversity of vegetative communities represented in a particular scenario; decline in an index value between scenarios indicates loss of habitat diversity.

Computations were made using the acreages (wetland only) in the FEIS (Appendix A, pp. 14 and 20) for existing conditions and Target Years +1, +10, +25, and +50 under Alternative V using Brillouin's index (H) for totally censused collections. The index values, in $\log_2$ format, are listed below.

Brillouin's Index
Ware Creek Without or With Reservoir

<u>"Scenario"</u>	H diversity	H evenness	% loss
No Action (TY+1)	1.696	0.7305	-
Alt. V (TY+1)	1.479	0.6370	-12.8
Alt. V (TY+10)	1.535	0.6610	- 9.5
Alt. V (TY+25)	1.527	0.6576	-10.0
Alt. V (TY+50)	1.527	0.6576	-10.0

The Brillouin diversity index values show a 9.5 - 12.8% loss in gross habitat diversity, thus confirming by a second, independent, quantitative methodology that significant adverse impacts will result from the creation of the large, relatively monotonic impoundment where a more diverse assemblage of habitats once existed. An equivalent loss in evenness of the index value, indicative of the less equitable distribution of the acreage among habitats under the impoundment scenario, is also seen (because the number of habitat categories does not change, the evenness index changes in the same proportions as does the diversity index).

This quantitative assessment of the existing and future habitat diversity indicates a significant adverse impact in terms of this ecosystem attribute. Habitat diversity is certainly a desireable attribute in natural and man-managed ecosystems, and may be fundamentally linked to overall environmental stability (Woodwell and Smith, 1969).

These habitat diversity comparisons using the summed acreages of the habitat types yield a very conservative picture of the existing wetlands communities. By lumping the acreages into one category, the watershed is treated as if it had one large tract of palustrine forest, one large tract of palustrine scrub-shrub, and so on. The real circumstance is, at least in the present watershed, that the wetlands communities are broken into many small habitat units juxtaposed in mosaic fashion. As shown below, an equivalent computation using the many small acreage values in each category yields changes in the H index indicative of a much more severe change in diversity attributes resulting from the creation of the impoundment.

The existing watershed has 66 mapped and classified wetland areas that would be inundated by the proposed reservoir. Use of these subacreages in Brillouin's computation yields an H diversity index value of 5.3588 and an evenness value of 0.8866. In contrast, the watershed with the impoundment has only 20 mapped areas (allowing two for the new lake), yielding an H index value of 1.4658 and an evenness value of 0.3392. Clearly, the creation of a large monotonic lake habitat significantly reduces the diversity and evenness of the wetland habitat in the watershed; and as a consequence, ecosystem attributes that derive from habitat diversity will also be reduced.

The revised mitigation plan for the impoundment (J.R. Reed & Associates, Inc.; 1986) proposes to mitigate lost values of this interconnected complex of wetlands at the margins of the watershed. Some headwater wetland mitigation areas will be above the normal pool elevation, some others at normal pool elevation will be enhanced by low water-impoundment structures to strive to maintain wetland hydrology, and some wetland sites will be created. Cranston's Pond in the James River watershed will be breached, draining the 37 acres of standing water and sprigging the exposed bottom with hydrophytes. Assuming that all of these mitigative measures are completely effective, 274.8 acres of freshwater and estuarine wetland will be created or enhanced.

Mitigation by accounting (i.e., counting acres lost and acres gained) fails to acknowledge fully the favorable geometry of the system to be lost. The Ware Creek wetlands complex includes a wide variety of habitats distinguishable as different under Cowardin's (1979) classification scheme. These subareas are strongly linked in linear fashion, providing a complex mosaic of discrete habitat types, transitions zones, and edge environments having continuous contact with upland forested areas and a gradual gradient of change from headwaters to confluence.

The wetland mitigation areas will have fewer of these desireable attributes. The breaching of Cranston's Pond may eventually result in the formation of a smaller wetlands complex with some of the mosaic and gradient features of the Ware Creek system, but the other wetland mitigation areas are largely isolated areas where appropriate hydrology would be encouraged and hydrophytes would be planted.

A.4. Wildlife Habitat

Two of the fundamental attributes of the Ware Creek ecosystem discussed above - high primary production of wetlands, and high habitat diversity - combine to make the system a superior wildlife habitat. The productivity and wide diversity of plant species offers abundant food of many types to foraging wildlife, and the habitat diversity offers a wide spectrum of "niches" for use by resident and migratory species. It should be noted that the abundance and distribution of wildlife species, and the numbers of species found in a particular area, may be a function of those two fundamental attributes cited.

This concept is well articulated by Pielou (1975). In discussing diversity in heterogeneous habitats, Pielou (p. 119) indicates that "if the habitat of a community, instead of being strictly uniform, is made up of a mosaic (two- or three-dimensional) of different microhabitats or substrates, the chance that many similar species will be able to coexist is greatly increased." As was shown in Section A.3, the mosaic characteristics of the Ware Creek system will be significantly reduced by the impoundment.

Quantification of changes in wildlife habitat were conducted by joint Federal agency personnel applying HEP analyses to the watershed. As cited in the FEIS (p. 4-23) and detailed in Appendix A of the FEIS, significant losses of average annual habitat units (AAHU's) were predicted for forested wetlands (48%) and herbaceous wetlands (64%), with a smaller loss for scrub-shrub wetlands (7%). A huge gain for lacustrine open water (1298%) was predicted, as was a minor decline in estuarine open water (1.4%). Upland mixed pine-hardwood forest was predicted to gain 0.4% in AAHU's, while upland hardwood forest would lose 7%.

The HEP applications treat the habitats by analysing specific features that are important in attracting and promoting wildlife success, based on key species that represent wildlife communities characteristic of particular habitat types. To some extent, these analyses are focused on the immediate properties of a habitat tract, rather than on the broader picture of the environment that surrounds the habitat being evaluated. Thus, a parcel of woodland can be evaluated as habitat for yellow warbler or red-winged blackbird without incorporating information on its location relative to human development and activity. In fact, these additional factors influence the overall wildlife value of a habitat.

In its current configuration, the Ware Creek watershed has some development on the periphery; future development will likely encroach further, but still remain peripheral to the wetlands (despite claims by some evaluators that the Ware Creek wetlands will inevitably be lost to development if they are not immediately inundated). In this current configuration, wildlife can still find habitats in the watershed that are relatively isolated form human influence.

Were the reservoir to be created, and inland water recreational activities centered on the lake, the pattern of future development and human disturbance would be inverted. Human disturbance would originate from both the interior and exterior of the watershed, and wildlife would be forced to occupy a more strip-like range between these lake activities and the ongoing development of the periphery. Thus, the creation of a lake that is used for recreation will diminish the existing wildlife values of the watershed to an even greater degree than the HEP applications would predict.

Finally, the superposition of a lacustrine habitat on the watershed would destroy an existing system of small habitats intergrading with one another (a continuum) and replace this with a large, monotonic habitat (the lake) having an abrupt interface with the upland habitats that are left after inundation. In this regard, the wildlife value of the area is again diminished in a qualitative fashion.

In this context, it is very informative to review some of the fundamental concepts set forth in Gosselink and Lee (1987), where recommendations for management of bottomland hardwood forests (i.e., forested wetland areas) are set forth. The context of this discussion is the establishment of natural reserves - areas that could be set aside to benefit floral and faunal species that might otherwise be lost to human encroachment. These concepts are also applicable to decision making in the preservation of the existing functional ecosystems such as Ware Creek.

- Reserve Area. Species richness increases with area; large reserves are better than small ones.
- Reserve Fragmentation. For a given total area, one large reserve will support more native species than two or more smaller ones. Further, the invasion of opportunistic species that could displace native biota is reduced.
- Reserve Patch Proximity. For a given area, disjunct patches that are close together will support more species than patches far apart. Proximity increases immigration rates among patches, thus buffering the total system against local extinctions (Ehrlich and Holm, 1963). Proximity tends to increase with an increasing number of patches (and hence, decreasing patch size).
- Continuity and Contiguity. Disjunct reserves connected by strips of protected habitat are preferable to isolated reserves. Riparian habitats are natural corridors in the landscape. Reserves that are bordered by similar habitats support more native species than reserves bordered by dissimilar habitats. Similar habitats provide a gradual ecotone that is not as inhospitable to most species as an abrupt edge.

- Reserve Shape. All other things being equal, a circular-shaped reserve is preferrable to a linear one. This is because the circular reserve area maximizes dispersal distances within the reserve, and minimizes the edge relative to the interior

When the Ware Creek watershed is considered in light of these principles, the existing system clearly grades high as a natural reserve area. It is a large, unfragmented, mosaic of habitat patches with high continuity and contiguity and gradual edges, and provides an exceptional habitat for wildlife. The small proportion of impounded water (i.e., Richardson's Millpond and the beaver dams) in the overall landscape adds important habitat diversity without dominating the community structure of the watershed. If one were to identify potential reserve areas on the west bank of the lower York River, the Ware Creek system would surely be one of the premier candidates (if not the best candidate).

By comparison, the fragmented system of mitigation areas proposed to minimize the adverse environmental effects of the impoundment is inferior to the existing system. The overall mitigation acreage is smaller, more fragmented, less continuous and contiguous, and has more abrupt edges. This comparison is not made to denigrate the mitigation plan, which shows clear evidence of innovative planning; however, it is clear that the existing Ware Creek system has attributes and properties that derive from a combination of favorable elements in one location, and that re-creating such a combination of features is virtually impossible.

One last observation about the mitigative efforts stems from comments received at the 18 January, 1989 public hearing in James City County. Those comments include at least two references to the possibility of future expansion of the Ware Creek reservoir. If this is a realistic scenario, then the efficacy of wetlands mitigation at or just above the +35 ft msl elevation, as is proposed under the revised mitigation plan, becomes even more speculative. If the capacity of the reservoir were increased in the future, then some or all of the headwater mitigation areas could be flooded, and this component of the overall mitigation plan would be lost.

A.5. Water Quality and Lake Dynamics

The Ware Creek FEIS indicates (p. 4-15) that, based on lake nutrient budget analyses, the impoundment will be in the upper mesotrophic to eutrophic range of lake trophic categories. This anticipated condition could, in an impoundment serving only to store water, result in well defined vertical stratification of the lake, with a warmer, oxygenated epilimnion and a colder, oxygen-poor hypolimnion. The degree of development of such stratification would be expected to vary with average and maximum depth of the impoundment, surface wind shear, and the physical properties of the water feeding the impoundment.

It is uncertain from the FEIS discussion to what degree the trophic status analysis took into account the short- and long-term effects of the demand for oxygen that would be exerted by herbaceous vegetation and peaty deposits existing in the basin's wetlands. The effects of original vegetation on water quality of new reservoirs are reasonably well known; in general, organic materials covered by a new impoundment contribute to a high oxygen demand and decreased oxygen levels in the hypolimnion area of a newly-created lake (Ball et al, 1975). The manner and degree to which this occurs depends on the nature of the vegetation covered and the amount of vegetation removed before reservoir filling. In his discussion of such effects, Ball notes that some reservoirs are filled and flushed more than once to remove some of this high oxygen demand and reduce the possibility of oxygen depletion in the hypolimnion.

Assuming that most of the herbaceous vegetation and peaty deposits are not removed from the Ware Creek bottomlands, it is likely that this original vegetation will exert a strong short-term oxygen demand in the hypolimnion, and that water quality will be significantly affected. This reduction in ambient oxygen concentrations could consequently reduce the volume of good water habitat for recreational and forage fish species stocked in the reservoir. Such "compression" of aquatic habitats by anaerobiosis has been described for southeastern impoundments, as well as for Chesapeake Bay. The phenomenon will not be unique to the proposed Ware Creek impoundment; however, because of the nature of the vegetative communities covered by the impoundment (extensive areas of grasses and shrubs), the problem is likely to be more severe than it would be in a lake created over an upland vegetative community.

The massive withdrawals of water from the reservoir may actually aggravate this oxygen debt. The surface waters of productive impoundments are often supersaturated with oxygen (Wetzel, 1985). When this water is withdrawn, it will be replaced by inflows from the headwaters; such water is likely to be undersaturated. This flux, if it accurately describes normal operation of the reservoir, will result in a net loss of oxygen from the reservoir due to the withdrawals. The stratum of low oxygen may move upward in the water column, compressing the fisheries habitat even more from this effect.

The continued withdrawal of water from the reservoir, taking with it nutrients, plankton, and larval fish, could slow the development of equilibrium processes in the lake. Because the response to cropping would be strongest in the community with the shortest generation time (the phytoplankton), the lake ecosystem could be held in an "immature" state of development (Odum, 1971), with sporadic algal blooms that would be too extensive to be controlled by zooplankton cropping. The food webs could be simplified under such circumstances, and the fish community of the lake could be dominated by a few opportunistic species. There are circumstances where the attributes of immature ecosystems are desireable (e.g., in agriculture), but such attributes are not particularly desireable in ecosystems where impacts are meant to be minimized.

A.6. Fisheries

The existing Ware Creek system supports a fish community characteristic of the Coastal Plain of Virginia. Centrarchids dominate (as recreational species) in the freshwater reaches; white perch are found in the estuarine reaches near the York River. The FEIS notes (p. 4-12) that the habitat for freshwater fish will be greatly enhanced, while the habitat for estuarine fish will be diminished slightly.

The freshwater fish species that are likely to impacted significantly are those requiring moving water - some cyprinids, cottids, and perchids. The damming of Ware Creek will significantly reduce such lotic habit, replacing it with lentic waters that favor a different complex of fish species.

Estuarine fish populations in the lower York River estuary may experience some adverse impact, particularly in early life stages, due to the reduction in export of detritus from the impounded watershed.

The FEIS indicates that downstream water quality (at least in terms of temperature and dissolved oxygen) will be maintained by multilevel discharges from the dam. It should be noted that this "maintanence" is not as easy as it sounds. In productive lakes, the temperature and dissolved oxygen curves generally parallel each other (during warm weather stratification, both are "clinograde" or sigmoid-shaped curves). Warmer (shallower) water has higher dissolved oxygen concentrations, and colder (deeper) water has lower dissolved oxygen contentrations. Clearly, one cannot maximize for cold, oxygenated water because of the relationship of these variables. Optimizing for these variables could be an intricate process requiring frequent monitoring and readjustment to avoid stressing downstream fish populations.

The water supply drawdowns anticipated for the reservoir will result in a sparsely-vegetated littoral zone in the lake (the nearby reservoirs of varying age - Little Creek and Diascound - exhibit this characteristic). Several common sport fish species (e.g., yellow perch, pickerel, sunfishes, some minnows) use vegetation in the littoral zone as spawning habitat. Thus, the fish community of the lake is likely to be dominated by species not having a littoral zone requirement for success, and the diversity of the reservoir fishery will be adversely affected.

A.7. Recreational Values

The recreational opportunities offered by the Ware Creek ecosystem at present center around hunting. Game species in the watershed include white-tailed deer, bobwhite, turkey, grey squirrel, and a variety of waterfowl. There are 32 duck blinds in the lower portion of the watershed, but these are not open for public use.

The potential for additional recreational activities in the unaltered watershed is high. The diversity of bird species offers exceptional opportunities to the birdwatcher, and the entire system can be viewed by an educator as a living laboratory.

Inundation of the wetlands complex and a fringe of uplands will diminish the recreational value of the watershed for upland game hunters. Most of the duck blinds are in the estuarine areas of the wetland complex; however, changes in the tidal freshwater and oligohaline vegetative communities resulting from reduced downstream flows may affect such hunting efforts by altering the foraging areas of waterfowl.

The loss of the extensive wetland complex will mean fewer potential opportunities for birdwatchers. The inundation of the wetlands complex will detract from the existing value of the habitat for ecological research and education.

The wetlands that may grow back over the Cranston's pond area and in the newly-created areas may provide some of these recreational functions, but will not fully replace the values lost in the creation of the reservoir. Breaching of the dam at Cranston's Pond may result in a wetlands succession that is of interest to ecologists, but it would be the study of a disturbed, recovering environment, not the description of processes within a large, complex natural system that has experienced little human disturbance.

A.8 Cumulative Impacts

The understanding that wetlands habitats are dwindling in quantity and quality on a national scale is widely understood and accepted. Regulations concerning the protection and enhancement of remaining wetlands tracts continue to be applied by Federal, State, and local governments and agencies. Such regulations and permits have slowed, but not eliminated, continued loss of wetlands acreages in inland and coastal areas. Tiner (1987) summarizes trends and current status of wetlands in Mid-Atlantic states; for Virginia, those data indicate that the total acreages of wetland types in the state are (in thousands of acres):

Current Status of Wetlands
State of Virginia

	Acreage (x1000)	Percent
Coastal Marshes	135.4	13.0
Tidal Flats/Beaches	101.5	9.7
Inland Emergent Wetlands	63.0	6.0
Inland Shrub Wetlands	63.9	6.1
Inland Forested Wetlands	625.8	59.3
Freshwater Ponds	55.3	5.3
TOTAL	1044.9	100.0

Source: Tiner, 1987.

Most of these wetland (64%) are found in the Coastal Plain area, almost equally divided among Coastal Zone (22%), Lower Coastal Plain (28%), and Upper Coastal Plain (22%) areas.

Tiner's data on wetland trends in Virginia show that, between 1956 and 1977, over 63000 acres (6%) of Virginia's wetlands were lost. Inland forested wetlands experienced a 9% loss in 21 years, while inland vegetated wetlands in the Coastal Plain were reduced by about 14%. During this same period, lake and pond acreage increased by about 170%.

The creation of lakes and ponds from inland vegetated wetlands accounted for approximately 25% of Virginia's wetland losses, a causative factor third to agricultural losses and losses to other development (e.g., channelization). This state-wide trend parallels trends in the Chesapeake watershed, where Tiner estimates that 29% of losses of inland vegetated wetlands resulted from creation of lakes and ponds.

It is clear that the proposed impoundment contributes to the overall loss of wetlands sacrificed to open water habitats. In this regard, it directly contributes additional adverse impacts to an ongoing adverse regional trend.

Gannett-Fleming (1989) has quantified acreages of NWI-mapped wetlands in the lower York River watershed; freshwater vegetated wetlands (of individual areas greater than 10 acres) sum to 4149.6 acres. Of this total, 1145.2 acres (27.6%) are situated upstream of existing impoundments, where their functional values are diminished from a watershed perspective. It is clear that the watersheds to the west of the lower James River are being dammed in temporal and spatial succession; barring a change in this trend, it is possible that the only free-flowing watersheds to the York River in this vicinity could be those too small to impound.

As each new impoundment goes in place, watersheds that were considered poor(er) alternatives in the past become, by default, preferred alternatives for dam locations (as was apparently the historical circumstance with Ware Creek). Environmental impact assessments would consider the need for additional water supplies, and argue that the proximal impacts of another new impoundment were tolerable. From a cumulative impact assessment perspective, this type of development sequence invites long-term problems and long-range significant adverse impacts on local and regional ecosystems.

III. SUMMARY OF POTENTIAL ADVERSE IMPACTS OF THE WARE CREEK IMPOUNDMENT

The assessments and evaluations discussed in Chapter II clearly indicate that impoundment of the Ware Creek watershed will result in significant adverse impacts to several fundamental attributes of the ecosystem. The revised mitigation plan could, if fully successful, replace some, but not all, of the wetlands values lost or significantly reduced by the project.

A. Primary Production

Estimates of total existing primary production and primary production based on future land use scenarios with the reservoir in place (but not withdrawing water) show no significant change in total production of plant biomass. However, when the effects of massive water withdrawals and seasonal drawdowns are considered, the primary production that is available for ecosystem use is significantly reduced.

B. Secondary Production

The significant loss of primary production, coupled with the trapping and extraction of particulate material in the reservoir, will result in a significant reduction of the amount of organic material exported to the estuarine system.

C. Habitat Diversity

The loss of the existing wetlands complexes in the Ware Creek watershed will result in a significant loss of habitat diversity. Mitigation efforts, though well-planned and well-intentioned, will not reduce this level of impact of insignificant levels.

D. Wildlife

Due to the reduction in primary and secondary productivity, loss of wetlands habitat, reduction of overall habitat diversity, and inversion of land use patterns in the watershed, the value of the watershed for wildlife intolerant of human disturbance will be significantly diminished. The spatial arrangement of wetlands mitigations areas is inferior to the existing system in terms of "natural reserve" attributes favoring continued success of native biota. Species of conern, including great blue herons, black ducks, and other waterfowl, are likely to suffer significant adverse impacts. The creation of smaller, non-continguous wetland mitigation areas could adversely affect gene flow among local populations, increasing chances of local extinctions of wetlands biota.

E. Water Quality and Lake Dynamics

In the near-term, the reservoir could have poor water quality due to the high oxygen demand of original vegetation and peaty deposits. Quality habitat for desireable forage and recreational fish species will be limited by these processes. The long-term characteristics of the reservoir are difficult to predict because of the adverse effects of massive water withdrawals and annual drawdowns on planktonic productivity and water quality, but it is likely that such processes will adversely affect the establishment of equilibrium processes within the lacustrine ecosystem.

F. Fisheries

Replacement of the existing lotic system with a limnetic system will significantly reduce the success of fish species requiring flowing water for successful existence. The likely absence of a vegetated littoral zone in the reservoir will reduce the success of sport and forage fish species having such a habitat requirement. The available habitat for fish in the proposed reservoir could be significantly reduced by oxygen depletion in the hypolimnion. Local estuarine fish populations may be adversely affected by the reduced export of detritus from the watershed and by variations in water quality due to discharge of water from the impoundment.

G. Recreation

Patterns of recreation within the watershed will be substantially altered, with water-based recreation emphasis supplanting the upland/wetland recreational opportunities now available or potentially available. The educational value of the Ware Creek ecosystem will be significantly reduced.

H. Cumulative Impacts

Implementation of the proposed project will contribute to adverse regional trends in inland freshwater wetlands losses, and will extend the regional trend of impounding increasing numbers of the lower York River watersheds.

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ECOLOGICAL IMPACT ASSESSMENT OF WARE CREEK IMPOUNDMENT

Draft Material

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REVIEW OF MOST RECENT GROUNDWATER INVESTIGATION

In this report a review of the most recent USGS report of the York-James Peninsula of Virginia, Ground-water Resources of the York-James Peninsula of Virginia, Water-Resources Investigations Report 88-4059 is presented. The USGS report was prepared by Mr. Randell J. Laczniak and Mr. Andrew A. Meng III of the Richmond, Virginia office of the USGS.

The main purposes of this review are to (1) review the various projections of increased withdrawal, (2) review the discussion and conclusions associated with the projections presented in the USGS report, and (3) relate the findings presented in the USGS report to James City County's need for additional water supply.

Base Conditions

The USGS used 1983 as the base year within the report. Maximum water-level declines from prepumped conditions to 1983 conditions can be summarized as follows:

Aquifer	Maximum Water-Level Decline	Approximate Areal Location
Yorktown-Eastover	7	City of Virginia Beach
Chickahominy-Piney Point	100	Town of West Point
Aquia	128	Town of West Point
Upper Potomac	157	Town of West Point
Middle Potomac	128	Town of Smithfield
Lower Potomac	126	Town of Smithfield

It can be seen that considerable drawdown had occurred within five of the six aquifers. In 1983, thirty-eight mgd were being pumped from wells located within the Coastal Plain of Virginia. The withdrawals by each aquifer are presented in Table 1.

Projections

The USGS modeled four different water projections. The pumping by aquifer for each of the projections are presented in Table 1.

For Projection I, the withdrawals for each of the wells located in the Coastal Plain of Virginia were doubled, thus the total withdrawal associated with the projection was 76 mgd. Maximum water-level declines from 1983 conditions for Projection I are shown in Table 2. The USGS report states "The extent of water-level declines suggest that increasing withdrawal from established pumping centers is an impractical means of meeting future water needs." "Comparison of simulated potentiometric surfaces and top of aquifer maps show that water levels in the Chickahominy-Piney Point aquifer are approaching the top of the aquifer near the Town of West Point."

For Projection II, 49 new wells were assumed to be located at various points within the study area. These wells represented 33 mgd of additional pumpage; for a total of 71 mgd. Twenty-nine wells were located within James City County and represented 12 mgd of additional pumpage. Maximum water-level declines from 1983 conditions for Projection II are shown in Table 3. The USGS report states "Water levels remained well above the top of respective aquifers, except in the Chickahominy-Piney Point aquifer near Westpoint and in the Yorktown-Eastover aquifer in eastern York County. Major cones of depression developed in James City County."

For Projection III, 29 new wells were located within James City County which represented 12 mgd of additional pumpage, or a total of 50 mgd. Maximum water-level declines from 1983 conditions for Projection III are shown in Table 4. No other new wells or increases in pumpage of existing wells were represented. The USGS report states "Though water levels were deepest near

Table 1 -- Withdrawal by aquifer for projections I, II, III, and IV

[Values in millions of gallons per day]

Aquifer	1983 Pumping Period	Projection I	Projection II	Projection III	Projection IV
Columbia	0.128	0.256	0.128	0.128	0.128
Yorktown-Eastover	1.403	2.806	4.406	1.403	4.406
Chickahominy-Piney Point	2.641	5.282	5.214	4.439	4.164
Aquia	1.003	2.006	1.685	1.685	1.410
Virginia Beach	0.006	0.012	0.006	0.006	0.006
Upper Potomac	13.644	27.228	21.814	17.702	19.066
Middle Potomac	15.150	30.300	28.415	19.502	25.548
Lower Potomac	4.135	8.270	9.588	5.251	8.317
Total	38.110	76.160	71.256	50.116	63.045

Source: **Table 28, USGS Report 88**-4059.

Table 2 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection I

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	7	City of Richmond
Chickahominy-Piney Point	100	Town of West Point
Aquia	126	City of Williamsburg
Upper Potomac	155	Town of West Point
Middle Potomac	127	Town of Suffolk
Lower Potomac	122	Town of West Point

Source: Table 30, USGS Report 88-4059.

Table 3 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection II

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	14	York County
Chickahominy-Piney Point	75	Central James City County
Aquia	99	Central James City County
Upper Potomac	155	Western James City County
Middle Potomac	76	Western James City County
Lower Potomac	74	Western James City County

Source: Table 34, USGS Report 88-4059.

Table 4 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection III

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	1	Central James City County
Chickahominy-Piney Point	52	Central James City County
Aquia	65	Western James City County
Upper Potomac	76 .	Western James City County
Middle Potomac	34	Western James City County
Lower Potomac	26	Central James City County

Source: Table 35, USGS Report 88-4509.

the Town of West Point in the Potomac aquifers, major cones of depression developed in James City and New Kent Counties."

For Projection IV, withdrawals were from the same new wells as in Projection II; however, the withdrawal rates were reduced for most wells. The projection represent an increase of 25 mgd, or a total of 63 mgd of pumpage. Within James City County new wells would provide an additional 7.25 mgd. Maximum water-level declines from 1983 conditions for Projection IV are shown in Table 5. The USGS report states" Water levels remained above tops of respective aquifers. Major cones of depression developed in the western part of James City County and in the eastern part of New Kent County." "Much less severe water-level decline was projected than in Projection II which suggests that if water-level decline is a concern, the resources would be better utilized as a supplemental source of water supply."

Discussion

Most water supply concerns are related to either decreases in aquifer yields or to deterioration of the quality of water within the aquifers. Decline of water levels below pump intake intervals require that pumps be lowered. Decline below screen levels require that wells be deepened in order to obtain water from lower horizons within the aquifer or from lower aquifers.

The USGS report states that "Because numerous users already withdraw ground water, it is far more likely that water-level declines will result in unacceptable interference among ground-water users before dewatering of the aquifers is a concern. From a water management prospective, this means water-level declines will limit the yields from aquifers before available recharge is depleted unless existing users lower screen intakes."

"Projection I, which doubled withdrawal from all wells located in the Virginia Coastal Plan resulted in severe water-level declines at the established pumping centers and moderately severe declines throughout the remainder of the aquifers. Other projections, which increased withdrawal from

Table 5 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection IV

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	14	York County
Chickahominy-Piney Point	45	Central James City County
Aquia	62	Central James City County
Upper Potomac	93	Western James City County
Middle Potomac	58	Hanover County
Lower Potomac	61	Charles City County

Source: Table 36, USGS Report 88-4509.

wells located away from the established centers, generally resulted in less severe water-level decline in the aquifers and far less severe decline at previously established pumping centers."

"Projection III, which withdrew water from the deeper confined aquifer, had minimal effect on water levels in the Yorktown-Eastover aquifer and suggests that increased withdrawal from the deeper confined aquifers does not impact users withdrawing water from the shallow aquifers."

The authors of the USGS report did not attempt to provide an answer to the question as to how much additional water can be withdrawn from the York-James Peninsula of Virginia. They presented a discussion of each of the four projection modeled and certain portions of their discussion has been presented above.

Contents of the USGS report indicated that to optimize the yield of the York-James Peninsula groundwater system it would be necessary to develop a regional approach so that each new well's location, spacing, pumping rate, aquifer selection and screening and other factors could be part of an overall regional management plan.

James City County Needs

Projection III most closely represents fulfilling James City County's additional water supply needs with groundwater. At first glance, it appears that groundwater could satisfy the needs. However, the projection was based on no increase in pumping from existing wells or any new wells being constructed outside of James City County. Because at present there is no state regulation to ensure that increases in pumping will not occur or new wells will be constructed, it is not possible to say that James City County's additional water supply needs can be met entirely with groundwater.

Groundwater Management Areas

The Commonwealth of Virginia's Groundwater Act of 1973 provides for the establishment of Groundwater Management Areas within the State by the State Water Control Board. Currently, two areas have been established by the State Water Control Broad. The first is located in Southeastern, Virginia south of the James River and the second is located on the Eastern Shore of Virginia.

To establish a Groundwater Management Area, one of the following criteria must be met: (1) Groundwater levels must be declining excessively; (2) Existing wells of two or more users must be interfering with each other substantially; (3) Available groundwater supply is or about to be overdrawn; and (4) Groundwater has been or reasonably may be expected to become polluted. If any of the above four criteria are met, the Water Control Board may elect to establish a Groundwater Management Area after public notices, hearings, etc.

If a Groundwater Management Area is created, all existing wells are grandfathered at the their historical maximum daily pumping rate. New wells, except agricultural wells, must not cause significant impacts on existing wells. Also, the Board will ask if there are other available water supply alternatives, such as surface water. If there are other alternatives, the owner can provide reasons for going to groundwater -- such as economics.

If the State Water Control Board creates a Groundwater Management Area in the York-James Peninsula sometime in the future, then there would be a potentially a greater degree of protection of existing wells and future groundwater users. However, at present, in the two existing Groundwater Management Areas there is no long-range groundwater plan. Rather, the Board staff acts on new well requests on a case-by-case basis to determine the impacts on the well. In a sense, this approach appears to allow those users who ask for new wells first to have additional water first, as long as there are not unacceptable impacts, as defined by the Board, to other existing groundwater users.

ADDENDA/ERRATA

p. 2, para. 3 - the total acreage of the Ware Creek watershed is approximately 14,600 acres. The 10,838 acreage value used here refers to undeveloped lands within the watershed (Appendix A, p. 12).

p. 15, para. 4 - the acreages above Richardson's Millpond and other acreages used in this example are taken from the Revised Wetlands Mitigation Plan (J.R. Reed and Associates, Inc., 198[illegible]; p. 12). No independent calculation of such acreages was performed for this computation.

p. 18, para. 4 - the acreages used in this analysis were derived from wetland area computations presented in Bannett-Fleming (1989). The scenario with the reservoir used wetland acreages remaining after damming, and partitioned the lake acreage into two habitat types: a 1000-acre central area and a 217-acre near-shore area.

Clearly, there are many permutations of this latter analysis that could be conducted; adding in the isolated wetland mitigation areas or other "protection " areas could yield a somewhat higher H value for the impoundment scenario.

GANNETT FLEMING

CONTRACT NO. 68-D-80024

WORK ASSIGNMENT NO. 10

ECOLOGICAL IMPACT ASSESSMENT OF WARE CREEK IMPOUNDMENT

Draft Material

Task Series 100 - Cumulative Impacts Study

February 6, 1989

U.S. Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Prepared by

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ECOLOGICAL IMPACT ASSESSMENT OF WARE CREEK IMPOUNDMENT

CUMULATIVE IMPACTS STUDY

The following describes the measurement of wetlands within the lower York River Basin:

1. The wetlands were grouped by the first three digits.

2. Isolated wetlands areas of 10 acres or less were not included. However, if a wetland area of less than 10 acres is adjacent to a larger wetland system, it was included.

3. Only those existing reservoirs which are labeled Lacustrine on the NWI maps were identified. The acreages of wetland areas above these reservoirs were determined.

4. If two or more reservoirs are in series on a tributary to the York River, only the reservoir located the nearest to the York River was identified.

Table 1 contains the acreages of wetlands located in the lower York River Basin. Total acreages for each topo map and each wetland type are included in the Table. Worksheets are included for each of the 13 maps.

Table 2 contains the acreages of wetlands located above 20 existing reservoirs. Total acreages for each reservoir and each wetland type are included in the Table. Worksheets are included for each of the 20 reservoirs.

Prepared by
Gannett Fleming
Environmental Engineers, Inc.
February 3, 1989

TABLE 1

ACREAGE OF WETLANDS LOCATED IN THE LOWER YORK RIVER BASIN

TOPO MAP	Wetland type											
	PFO	PEM	PSS	LOW	EEM	POW	EFL	EOW	EBB	LAB	EOS	Totals
ACHILLIES	70.7		1.3		1.0			1,100.9			9.6	[illegible]
CLAY BANK	540.3	677.3	16.1	544.4	1,847.5	12.1	1,179.2	12,027.3	1.3	38.9		16,794.6
GLOUCESTER	150.4		6.2			16.3						172.9
GRESSITT	508.0	77.6		21.7	2,456.1	14.3	591.4	9,170.4				12,950.0
HOG ISLAND	6.4			14.6								21.0
NORGE	24.5											24.5
POQUOSON WEST	103.5		1.2	16.9	9.3	15.8	157.3	5,598.5				5,890.5
SALUDA	12.6	5.9				0.9						19.4
SHACKLEFORDS	632.5		23.9			16.1						672.5
TOANO	505.4	10.2	40.8	125.5	1,008.5	0.5		2,254.8				3,945.7
WEST POINT	59.2	5.0	3.0		649.2			1,945.5				2,660.9
WILLIAMSBURG	559.9	30.7	8.7	681.1	1,387.4	16.4	170.8	3,565.6				5,413.6
YORKTOWN	18.2	13.7			87.0	6.2						125.1
Totals	3,390.6	821.8	99.2	1404.2	7,456.0	99.1	2,098.7	25,850.7	1.3	38.8	9.6	50,853.6

Prepared by:
[illegible]
Environmental Engineers, Inc.
February [illegible] 1993

TABLE 2

ACREAGE OF WETLANDS LOCATED ABOVE EXISTING IMPOUNDMENTS

	Wetland Type						
RESERVOIR	PFO	EM	PSS	[illegible]	[illegible]	[illegible]	Totals
BARLOW POND	203.9			[illegible]			225.[illegible]
BEAVERDAM POND	[illegible]		9.3	3.[illegible]			[illegible]
BIBLIS MILLPOND	.4	[illegible].0		150.5			152.9
CHEATHAM POND				[illegible]			[illegible].6
FRANCE SWAMP 1				[illegible]			[illegible].2
FRANCE SWAMP 2			1.9	3.3			[illegible]
[illegible] POND	48.[illegible]	5.4		[illegible]			[illegible]
[illegible] POND	[illegible].3			[illegible]			[illegible].3
HAYNES POND	[illegible]	444.9				38.[illegible]	5[illegible]
JONES CREEK 1	[illegible]			21.5	[illegible]		[illegible].3
JONES CREEK 2	5.6			37.0			42.6
JONES MILLPOND			1.[illegible]	55.[illegible]	[illegible].5		[illegible].5
PENNINGTON LAKE				50.[illegible]			50.2
POWELL LAKE				23.0			23.0
[illegible] LAKE	6.6	1.5		60.[illegible]			68.[illegible]
RICHARDSON MILLPOND	[illegible]	[illegible].8	23.5	39.5			[illegible]93.9
[illegible] POND				20.2			20.2
WALLER MILL POND	5.[illegible]			294.9			[illegible]
WAWLEY POND			[illegible].2	[illegible]6.9			[illegible]
WILLIAMSBURG C. C.				[illegible]5			[illegible].5
Totals	5[illegible]9.7	45[illegible].6	[illegible]9.[illegible]	1,[illegible]22.5	[illegible].3	[illegible]9.3	2,529.0

WETLAND WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

QUAD-ACHILLES

WETLAND TYPE-PFO		WETLAND TYPE-PSS		WETLAND TYPE-EEM		WETLAND TYPE-EOW		WETLAND TYPE-ESS	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
1	24.7	4	1.3	10	0.6	6	365.5	5	2.0
2	22.2		-------	13	0.4	15	339.5	11	1.7
3	6.9		1.3		-------	16	395.9	12	5.9
7	1.3				1.0		-------		-------
8	3.2						1,100.9		9.6
9	3.1								
14	9.3								

	70.7								

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QUAD-CLAY BANK

WETLAND TYPE-PFO

NUMBER	ACRES
3	1.9
25	0.4
32	5.6
33	3.5
36	483.9
37	2.2
40	31.8
41	12.4
42	3.9
43	7.3
44	1.1
46	1.4
47	11.1
51	1.4
52	1.9
53	6.8
54	6.6
55	4.3
60	12.8
63	5.9
64	3.1
65	3.7
67	25.3
68	2.0
	640.3

WETLAND TYPE-PEM

NUMBER	ACRES
23	7.3
35	25.7
39	2.7
45	442.2
	477.9

WETLAND TYPE-PSS

NUMBER	ACRES
12	16.1
	16.1

WETLAND TYPE-LOW

NUMBER	ACRES
10	21.6
11	37.0
111	50.2
114	435.6
	544.4

WETLAND TYPE-EEM

NUMBER	ACRES
1	35.2
2	524.2
4	48.4
5	3.0
6	24.3
7	20.0
9	2.2
14	13.7
15	0.8
17	24.8
19	2.7
22	4.0
24	18.4
26	23.8
27	3.8
28	52.1
29	9.0
30	12.6
31	8.3
34	94.6
48	13.4
49	1.7
50	206.1
56	1.3
58	2.3
59	8.7
61	45.4
66	19.9
70	3.8
71	2.0
72	0.8
73	17.9
74	8.5

WETLAND TYPE-P

NUMBER	ACRE
86	[illegible]
109	[illegible]
	[illegible]

WETLAND TYPE-EFL

NUMBER	ACRES
18	20.0
20	770.5
21	36.6
57	16.0
62	22.9
69	187.2
80	7.8
81	13.7
82	1.8
83	3.0
92	6.9
112	2.9
114	38.7

WETLAND TYPE-EOW

NUMBER	ACRES
8	15.9
16	7.1
91	76.9
119	11,927.1
	12,027.0

WETLAND TYPE-EBB

NUMBER	ACRES
93	1.3
	1.3

WETLAND TYPE-LAB

NUMBER	ACRES
38	38.8
	38.8

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QUAD-GLOUCESTER

WETLAND TYPE-PFO		WETLAND TYPE-PSS		WETLAND TYPE-POW	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
1	3.7	12	6.2	6	2.5
2	15.4		-------	15	13.8
3	5.7		6.2		-------
4	2.0				16.3
5	25.6				
7	1.2				
8	3.3				
9	4.3				
10	14.9				
11	21.9				
13	12.6				
14	10.3				
16	5.6				
17	5.6				
18	18.3				

	150.4				

WETLAND WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

QUAD-BRESSITT

WETLAND TYPE-PFO

NUMBER	ACRES
3	8.0
4	5.3
5	13.5
6	15.1
7	4.4
8	8.4
11	2.0
12	10.2
14	5.2
15	3.4
16	9.8
20	6.9
21	15.1
22	1.5
23	6.7
24	18.8
25	8.7
26	7.9
29	5.1
30	3.9
31	12.6
33	7.8
35	2.6
39	3.2
40	3.7
41	2.0
55	2.1
56	14.1
57	5.7
59	0.9
64	14.2
65	6.5
66	6.4
76	0.7
77	11.5
78	10.1
79	13.5
80	5.6
83	7.3

WETLAND TYPE-PEM

NUMBER	ACRES
81	9.1
82	6.9
95	8.5
102	27.4
123	6.8
137	17.0
148	1.9

	77.6

WETLAND TYPE-LOW

NUMBER	ACRES
160	21.7

	21.7

WETLAND TYPE-EEM

NUMBER	ACRES
2	24.8
9	32.1
10	1.5
13	49.8
17	7.2
19	105.0
28	24.3
32	3.4
36	17.4
37	31.3
38	39.0
43	15.8
44	2.7
45	2.5
46	11.8
47	4.0
48	7.0
49	0.5
51	0.7
52	3.4
53	3.2
54	27.9
58	3.6
60	16.9
61	43.1
62	3.6
63	1.5
67	50.6
68	2.0
69	0.3
70	9.5
71	5.2
72	6.7
73	1.2
74	5.9
75	34.7
84	17.9
85	32.4
86	3.7

WETLAND TYPE-POW

NUMBER	ACRES
18	9.0
144	1.8
145	0.8
176	3.2

	14.8

WETLAND TYPE-EOW

NUMBER	ACRES
50	21.4
172	4.8
177	9,144.2

	9,170.4

WETLAND TYPE-E

NUMBER	ACR
1	1[illegible]
27	1[illegible]
34	[illegible]
42	[illegible]
115	[illegible]
116	[illegible]
117	[illegible]
120	[illegible]
124	[illegible]

	5[illegible]

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QUAD-CLAY BANK

WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-PSS		WETLAND TYPE-LOW		WETLAND TYPE-EEW		WETLAND TYPE	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	A
								75	2.0		
								76	1.3		
								77	1.9		
								78	2.5		
								79	5.4		
								84	15.2		
								85	1.0		
								87	13.4		
								88	89.3		
								89	4.5		
								90	4.8		
								94	9.5		
								95	69.2		
								96	0.2		
								97	42.3		
								98	9.1		
								99	4.5		
								100	8.9		
								101	37.4		
								102	9.1		
								103	14.1		
								104	20.9		
								105	10.1		
								106	35.6		
								107	60.8		
								108	11.5		
								110	16.8		
								113	23.2		
								115	4.4		
								117	60.9		

									1847.5		

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QUAD-GRESSITT

WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-LOW		WETLAND TYPE-EEM		WETLAND TYPE-POW		WETLAND TYPE-	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	AC
96	8.9					87	10.6				
97	14.9					88	54.5				
98	11.9					89	3.1				
99	7.3					90	14.4				
100	22.2					91	2.2				
101	9.7					92	29.3				
103	5.9					93	0.8				
107	3.7					94	13.1				
108	3.1					104	44.8				
114	9.3					105	105.5				
118	3.7					106	13.7				
127	51.6					109	2.6				
133	1.8					110	0.8				
138	2.4					111	3.8				
139	1.9					112	60.0				
140	8.3					113	125.0				
141	10.6					121	271.6				
142	9.8					122	56.8				
143	11.2					125	216.4				
146	11.0					126	43.0				
147	3.4					128	53.7				
149	2.0					129	385.9				
150	0.6					130	4.2				
151	12.6					131	44.4				
152	0.8					132	1.2				
153	2.4					134	4.4				
154	7.0					135	3.1				
156	1.2					136	25.7				
157	37.8					155	58.5				
158	6.6					163	26.0				
159	6.6					164	3.4				
161	2.9					165	5.4				
162	13.1					166	6.7				
174	6.9					167	1.5				
175	4.5					168	0.6				
	608.0					169	9.5				
						170	78.8				
						171	6.5				
						173	2.4				
						177	18.1				
							2,466.1				

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QUAD-HOG ISLAND

WETLAND TYPE-PFO		WETLAND TYPE-LOW	
NUMBER	ACRES	NUMBER	ACRES
2	6.4	1	14.6
	6.4		14.6

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QUAD-NORGE

WETLAND TYPE-PFO

NUMBER	ACRES
1	1.4
2	7.3
3	15.8
	24.5

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QUAD-POQUOSON WEST

WETLAND TYPE-PFO

NUMBER	ACRES
11	10.2
12	4.8
13	1.2
19	4.0
20	52.1
23	10.7
24	20.5
	103.5

WETLAND TYPE-PSS

NUMBER	ACRES
2	1.2
	1.2

WETLAND TYPE-LOW

NUMBER	ACRES
1	16.9
	16.9

WETLAND TYPE-EEM

NUMBER	ACRES
3	1.6
5	3.7
10	0.6
14	0.9
16	2.5
	9.3

WETLAND TYPE-POW

NUMBER	ACRES
15	9.9
21	1.9
22	4.0
	15.8

WETLAND TYPE-EFL

NUMBER	ACRES
4	1.
7	23.
8	58.
9	26.
18	48.
	157.

WETLAND TYPE-EOW

NUMBER	ACRES
6	80.9
25	5,505.6
	5,586.5

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QUAD-SALUDA

WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-POW	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
1	1.3	2	5.9	3	0.9
4	11.3		-------		-------
	-------		5.9		0.9
	12.6				

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QUAD-SHACKLESFORD

WETLAND TYPE-PFO

NUMBER	ACRES
1	17.4
2	52.9
3	4.2
4	10.5
5	31.8
6	6.2
7	1.2
8	1.5
9	11.0
10	191.3
12	2.5
15	2.9
16	5.8
17	8.0
18	7.9
19	19.3
21	17.0
22	1.6
24	34.7
25	11.4
26	8.4
27	21.8
28	4.1
29	30.2
32	1.7
33	11.0
34	60.3
35	40.2
36	15.7
	632.5

WETLAND TYPE-PSS

NUMBER	ACRES
13	2.9
20	11.2
30	5.3
31	4.5
	23.9

WETLAND TYPE-POW

NUMBER	ACRES
11	6.4
14	1.9
23	7.8
	16.1

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TOPO-TOANO

WETLAND TYPE-PFO

NUMBER	ACRES
1	15.7
2	6.4
3	23.0
4	14.4
5	7.5
8	2.1
9	4.1
10	5.4
11	33.0
13	5.3
15	34.1
16	2.1
17	5.3
18	7.1
19	1.8
20	1.6
21	1.7
22	0.9
23	1.7
24	11.2
25	9.1
26	30.5
27	3.8
31	14.1
32	3.2
33	3.8
34	12.2
44	1.1
45	1.6
46	6.3
47	3.7
48	6.8
57	8.2
59	2.3
60	0.7

WETLAND TYPE-PEM

NUMBER	ACRES
72	4.1
7	1.3
86	3.3
94	1.5

	10.2

WETLAND TYPE-PSS

NUMBER	ACRES
6	1.9
12	3.1
14	12.3
88	7.5
90	9.4
97	5.2
100	1.4

	40.8

WETLAND TYPE-LOW

NUMBER	ACRES
7	9.8
70	56.5
75	19.7
85	39.5
	18.3

	125.5

WETLAND TYPE-EEM

NUMBER	ACRES
28	2.4
29	2.0
30	42.3
35	10.9
36	4.6
37	4.8
38	3.2
39	10.6
40	3.1
41	5.5
42	6.5
43	46.9
49	60.2
50	4.9
51	2.4
52	17.8
53	11.4
54	39.4
55	1.6
56	32.8
58	533.1
66	69.0
102	46.1
103	11.0
104	36.0

	1008.5

WETLAND TYPE-POW

NUMBER	ACRES
68	0.5

	0.5

WETLAND TYPE-EOW

NUMBER	ACRES
106	2,254.8

	2,254.8

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TOPO-TOANO

WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-PSS		WETLAND TYPE-LOW		WETLAND TYPE-EEM		WETLAND TYPE	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	A
61	10.4										
62	4.3										
63	1.5										
64	0.7										
65	5.4										
67	2.9										
69	3.4										
71	2.2										
73	9.8										
74	13.4										
76	6.0										
78	19.4										
79	33.0										
80	4.3										
81	13.7										
82	19.8										
83	4.9										
84	18.3										
87	5.3										
89	2.5										
91	8.0										
92	1.2										
93	3.6										
95	2.7										
96	2.7										
98	1.3										
99	4.2										
100	[illegible]										

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QUAD-YORKTOWN

WETLAND TYPE-PFO

NUMBER	ACRES
3	1.8
4	0.8
5	1.8
7	4.5
10	2.4
13	6.9
	18.2

WETLAND TYPE-PSS

NUMBER	ACRES
6	7.8
9	5.9
	13.7

WETLAND TYPE-EEM

NUMBER	ACRES
1	46.7
2	7.4
11	6.4
12	26.5
	87.0

WETLAND TYPE-POW

NUMBER	ACRES
8	6.2
	6.2

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QUAD-WEST POINT

WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-PSS		WETLAND TYPE-EEM		WETLAND TYPE-EOW	
NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
1	4.2	2	5.0	10	3.0	5	22.0	15	1,945.5
3	25.6		-------		-------	6	5.5		-------
4	9.8		5.0		3.0	7	5.5		1,945.5
11	8.9					8	349.7		
12	9.7					9	41.8		
	-------					13	91.6		
	58.2					14	133.1		

							649.2		

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QUAD-WILLIAMSBURG

WETLAND TYPE-PFO

NUMBER	ACRES
1	9.6
2	3.7
4	10.1
5	5.6
6	2.1
7	1.0
10	8.5
13	9.9
15	4.4
16	4.7
17	7.3
18	13.1
19	2.1
23	42.8
24	0.4
25	53.7
26	7.9
27	4.6
28	13.4
29	15.5
31	5.5
35	2.3
49	5.6
50	18.3
51	17.2
52	4.8
53	45.8
55	8.6
58	1.4
61	3.3
62	69.7
63	39.4
70	3.7
72	6.6
76	7.1
79	2.0
82	1.3
83	2.4
87	2.8
89	39.0
90	8.6
92	1.7
93	42.4

	559.9

WETLAND TYPE-PEM

NUMBER	ACRES
12	28.2
57	1.0
71	1.5

	30.7

WETLAND TYPE-PSS

NUMBER	ACRES
60	0.8
77	4.2
85	1.7

	6.7

WETLAND TYPE-LOW

NUMBER	ACRES
14	182.2
20	112.6
21	5.5
22	16.2
45	20.2
46	20.0
56	150.5
59	48.3
84	65.4
91	60.2

	681.1

WETLAND TYPE-EEM

NUMBER	ACRES
8	4.8
9	6.4
11	30.3
30	28.9
33	1.7
34	2.2
36	15.5
37	38.5
39	23.8
40	48.8
43	224.7
47	168.6
48	110.8
54	54.1
64	87.7
65	68.1
66	41.5
67	75.4
68	10.0
69	2.6
73	12.7
75	100.5
78	36.1
80	138.9
81	10.6
86	44.2

	1387.4

WETLAND TYPE-POW

NUMBER	ACRES
3	7.5
88	8.9

	16.4

WETLAND TYPE-EFL

NUMBER	ACRES
41	13.7
42	126.8
94	30.3

	170.8

WETLAND TYPE-EOW

NUMBER	ACRES
32	4.1
74	74.6
95	3,307.4
96	179.5

	3,565.6

R

RVOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

GOODINS POND

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
TOANO						
	73	9.8	72	4.1	75	19.7
	74	13.4	77	1.3	70	56.5
	78	6.0		-------		-------
	79	19.4		5.4		76.2

		48.6				

R

[illegible]VOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 2[illegible], 1989

HAYNES POND

TOPO	WETLAND TYPE-PFO NUMBER	WETLAND TYPE-PFO ACRES	WETLAND TYPE-PEM NUMBER	WETLAND TYPE-PEM ACRES	WETLAND TYPE-LAB NUMBER	WETLAND TYPE-LAB ACRES
CLAY BANK						
	40	21.9	39	2.7	38	38.9
	42	3.9	45	442.2		------
	43	7.3		-------		38.8
	44	1.1		444.9		
	46	1.4				
	47	11.[illegible]				
GLOUCESTER						
	19	18.3				

		74.9				

R

[illegible] WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January [illegible]

[illegible]

[illegible]	WETLAND TYPE-[illegible]		WETLAND TYPE-[illegible]		WETLAND TYPE-[illegible]	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
CLAY BANK						
			1[illegible]	2[illegible].5	15	1[illegible].9
				2[illegible] 5		13.9
GLOUCESTER						
	14	[illegible]0.[illegible]				
	1[illegible]	[illegible].6				
		[illegible]5.9				

R

VOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

JONES CREEK 2

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES
CLAY BANK				
			11	37.0
				37.0
GLOUCESTER				
	17	5.5		
		5.6		

R

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JONES MILLPOND

TOPO	WETLAND TYPE-PSS		WETLAND TYPE-LOW		WETLAND TYPE-POW	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
WILLIAMSBURG	85	1.7	84	65.4	3	7.5
		1.7		65.4		7.5

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VOIR WORKSHEET Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

PENNIMAN LAKE

TOPO	WETLAND TYPE-LOW	
	NUMBER	ACRES
CLAY BANK		
	111	50.2
		50.2

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POWELL LAKE

TOPO	WETLAND TYPE-LOW	
	NUMBER	ACRES
WILLIAMSBURG		
	46	20.0

		20.0

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OIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

QUEENS LAKE

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-L2W	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
WILLIAMSBURG						
	72	6.6	71	1.5	91	60.2
		6.6		1.5		60.2

R

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RICHARDSON MILLPOND

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-PSS		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
TOANO								
	79	33.0	86	3.3	88	7.5	85	39.5
	80	4.3	94	1.5	90	9.4		-------
	81	13.7		-------	97	5.2		39.5
	82	19.8		4.8	100	1.4		
	84	18.3				-------		
	87	5.3				23.5		
	89	2.5						
	91	8.0						
	92	1.2						
	93	3.6						
	95	2.7						
	96	2.7						
	98	1.3						
	99	4.7						

		121.1						

R

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:KIMINO POND

TOPO	WETLAND TYPE-LOW	
	NUMBER	ACRES
WILLIAMSBURG		
	45	20.2
		20.2

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VOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

WALLER MILL POND

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES
WILLIAMSBURG				
	15	4.4	14	182.2
	16	4.7	20	112.6
	17	7.3		-------
		-------		294.9
		16.4		

R

CIR WORKSHEET   Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

WAMLEY TOPO

TOPO	WETLAND TYPE-PSS		WETLAND TYPE-POW	
	NUMBER	ACRES	NUMBER	ACRES
POQUOSON WEST				
	2	1.2	1	16.9
		1.2		16.9
YORKTOWN				

?

-L .OIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

WILLIAMSBURG D -

TOPO	WETLAND TYPE-LOW	
	NUMBER	ACRES
HOG ISLAND		
	1	14.6
		14.6

RESERVOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

BARLOWS POND

TOPO	WETLAND TYPE-PFO NUMBER	WETLAND TYPE-PFO ACRES	WETLAND TYPE-L1W NUMBER	WETLAND TYPE-L1W ACRES
WILLIAMSBURG				
	18	13.1	21	5.5
	19	2.1	22	16.2
	23	42.8		-------
	24	0.4		21.7
	25	53.7		
	26	7.9		
	27	4.6		
	28	13.4		
NORGE				
	1	1.4		
	2	7.3		
	3	15.8		
GRESSITT				
	5	13.5		
	6	15.1		
	7	4.4		
	8	8.4		

		203.9		

E.. VOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1999

BEAVERDAM POND

TOPO	WETLAND TYPE-PFO		WETLAND TYPE LOW		WETLAND TYPE-PSS	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
WILLIAMSBURG						
	61	3.3	59	48.3	90	0.8
	62	69.7		-------		-------
		-------		48.3		0.8
		73.0				

R

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.RVOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1989

BIGLER MILLPOND

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-PEM		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES	NUMBER	ACRES
WILLIAMSBURG						
	58	1.4	57	1.0	58	150.5
		1.4		1.0		150.5

R

R

RESERVOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc January 23, 1989

CHEATHAM POND

TOPO	WETLAND TYPE-LOW	
	NUMBER	ACRES
CLAY BANK		
	116	635.6
		635.6

R

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. A/OIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1999

FRANCE SWAMP 1

TOPO	WETLAND TYPE-LOW	
	NUMBER	ACRES
TOANO		
	105	18.3

		18.3

R

R

E . VOIR WORKSHEET - Prepared by Gannett Fleming Environmental Engineers, Inc. January 23, 1999

FRANCE SWAMP 2

TOPO	WETLAND TYPE-PSS		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES
TOANO				
	6	1.9	7	9.9
		-------		-------
		1.9		9.9

R

R

[illegible]TT POND

TOPO	WETLAND TYPE-PFO		WETLAND TYPE-LOW	
	NUMBER	ACRES	NUMBER	ACRES
GRE[illegible]ITT				
	159	6.6	160	21.7

				21.7
SHACKEFORDS				
	25	11.4		
	26	8.4		
	27	21.8		
	28	4.1		

		52.3		

R

GANNETT FLEMING

CONTRACT NO. 68-D-80024

WORK ASSIGNMENT NO. 10

ECOLOGICAL IMPACT ASSESSMENT OF WARE CREEK IMPOUNDMENT

Draft Material

Task Series 300 - File Review and Consultation

February 9, 1989

U.S. Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Prepared by

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REVIEW OF MOST RECENT GROUNDWATER INVESTIGATION

In this report a review of the most recent USGS report of the York-James Peninsula of Virginia, Ground-water Resources of the York-James Peninsula of Virginia, Water-Resources Investigations Report 88-4059 is presented. The USGS report was prepared by Mr. Randell J. Laczniak and Mr. Andrew A. Meng III of the Richmond, Virginia office of the USGS.

The main purposes of this review are to (1) review the various projections of increased withdrawal, (2) review the discussion and conclusions associated with the projections presented in the USGS report, and (3) relate the findings presented in the USGS report to James City County's need for additional water supply.

Base Conditions

The USGS used 1983 as the base year within the report. Maximum water-level declines from prepumped conditions to 1983 conditions can be summarized as follows:

Aquifer	Maximum Water-Level Decline	Approximate Areal Location
Yorktown-Eastover	7	City of Virginia Beach
Chickahominy-Piney Point	100	Town of West Point
Aquia	128	Town of West Point
Upper Potomac	157	Town of West Point
Middle Potomac	128	Town of Smithfield
Lower Potomac	126	Town of Smithfield

It can be seen that considerable drawdown had occurred within five of the six aquifers. In 1983, thirty-eight mgd were being pumped from wells located within the Coastal Plain of Virginia. The withdrawals by each aquifer are presented in Table 1.

Projections

The USGS modeled four different water projections. The pumping by aquifer for each of the projections are presented in Table 1.

For Projection I, the withdrawals for each of the wells located in the Coastal Plain of Virginia were doubled, thus the total withdrawal associated with the projection was 76 mgd. Maximum water-level declines from 1983 conditions for Projection I are shown in Table 2. The USGS report states "The extent of water-level declines suggest that increasing withdrawal from established pumping centers is an impractical means of meeting future water needs." "Comparison of simulated potentiometric surfaces and top of aquifer maps show that water levels in the Chickahominy-Piney Point aquifer are approaching the top of the aquifer near the Town of West Point."

For Projection II, 49 new wells were assumed to be located at various points within the study area. These wells represented 33 mgd of additional pumpage; for a total of 71 mgd. Twenty-nine wells were located within James City County and represented 12 mgd of additional pumpage. Maximum water-level declines from 1983 conditions for Projection II are shown in Table 3. The USGS report states "Water levels remained well above the top of respective aquifers, except in the Chickahominy-Piney Point aquifer near Westpoint and in the Yorktown-Eastover aquifer in eastern York County. Major cones of depression developed in James City County."

For Projection III, 29 new wells were located within James City County which represented 12 mgd of additional pumpage, or a total of 50 mgd. Maximum water-level declines from 1983 conditions for Projection III are shown in Table 4. No other new wells or increases in pumpage of existing wells were represented. The USGS report states "Though water levels were deepest near

Table 1 -- Withdrawal by aquifer for projections I, II, III, and IV

[Values in millions of gallons per day]

Aquifer	1983 Pumping Period	Projection I	Projection II	Projection III	Projection IV
Columbia	0.128	0.256	0.128	0.128	0.128
Yorktown-Eastover	1.403	2.806	4.406	1.403	4.406
Chickahominy-Piney Point	2.641	5.282	5.214	4.439	4.164
Aquia	1.003	2.006	1.685	1.685	1.410
Virginia Beach	0.006	0.012	0.006	0.006	0.006
Upper Potomac	13.644	27.228	21.814	17.702	19.066
Middle Potomac	15.150	30.300	28.415	19.502	25.548
Lower Potomac	4.135	8.270	9.588	5.251	8.317
Total	38.110	76.160	71.256	50.116	63.045

Source: **Table 28, USGS Report 88-4059.**

Table 2 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection I

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	7	City of Richmond
Chickahominy-Piney Point	100	Town of West Point
Aquia	126	City of Williamsburg
Upper Potomac	155	Town of West Point
Middle Potomac	127	Town of Suffolk
Lower Potomac	122	Town of West Point

Source: Table 30, USGS Report 88-4059.

Table 3 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection II

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	14	York County
Chickahominy-Piney Point	75	Central James City County
Aquia	99	Central James City County
Upper Potomac	155	Western James City County
Middle Potomac	76	Western James City County
Lower Potomac	74	Western James City County

Source: Table 34, USGS Report 88-4059.

Table 4 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection III

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	1	Central James City County
Chickahominy-Piney Point	52	Central James City County
Aquia	65	Western James City County
Upper Potomac	76	Western James City County
Middle Potomac	34	Western James City County
Lower Potomac	26	Central James City County

Source: Table 35, USGS Report 88-4509.

the Town of West Point in the Potomac aquifers, major cones of depression developed in James City and New Kent Counties."

For Projection IV, withdrawals were from the same new wells as in Projection II; however, the withdrawal rates were reduced for most wells. The projection represent an increase of 25 mgd, or a total of 63 mgd of pumpage. Within James City County new wells would provide an additional 7.25 mgd. Maximum water-level declines from 1983 conditions for Projection IV are shown in Table 5. The USGS report states" Water levels remained above tops of respective aquifers. Major cones of depression developed in the western part of James City County and in the eastern part of New Kent County." "Much less severe water-level decline was projected than in Projection II which suggests that if water-level decline is a concern, the resources would be better utilized as a supplemental source of water supply."

Discussion

Most water supply concerns are related to either decreases in aquifer yields or to deterioration of the quality of water within the aquifers. Decline of water levels below pump intake intervals require that pumps be lowered. Decline below screen levels require that wells be deepened in order to obtain water from lower horizons within the aquifer or from lower aquifers.

The USGS report states that "Because numerous users already withdraw ground water, it is far more likely that water-level declines will result in unacceptable interference among ground-water users before dewatering of the aquifers is a concern. From a water management prospective, this means water-level declines will limit the yields from aquifers before available recharge is depleted unless existing users lower screen intakes."

"Projection I, which doubled withdrawal from all wells located in the Virginia Coastal Plan resulted in severe water-level declines at the established pumping centers and moderately severe declines throughout the remainder of the aquifers. Other projections, which increased withdrawal from

Table 5 -- Maximum water-level decline from 1983 flow conditions for each aquifer, projection IV

Aquifer	Decline (feet)	Approximate Areal Location
Yorktown-Eastover	14	York County
Chickahominy-Piney Point	45	Central James City County
Aquia	62	Central James City County
Upper Potomac	93	Western James City County
Middle Potomac	58	Hanover County
Lower Potomac	61	Charles City County

Source: Table 36, USGS Report 88-4509.

wells located away from the established centers, generally resulted in less severe water-level decline in the aquifers and far less severe decline at previously established pumping centers."

"Projection III, which withdrew water from the deeper confined aquifer, had minimal effect on water levels in the Yorktown-Eastover aquifer and suggests that increased withdrawal from the deeper confined aquifers does not impact users withdrawing water from the shallow aquifers."

The authors of the USGS report did not attempt to provide an answer to the question as to how much additional water can be withdrawn from the York-James Peninsula of Virginia. They presented a discussion of each of the four projection modeled and certain portions of their discussion has been presented above.

Contents of the USGS report indicated that to optimize the yield of the York-James Peninsula groundwater system it would be necessary to develop a regional approach so that each new well's location, spacing, pumping rate, aquifer selection and screening and other factors could be part of an overall regional management plan.

James City County Needs

Projection III most closely represents fulfilling James City County's additional water supply needs with groundwater. At first glance, it appears that groundwater could satisfy the needs. However, the projection was based on no increase in pumping from existing wells or any new wells being constructed outside of James City County. Because at present there is no state regulation to ensure that increases in pumping will not occur or new wells will be constructed, it is not possible to say that James City County's additional water supply needs can be met entirely with groundwater.

Groundwater Management Areas

The Commonwealth of Virginia's Groundwater Act of 1973 provides for the establishment of Groundwater Management Areas within the State by the State Water Control Board. Currently, two areas have been established by the State Water Control Broad. The first is located in Southeastern, Virginia south of the James River and the second is located on the Eastern Shore of Virginia.

To establish a Groundwater Management Area, one of the following criteria must be met: (1) Groundwater levels must be declining excessively; (2) Existing wells of two or more users must be interfering with each other substantially; (3) Available groundwater supply is or about to be overdrawn; and (4) Groundwater has been or reasonably may be expected to become polluted. If any of the above four criteria are met, the Water Control Board may elect to establish a Groundwater Management Area after public notices, hearings, etc.

If a Groundwater Management Area is created, all existing wells are grandfathered at the their historical maximum daily pumping rate. New wells, except agricultural wells, must not cause significant impacts on existing wells. Also, the Board will ask if there are other available water supply alternatives, such as surface water. If there are other alternatives, the owner can provide reasons for going to groundwater -- such as economics.

If the State Water Control Board creates a Groundwater Management Area in the York-James Peninsula sometime in the future, then there would be a potentially a greater degree of protection of existing wells and future groundwater users. However, at present, in the two existing Groundwater Management Areas there is no long-range groundwater plan. Rather, the Board staff acts on new well requests on a case-by-case basis to determine the impacts on the well. In a sense, this approach appears to allow those users who ask for new wells first to have additional water first, as long as there are not unacceptable impacts, as defined by the Board, to other existing groundwater users.

TECHNICAL MEMORANDUM

TO: Charles Rhodes; EPA, Region III

FROM: David Bell; EcolSciences, Inc.

DATE: 10 January 1989

SUBJECT: Comments on "REVIEW OF THE 404 C RELATED ISSUES FOR THE WARE CREEK RESERVOIR FOR JAMES CITY COUNTY, VIRGINIA" submitted by Dames and Moore, dated January 30, 1989

A. GENERAL COMMENTS

The overall perspective adopted by this review couples a quite optimistic picture of the benefits of the revised mitigation plan with a rather pessimistic view of trends in the county over the next few decades under the No Project scenario. I believe that this perspective overstates the benefits of the project and understates the positive features of the watershed as it now exists.

In essence, the pervading logic in this approach seems to be: if you don't allow the wetlands to be inundated, they will likely be destroyed, together with the areas earmarked for restoration or preservation. This may seem a rather flippant description of a recurrent theme of the report, but just such logic is extensively used as justification for the proposed action. I would have appreciated a somewhat more realistic tone, perhaps even conceding that accepting the proposed mitigation is tacitly accepting some loss in overall environmental quality in the region. That is almost always the case with impacts and mitigation, and the involved parties must try to agree on how acceptable those losses are.

The review uses a variety of semantic techniques to cast the benefits of the project in the best possible light. Among the most conspicuous are:

- Hyperbole: use of a worst-case scenario to justify the benefits of the mitigation plan. The scenario of the future without the project is portrayed rather bleakly, with existing wetlands filled or polluted, and residential development growing in an uncontrolled manner. It is generally considered appropriate to present intermediate-case scenarios that permit the reader to come to his or her own conclusions based on an objective discussion of facts and realistic projections.

- Generality: a disproportionate amount of discussion is dedicated to generalizations on how the downstream water quality will be maintained by judicious use of multi-level reservoir discharges. I find it difficult to accept without demonstration that the DO, temperature, nutrients, tychoplankton, and suspended sediment loadings downstream can be simultaneously "optimized." Further, even if this were achieved to the satisfaction of the scientist-in-charge, such manipulations might be detrimental to the continued success of the native biota, which have presumably adapted to the environmental regime now characteristic of the tidal portions of the creek.

- Redefinition: the concerns over shellfish are presented and discussed in terms of the immediate commercial value of the area around Ware Creek. I believe that the issue is somewhat different and of a broader scale than defined by the author; watersheds such as Ware Creek are valuable contributors to the nursery functions of the estuary and its shellfish populations.

I've referenced several of these argument forms in the specific comments that follow.

B. SPECIFIC COMMENTS

1. Re p. 2-1 (Sec. 2.1) - "this area is not an important resource for shellfish" is a conclusion based on a very anthropocentric viewpoint - whether or not adult shellfish occur here and can be caught and eaten. The discussion glosses over the fact that these upper estuarine areas serve generically as spawning and nursery areas. Elevated coliform levels do not interfere with these latter functions, and larvae or juveniles spending early life stages here may ultimately contribute to the commercial and recreational value of other estuarine areas.

2. Re p. 2-3 (Sec. 2.3.2) - "the tidal freshwater and oligohaline wetlands ... may be expected to change somewhat ..." grossly understates the VIMS conclusion that the anticipated salinity changes will result in "the loss of the tidal freshwater vegetation of Ware Creek and a great reduction or elimination of the oligohaline assemblage" (Herschner and Perry, 1987). These researchers viewed the change as significant.

Also, regarding the preadaptation of estuarine organisms to salinity stress, the real concern is that shellfish predators and parasites will extend their ranges as freshwater flows diminish. The ability to tolerate an altered salinity regime is only one of the stresses an estuarine organism endures; such a tolerance is of secondary consequence to a mollusc when it is being eaten by a drill or being parasitized by MSX.

3. Re P. 204 (Temperature and Dissolved Oxygen) - because the DO and temperature curves run parallel in a stratified clinograde lake, it is impossible to maximize for both variables (i.e., high DO and low temperature), and difficult to even optimize for these variables. Further, the comment implies that the natural temperature cycle is somehow harmful to the native biota, or at least inferior to the proposed, highly-managed release cycle. It is more likely that the annual variations, being generally predictable on an annual basis, serve as cues for life-cycle stages of native biota. The manipulation of the discharge to try to meet water quality criteria may interfere with the reproduction and/or maturation of native biota. Also, the natural fluctuations in flow could permit more than one suite of species to use the habitat - one suite in wetter periods and another in drier periods.

4. Re p. 2-5 (Sediment Load) - to "attain comparable deposition and marsh expansion below the dam, if desired" is not a trivial feat, and may require water management contrary to water supply objectives. Would the detritus-rich spring flows be passed rather than stored? Can hypolimnetic discharges be controlled so as not to generate stressful DO conditions? Detail is needed on these points to make reasoned judgements on possible effects.

5. Re. p 2-5 (Vegetation) - this discussion begs the question. The principal concern that has been raised is the loss of the valuable tidal freshwater and oligohaline vegetation. I don't believe anyone would doubt that something will grow downstream; it's the question of whether specific valuable resources are being lost. Also, tychoplankton are indeed a useful food source; however, the author does not address the cropping issue resulting from water withdrawals.

6. Re p.2-6 (Water Flow) - "more suitable environmental conditions" for what species? The native biota have evolved under the present variable flow regime; are they the species that would find the reduced flows more suitable? Or will there be replacement by other opportunistic forms. This remains unresolved by the author.

7. Re 2-6 (Nutrient Changes) - what appears to be building here is a very complex programming of reservoir discharges. Based on these and earlier comments, the releases are supposed to be managed to optimize for DO, temperature, tychoplankton, and suspended sediments. First, this assumes a detailed understanding of how the existing system is operating, as well as a detailed picture of what the desired post-construction picture would be. Further, the actual optimization appears to be a full-time task. Finally, as mentioned above, will these altered releases interfere with natural cycles of native biota in the downstream area? I remain unconvinced that all of the goals can be achieved simultaneously, and insufficient details are offered.

8. Re p.2-7 (Nutrient Changes) - here again, the conclusion reached by the author, that diversity would increase, involves partial or complete replacement of the native biota (the additional species have to come from somewhere). Flow rates, salinities, DO, temperature, and suspended solids will alll vary in ways new to the established biota, and will likely result in wholesale community structure changes.

9. Re p. 2-9 (para. 3) - although I'd have to do some literature searching on this, it is my sense based on looking at a lot of lakes that lentic systems do a poorer job of processing leaves that do streams. Lakes that I've seen often build up large deposits of unprocessed leaves. The invertebrates in streams are highly adapted to using this resource; it is a principal source of organic carbon. The cycling of allochthonous inputs could be much less efficient than portrayed here.

10. Re p. 2-10 (para. 2) - that Ware Creek is "a marginal resource (at best)" for shellfish reflects the anthropocentric perspective noted in Comment 1.

11. Re p 3.2 - if these premises are accepted, that the region would be better environmentally with the Ware Creek system under

water and the Yarmouth Creek system conserved, will ongoing residential development stop? It seems to me that the surface runoff from development will still affect some drainage systems. This type of discussion seems to have a very narrow view, and doesn't present the full picture. I also perceive such arguments as veiled, "use it or lose it" threats to particular ecosystems.

12. Re p. 3.3. (Sec. 3.3.1) - with it being likely that the lake will fluctuate in level, will lack a well-vegetated littoral zone, and will have ichthyoplankton cropped by the water withdrawals, it seems optimistic to predict that the temperature regime will "result in a fish community that is typical of a lake environment."

13. Re p. 3-4 (Sec. 3.3.2) - the development of a "balanced aquatic community including abundant plankton, benthic organisms, and a substantial fishery resource" is, in my opinion, not a certainty. The lake will be subject to fluctuating water levels, massive extractions of water (and anything in that water), and DO stress from decomposing original vegetation. Near-shore areas alternately subject to dessication and wave chop will likely be eroded down to sand-sized particles, a substratum not conducive to diverse benthic productivity. The water quality downstream may be above minimum standards, but I do not believe that, under current planning, it will be "very good."

14. p. 4-3 (para. 2) - it is true that most of the "freshwater palustrine habitats in the Ware Creek watershed are 'abundant natural community types'." I don't think that is the real issue - the exceptional feature of Ware Creek is the collection of many of these community types in one watershed. You can find a half-acre of palustrine emergent wetland in the center of a freeway cloverleaf, but that doesn't accord it the same value as a half-acre situated in the middle of the Ware Creek watershed. In this circumstance, the old adage probably applies - the whole is greater than the sum of its parts - and that is where the exceptional value of the Ware Creek watershed originates.

15. p. 4.4 et seq. (para. 4) - the Yarmouth Creek tidal freshwater wetland that is "characterized as the highest priority category for preservation ..." is the same general type as that in the Ware Creek system, where changes to such wetlands are viewed as "more beneficial than harmful" (see Comment 2).

16. p. 4.7 et seq. (Sec. 4.2.1.) - what is presented here is a worst-case scenario. My own sense of such argumentation (perhaps a little dated), based on CEQ guidance on this matter in the early 80's, is that worst-case scenarios should be used in decision making only if a range of less severe, higher probability scenarios are also presented. Although the Dames & Moore report is not a formal NEPA document, it should, in fairness, strive to adhere to that spirit and present a gradation

of scenarios. It is possible that development in the County could proceed within the framework of a more compassionate treatment of its existing natural resources than is described here.

17. p. 4-11 (Sec. 4.3.2.) - in terms of habitat properties, a "greenbelt" is still a belt or linear strip, and "perimeter protection basins" are still isolated wetlands. By Gosselink and Lee (1987) standards, the quality of the habitat is still diminished by such changes in the spatial arrangement of the "patches". Also, the transcript of the 01/18/89 public hearing has both T. Malone (p.21, l. 25) and S. Warner (p. 43, l. 24) referring to the possible future expansion of the reservoir (to +50 ft?). If this is to be the case, then one might as well strike all the benefits accorded to the perimeter protection basins.

18. Re p. 4-16 (sec. 4.4) - it seems to me that, if one is going to apply a State-wide or Bay-wide perspective to the magnitude of the impacts (by using State-wide or Bay-wide wetland acreages as divisors), then one should use the same perspective for the magnitude of the benefits. The benefits, however, are cast in the perspective of local needs, while the impacts are viewed against a much larger (regional) backdrop. This difference in perspective will inevitably magnify the perceived benefits and shrink the perceived impacts.

19. Re p. 4-18 (para. 2) - after computing a 3:1 mitigation ratio for the project, the benefits of the mitigation are further boosted by citing the merits of protecting "connected freshwater and estuarine wetlands as opposed to scattered isolated wetlands." Won't the project destroy just this type of connected system?

20. Re p. 5-2 (para. 2) I believe that the reference here to "a significant gain in the freshwater, marine, and terrestrial resources of the region" encapsulates the optimistic/pessimistic duality of themes of this report. In my opinion, the environmental losses are more significant, and the restoration/preservation gains less substantial, than their representations in this review.