1982

Water quality trends in the Northwest River : a report to the Hampton Roads Water Quality Agency

Bruce J. Neilson
Virginia Institute of Marine Science

WATER QUALITY TRENDS IN THE NORTHWEST RIVER

A Report to the Hampton Roads Water Quality Agency

by

Bruce J. Neilson

The preparation of this report was financed in part through a grant from the United States Environmental Protection Agency under Section 208 of the Federal Clean Water Act (Grant No. P003085-03). The contents do not necessarily reflect the views and policies of the EPA, nor does the mention of trade names or commercial products constitute an endorsement or recommendation.

Department of Physical Oceanography
and Environmental Engineering

Virginia Institute of Marine Science
College of William and Mary

Dr. Frank O. Perkins, Director
Gloucester Point, Virginia 23062

October, 1982

EXECUTIVE SUMMARY

The Northwest River is a small coastal river within the Dismal Swamp system. Much remains to be learned about this river, but we do know that:

- The river is the primary source of drinking water for a large portion of the population in Chesapeake.
- The river has limited ability to assimilate pollution.
- Dissolved oxygen values between 2 mg/1 and 4 mg/1 are not uncommon during the summer.
- Any additional increase in pollutant loads will increase in further degradation of water quality

The importance of the public water supply dictates that activities within the watershed be managed in a prudent fashion. Specifically, it is recommended that:

Awareness of the special characteristics of the Northwest River and the need for water quality management be promoted;

Activities which threaten the water supply should be excluded from the basin, or at least the portion of the basin near the intake;

Water quality conditions in the river should be monitored;

Land disturbing activities should be controlled and monitored; Good land management practices should be encouraged in order to reduce nonpoint source pollution loads to the river. If these actions are taken, it is believed that the projected trend of deteriorating water quality can be minimized and perhaps even reversed.

INTRODUCTION

During the initial 208 studies of the Hampton Roads area, no mathematical model of receiving water quality was applied to the Northwest River. At the request of the City of Chesapeake, the HRWQA P003085-03 work program included tasks leading to development of a water quality model of the Northwest River. Data from field studies conducted in 1980 and 1981 and the math model applied to the river have been presented in a companion volume report (Kuo et al., 1982). This report summarizes the results of model simulations made to determine future water quality conditions and trends.

Funding for this work was provided in part by the U. S. Environmental Protection Agency under grant P003085-03 to the Hampton Roads Water Quality Agency. The field studies and the laboratory analysis of water samples were supported by the City of Chesapeake. Additional water quality analyses were performed by the staff of the Hampton Roads Sanitation District.

Although the report was written by a single author, it summarizes work which was performed by a number of scientists. Specifically, Dr. Albert Kuo developed the mathematical model of water quality, Dr. Paul Hyer applied the model STORM to the basin to provide nonpoint source loadings, Mr. Gary F. Anderson assisted with field work and model studies, and Mrs. Linda Kilch coordinated the monitoring efforts. The work of the member agencies of HRWQA and the original Hampton Roads 208 study were utilized extensively, too.

Description of the Study Area

The Northwest River is a small, coastal plains river draining a portion of the Dismal Swamp (see Figure 1). "The Northwest River and its tidal tributaries from the Virginia-North Carolina State line to the free-flowing portion" have been classified as estuarine by the State Water Control Board (1982). The estuarine description applies because the river experiences reversing tidal flows, even though much of the time the river is essentially free-flowing. Water elevations and the strength and direction of the currents respond primarily to wind patterns and only to a much smaller degree to the movement of the moon and the sun. Consequently, it is difficult to project the tides except in terms of general responses to particular wind conditions. It also is difficult to determine where the river stops being free-flowing and becomes tidal.

The upper reaches of the river have been assigned to Class III - Free-flowing (Coastal Zone and Piedmont Zone). Within that class is a special Public Water Supply zone extending 5 miles downstream and 5 miles upstream of the City of Chesapeake's raw water intake (section 1c). Presumably the water supply designation extends downstream as well as upstream because of the tidal nature of the river.

The basin is relatively low lying (most of the basin is less than 25 feet above mean sea level). The soils consist primarily of mucky peat and over 80% of the basin has soils ranging from "somewhat poorly drained" to "very poorly drained" (SVPDC, 1978). As a consequence most of the land is unsuitable for installation of septic tank drain fields (SVPDC, 1978).

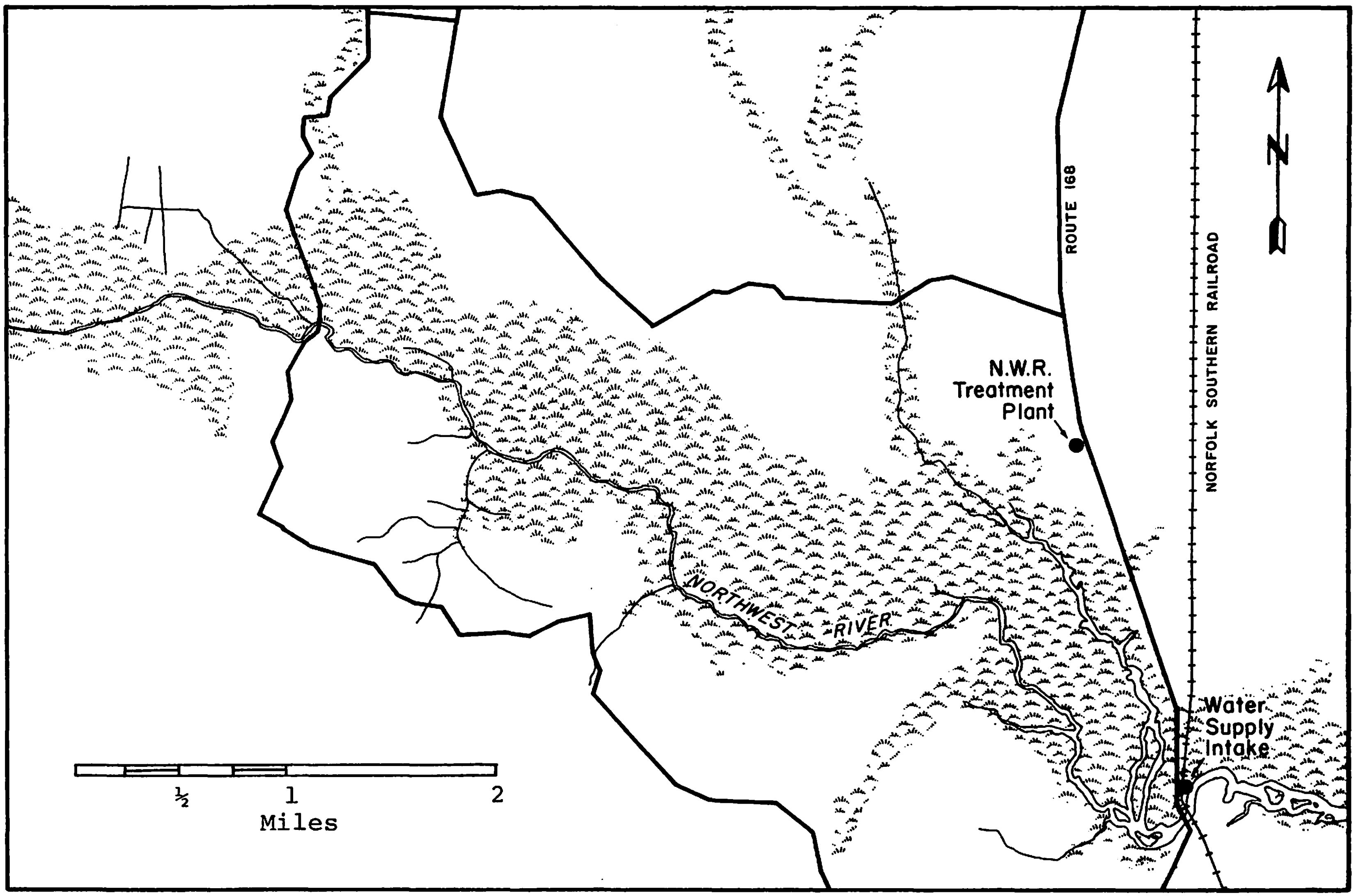

Figure 1. The Northwest River upstream of the water supply intake.

WATER USES AND WATER QUALITY STANDARDS

Water quality is a relative concept and cannot be defined in an absolute fashion. The intended use of the water determines the characteristics that are either necessary or desired. For each use, then, there is a set of water quality criteria which are defined as "the scientific data evaluated to derive recommendations for characteristics of water" for that use (NAS-NAE, 1972). Once the desired uses of a water body have been established, the water quality criteria for those uses, plus political, economic and social factors and the local situation are used to develop water quality standards for that water body. In Virginia the State Water Control Board has established some general standards that "will permit all reasonable, beneficial uses and will support the propagation and growth of all aquatic life, including game fish, which might reasonably be expected to inhabit them" (VSWCB, 1982). For the Northwest River the following general standards apply:

Dissolved oxygen	4.0 mg/1 - minimum
	5.0 mg/1 - daily average
pH	6.0 to 8.5

The dissolved oxygen standards are important because most higher life forms require oxygen for survival; reproductive success and growth also are affected by DO levels. Generally speaking, the more desirable the fish or other organism, the higher the desired oxygen level. For example, salmon require more oxygen than catfish. The minimum values encountered also appear to be more important than average values (NAS-NAE, 1972).

Other standards have been established for special circumstances and for special uses. Perhaps the most important use of the Northwest River is as a drinking water source, as suggested by the special "Public Water Supply" designation given a segment of the river by the SWCB. Insuring adequate supplies of drinking water has been a challenging goal for all Tidewater localities. The near surface groundwater can be contaminated easily and typically yields water at rates suitable for individual households but inadequate for municipal systems. Intrusion of saline waters is a source of concern when water is withdrawn from the deeper aquifers. As a result of these concerns, surface water sources have been tapped when available. Consideration of the Northwest River as a drinking water source dates back prior to 1970 (VDWR, 1970). In 1980 the City of Chesapeake began withdrawing water from a point just downstream of Route 168 crossing of the river. Current withdrawal rate is about seven million gallons per day (MGD). The safe yield is 10 MGD and the treatment capacity of the water treatment plant is 15 MGD.

Standards have been established by the state for "the protection of public or municipal water supplies" (VSWCB, 1982). These include maximum concentrations of trace metals, organic chemicals (insecticides, herbicides and others), and radioactivity. Of relevance to the present study are the following:

Constituent	Concentration
Chlorides	250 mg/1
Nitrate (as N)	10 mg/1
Total dissolved solids (filterable residue)	500 mg/1

Data from the field surveys indicate that chlorides were always within the limit, nitrates were present at very low concentrations, and the total suspended solids levels were low as well. The color of Northwest

River water is high (around 100-250 color units) and above the standard of 75 which was included in earlier versions of the drinking water standards (VSWCB, 1974).

The Northwest River is also used for recreation. Boat ramps and a campground are located near the Chesapeake water intake. No survey of boat traffic was made, but it is expected to be much lighter than that on nearby rivers which are part of the Intracoastal Waterway.

Water quality standards for recreational waters include bacteriological limits to reduce the incidence of water-borne diseases which could result from contact with or ingestion of the water. The state standard requires that the mean concentration of fecal coliforms (FC*) should be less than 200 per 100 milliliters (ml) of water and not more than 10% of the samples should have more than 400 FC/100 ml (VSWCB, 1974). The median value for 29 samples taken from the river during the summer of 1980 was 27 FC/100 ml. More than a third of the samples contained less than 10 FC/100 ml, but peak levels following storms reached as high as six to eight thousand FC per 100 mls of water. (Kuo et al., 1982).

It should be noted that the Water Control Board has established a class for swamp waters because "the natural quality of swamp water may fall outside the ranges for DO and pH set forth" for other water classes. Swamp water standards will be developed on a case-by-case basis (SWCB, 1982). As far as the author is aware, the standards applicable to the Northwest River have not been altered even though it is swamp water.

*Fecal coliforms are non-pathogenic bacteria typically found in the intestines of warm-blooded animals. The presence of these bacteria in high numbers is an indication that pathogenic microorganisms could be present as well.

WATER QUALITY MANAGEMENT

The goal of water quality managers is to provide for the maximum beneficial use of a water body by controlling pollution. At present none of the facilities or operations in the Northwest River basin is known to discharge wastewaters to the river on a daily basis. Therefore, the primary concern is to insure that runoff from the land does not cause water quality problems, and specifically that the drinking water supply is protected. The purpose of the current project has been to develop those tools that will allow us to predict future water quality trends. Of particular interest are the water quality changes that can be attributed to changes in land use patterns.

Land Use Trends

Land use projections for the Virginia and North Carolina portions of the Northwest River basin that are upstream of the Route 168 crossing of the river are given in Table 1 (SVPDC, 1981). These data are essentially the same as those used in the initial 208 studies but adjusted to account for only that portion of the basin upriver of the water intake. Recently these numbers have been revised to reflect existing and proposed land use changes, primarily a clearing of vacant or forested lands for agricultural purposes. The revised land use statistics given in Table 2 also have been adjusted to match the rural land use categories in the mathematical model "STORM" which has been used to project nonpoint source loads. The primary change has been to allocate the street acreage to the other categories.

TABLE 1. Land use projections - Northwest River Basin - Virginia, Upstream of Route 168*

SA	Comm/Inst	Industry/ Streets	Low Density	High Density	Agriculture	Vacant	Water	Total
1977	346.5	433.9	858.0	9.7	10,003.4	40,247.4	557.7	52,456.6
1980	366.5	460.2	916.8	9.8	9,981.1	40,164.5	557.7	52,456.6
1983	398.3	493.1	984.4	9.8	10,713.0	39,300.0	557.7	52,456.6
1985	419.5	514.8	1,029.2	9.8	10,657.2	39,268.4	557.7	52,456.6
1990	472.1	569.9	1,141.3	9.8	10,517.1	39,188.7	557.7	52,456.6
1995	506.4	613.6	1,237.8	9.8	10,388.1	39,143.2	557.7	52,456.6
2000	540.8	657.3	1,334.4	9.8	10,258.9	39,097.7	557.7	52,456.6

Northwest River Basin - North Carolina, Upstream of Route 168*

1980	1.0	-0-	84.5	-0-	1,753.9	3,487.6	-0-	5,327.0
2000 a	3.0	-0-	253.5	-0-	1,685.5	3,385.0	-0-	5,327.0
2000 b	1.5	-0-	126.7	-0-	1,736.8	3,462.0	-0-	5,327.0

*Data provided by Southeastern Virginia Planning District Commission (1981).
Land use statistics are given in acres.

Table 2. Revised Land Use Projections*
Northwest River Basin, Upstream
of Route 168

	Residential/ Nonurban	Commercial/ Nonurban	Light Industry	Forest	Agricultural
1980					
Va.	1150.9	443.6	158.8	40164.5	9981.1
N.C.	104.8	1.2	0	3467.1	1753.9
Sum	1255.7	444.8	158.8	43631.6	11735.0
		Grand Total	57,226		
1983					
Va.	1234.8	481.9	168.9	37300.0	12713.0
N.C.	104.8	1.2	0	3467.1	1753.9
Sum	1339.6	483.1	168.9	40767.1	14466.9
		Grand Total	57,226		
1995					
Va.	1549.0	612.7	205.9	34643.2	14888.1
N.C.	314.3	3.6	0	3323.6	1685.5
Sum	1863.3	616.3	205.9	37966.8	16573.6
		Grand Total	57,226		

*Land use categories are those required by the model STORM. The data reflect current and projected clearing of vacant land for agricultural purposes, as provided to VIMS by the HRWQA.

If all land uses generated roughly the same quantity and quality runoff, then land use changes would not be an important consideration. However, that is not the case. For some uses, commercial strips for example, a large portion of the land is covered by impervious surfaces such as paved parking lots, roofs and storage areas. As a result, a greater portion of the rainfall leaves the land as stormwater runoff and a smaller portion infiltrates the ground than would occur if the land were forested or in pasture. Annual areal loading rates (in pounds per acre per year) and average runoff concentrations for rural land uses are given in Table 3. These loading rates were calculated using the mathematical model STORM and employing the same model coefficients as were used in the initial Hampton Roads 208 studies.

With only one exception, the loading rates for forested lands are the smallest. Residential areas produce less solids, but nutrient and BOD loads are more than twice as high and fecal coliform loads about 40 times higher. Nutrient, BOD and solids loads from agricultural lands are almost exactly twice those for forests. The solids loading rate for agriculture is the highest of all categories, presumably because conventional tillage practices disturb the ground cover several times each year. Fecal coliform loads for agriculture are higher than for forests, but smaller than for industry, commercial development and residential areas.

It is clear from the data presented in Table 3 that the transfer of land from the vacant or forested category to agricultural and residential uses will result in larger pollutant loads being delivered

TABLE 3. Annual areal loading rates (pounds per acre per year) and average runoff concentrations (mg/1) for rural land uses.*

	Agricultural	Forest	Industry	Commercial	Residential
Loading Rates (#/acre/year)					
Suspended Solids	134.15	67.07	74.53	74.63	59.62
BOD	20.55	10.27	27.79	31.18	26.30
Nitrogen	8.24	3.78	12.20	12.21	9.67
Phosphorus	0.89	0.45	1.22	1.22	0.97
Fecal Coliforms (billions)	33.86	3.39	84.65	153.36	135.43
Concentrations (mg/1)					
Suspended Solids	112.17	56.08	62.32	49.85	112.17
BOD	17.07	8.54	22.94	25.72	21.70
Nitrogen	6.87	3.16	10.08	10.08	8.07
Phosphorus	0.74	0.37	1.01	1.01	0.81
Fecal Coliforms (1000/1)	61.36	6.14	153.40	276.12	245.44

*Loading rates calculated using the nonpoint source model STORM and employing those model coefficients determined during the original Hampton Roads 208 study.

to the Northwest River in stormwater runoff. This is significant because of the very limited ability of the river to assimilate pollutants and the importance of the river as a drinking water source. Fortunately, it is possible to mitigate the effects of these land use changes by incorporating good management practices in the design of projects. Residential areas could have street runoff pass through a detention basin where solids could settle out. For croplands, use of minimum tillage or "no-till" would disturb the land less thereby reducing soil erosion. These and many other good management practices have been compiled and described by HRWQA and the State Water Control Board. Additionally more information, especially on the effectiveness of these practices sponsored by EPA and the U. S. Department of Agriculture and the work of the State Water Control Board and the Extension Division of VPI&SU.

Natural Conditions and Model Simulations

The Northwest River basin is part of the Dismal Swamp system. This profoundly affects both the characteristics of the water and the nature of the water flows. Swamp water typically has a dark color and contains many humic acids and other organic compounds which result from the leaching of the litter on the forest floor. The high organic content and the sluggish flows typically encountered both act to produce low dissolved oxygen levels. For example, two thirds of the water samples taken from the river at the water intake at roughly weekly intervals during June through September 1980 had dissolved oxygen concentrations less than 4 mg/1 (Kuo et al., 1982). Values as low as 1.4 mg/1 were observed. Model simulation for the same period showed similar features - dissolved oxygen levels generally in the range between 2 mg/1 and 4 mg/1 during June through September. Even though the summer of 1980 was very dry, it is the author's judgment that similar episodes of poor water quality, and in particular periods of low dissolved oxygen concentrations, will occur during virtually every summer because of the characteristics of swamps.

The river responds to stormwater runoff in a series of phases. Immediately after the storm, concentrations of nutrients, fecal coliforms, BOD and dissolved oxygen rise rapidly. Chlorophyll levels decrease equally rapidly, presumably as a result of dilution (runoff typically contains no algae) and downstream transport. During the next few days (second phase) both DO and BOD levels drop rapidly; the obvious conclusion is that as the oxygen demand is satisfied, the oxygen supply is depleted faster than it is replenished. Reaeration from the atmosphere is expected to be small since water currents are weak and the river is moderately deep. This phase often is ended when another rain event occurs. In those cases where the interval between storms is long, one can observe a third phase characterized by an algal bloom in response to the nutrient inputs. Typically peak algal levels were projected to occur 10 to 15 days after the storm. At that time the dissolved oxygen added to the system as a result of photosynthesis balances that removed from the system by the decay and decomposition of organic matter. In one instance DO concentrations were projected to increase. If the dry period continues during the fourth stage the nutrient supplies are depleted and chlorophyll levels decline; consequently the oxygen addition from photosynthesis decreases and the oxygen demand may increase in response to the death of some of the algae. The end result is that dissolved oxygen levels further decline.

The sequence of events described above is based on interpretation of the math model simulations for 1980 (see Kuo et al., 1982). The model is useful because it incorporates the various processes at work and provides quantitative predictions. Unfortunately, the model is not as accurate as we would like due to limited field data and limited understanding of the role of swamplands. The movement of water through swamps is difficult to measure and characterize; no models are available from other sources to suit this type of system. The model STORM is believed to provide good estimates of the quantity and quality of runoff leaving the land. However, neither it nor the receiving water model includes stream transport processes. When the nonpoint source and receiving water models are coupled, the projections indicate a response to runoff which is more rapid than that observed in nature. In the real world, the swamp slows down the water movement and alters the water during its passage. This buffering capacity provides one form of protection for the receiving waters and some have recommended that it be retained (Duda, 1982). In the Chowan River basin, areas where channelization has occurred were observed to have more severe water quality problems than those areas where the marsh or swamp had been undisturbed.

Water Quality Projections

The nonpoint source model STORM and the receiving water quality model were used to assess water quality changes due to altered land use patterns. The rainfall sequence or "design storm sequence" utilized in the initial 208 studies was used to calculate the nonpoint loadings. For the base year, 1980, dissolved oxygen levels were projected to drop as low as 0.33 mg/l following the initial, large storm. Peak fecal coliform levels following rain events ranged between one and three thousand per 100 ml of water. Between storms nitrate supplies were exhausted and ammonia concentrations reduced to very low levels; phosphorus levels also dropped to rather low concentrations. This suggests that nutrients in general and nitrogen in particular are limiting algal growth.

When the original land use projections were used (Table 1), peak fecal coliform concentrations were projected to increase by about 15% by 1995 and post-storm minimum dissolved oxygen levels were projected to drop by about 0.2 mg/l. When the land use statistics were adjusted to reflect current and proposed forest clearing projects (Table 2), the water quality changes for 1995 were about twice those just described. Chlorophyll levels did not change significantly for any of the conditions tested and concentrations tended to range between 10 and 20 μg/l.

It should be noted that the design storm sequence includes five storms over a five week period. In terms of the river responses, the observed dissolved oxygen minima are those resulting from BOD impacts (the second phase mentioned in earlier sections), so it is not surprising that the decreases in DO levels from one plan to another are directly proportional to the corresponding increases in peak BOD concentrations. The limitations of the model dictate that the results be used with caution; however, several points are clear. First, the models demonstrate that the projected land use changes will result in larger BOD loads in stormwater runoff. In turn this produces a definite negative trend for dissolved oxygen conditions in the Northwest River.

Field observations during the dry summer of 1980 provide evidence that low DO's occur now. Comparison of model simulations made using the actual 1980 rainfall record and the design storm sequence indicate that DO levels decline gradually during extended dry periods, but that the drop can be rapid and large following large storms. In other words conditions during the drought of 1980 may have been less severe than would occur during a summer with several large storms. Whatever the rainfall sequence, it appears that DO's in the range of 2 mg/1 to 4 mg/1 are not uncommon.

Together these two points - DO's as low as 2 mg/1 occurring now and a trend of decreasing DO values - suggest that severe water quality problems will be encountered in the future. Stated somewhat differently, the Northwest River has limited ability to assimilate pollutant loads due to the nature of the basin and the characteristics of swamp water and the river flow. Model simulations and field observations indicate that the present nonpoint source loads are near the assimilation capacity. Furthermore, if anticipated land use changes occur, nonpoint source loads will increase and the water quality of the river will deteriorate. The model predictions for the year 1995 indicate that dissolved oxygen supplies will be totally depleted at times. It is not clear that this represents a major departure from historic conditions since it is likely that oxygen depleted waters have existed in portions of the river and the swamp for centuries. However, up to a few years ago, the river was not used as the drinking water source for tens of thousands of people. At a minimum a trend of deteriorating water quality probably will make the treatment processes more difficult and expensive. The shift from aerobic to anaerobic conditions usually has profound consequences for the biota and results in very different biochemical processes of decomposition and nutrient cycling in most aquatic systems. Perhaps the Northwest River and other swamps can accommodate this change with little or no ecological damage. However, it is unlikely that the anoxia provides any benefits to man or nature and a more prudent course would be to take steps to minimize the occurrence of oxygen depletion.

RECOMMENDATIONS

Traditionally one always recommends that additional study is needed. Certainly the water quality data base for the Northwest River is limited and there is much we can learn about the system and how it responds to various environmental factors. However, no amount of future study is likely to alter the following conclusions:

1) The river is the primary source of drinking water for a large portion of the population of the City of Chesapeake.

2) The Northwest River has limited ability to assimilate pollution.

3) At present dissolved oxygen concentrations in the range of 2 mg/l to 4 mg/l are not uncommon during the summer.

4) Any increase in pollutant loads will result in further degradation.

5) Prudent management of activities in the drainage basin is warranted to protect the public water supply.

Given the need for careful management of the Northwest River basin, it is recommended that the following steps be taken:

1) Promote awareness of the special characteristics of the Northwest River and the need for water quality management.

2) Exclude from the drainage basin, or at least portions of the basin, those activities which endanger the drinking water supply.

3) Monitor conditions in the river to insure that development of the basin does not seriously degrade water quality.

4) Control and monitor land disturbing activities.

5) Promote, encourage, and if necessary require good land management practices to reduce nonpoint source pollution loads to the river.

Awareness

The Northwest River is different from many river systems in Virginia and experiences elsewhere may not always be relevant to the swamp environment. Consequently, greater public awareness of the special characteristics of the Dismal Swamp in general and the Northwest River system in particular should be promoted. Well conceived recreational programs, similar to those centered on Lake Drummond, could provide both recreational opportunities to the citizens of the area as well as the opportunity to see and learn about the swamp ecosystem.

As important as public awareness is, to be effective it must be accompanied by increased sensitivity to the special needs of the river system (especially now that it is a public water source) on the part of agency personnel. Standard land and water quality management practices may not be appropriate to the Northwest River, at least with regard to maintaining water quality. For example, Duda (1982) interpreted field data from the Chowan River system in North Carolina and found that water quality was degraded where there was agricultural activity along the river. In addition, he noted that the degradation was greatest where fields had subsurface drain tiles to lower the water table or where the swamp had been channelized. The purpose for stating this is not to denigrate any person, occupation or agency, but rather to point out that:

- practices must be evaluated beforehand to insure that they are appropriate for the specific environment. For the case at hand, what is suitable for the Peninsula or the Lynnhaven Basin may not be appropriate or effective for the swampy environment of the Northwest River.

- practices should be evaluated with regard to water quality impacts as well as their intended purpose. It is likely that the subsurface drainage systems had a positive impact on agricultural production in the Chowan Basin. It is unlikely that the water quality impacts were foreseen or that anyone consciously made the decision to accept some level of water quality deterioration in order to gain enhanced agricultural production.

The activities occurring within the Northwest River basin will affect the water quality of the river and the suitability of the river water as a potable water supply. The average citizen and those who manage the activities must understand and be aware of the importance and relevance of their actions; efforts should be made to promote this awareness.

Exclude Some Uses

The Northwest River is the primary source of the water supplied to tens of thousands of residents of Chesapeake. No activity which threatens that public water supply should be permitted. Facilities for storage and transfer of hazardous materials, for example, should be located so that any release of these compounds does not enter the river. This is not to suggest that anyone involved with hazardous materials is careless or unconcerned. Rather it recognizes that accidents and "acts of God" do occur and that the use of the river as a water supply should be protected. Therefore, the prudent course of action is to exclude potentially threatening activities from at least a portion of the Northwest River basin and to locate them where the impacts of spills would be less. Important aspects to be considered are the persistence and toxicity of the substance. For example, pesticides such as DDT which are very persistent should be treated with more caution than those more recently developed pesticides which have been designed to degrade rapidly. These factors and others should be used to develop the zone(s) of exclusion to determine which substances are excluded.

Another class of activities probably should be excluded except when there is ample evidence to show that water quality impacts would be slight. For example, feedlot operations involving hundreds or thousands of cattle or swine are known to produce large volumes of wastes. We also know that the river cannot assimilate large waste loads. Therefore, activities of this nature should be precluded until appropriate measures are taken (e.g. construction of containment facilities, waste lagoons and land application systems) to minimize the pollution that will reach the river.

It does not seem appropriate to attempt to list those activities which fall into these two categories, because one cannot anticipate what will be proposed and the impact of any proposed facility will depend in part on the characteristics of the specific site. Simply stated any activity involving substances which could severely contaminate a drinking water source should be excluded from the area near the water intake or perhaps excluded from the entire basin. Any activity which results in large volumes of organic wastes should include measures to minimize the waste load reaching the river.

Monitoring

Field observations during the summer of 1980 showed that the state standard for dissolved oxygen levels was violated on many occasions. Development within the basin is occurring. Even though the rate of change is less than that for other basins in the Hampton Roads area (for example, the Lynnhaven Bay system), the limited assimilation capacity of the Northwest River dictates that water quality be monitored to insure that the drinking water supply is not degraded.

As a beginning it is recommended that temperature and dissolved oxygen be monitored on a daily basis at the water intake. At a later date the data from this effort should be examined to delineate critical periods or events when additional monitoring efforts would be fruitful.

Land Disturbing Activities

The potential for land disturbing activities to produce runoff with large areal pollutant loading rates dictates that these activities be monitored in sensitive areas. Given the special use (e.g. drinking water supply) and special characteristics (swamp water) of the Northwest River, land disturbing activities in this basin should be monitored.

In Virginia many land disturbing activities are regulated by sediment and erosion control ordinances adopted by the local jurisdictions. Although forestry and agriculture are not covered by the enabling act, the Extension Division of VPI&SU and other organizations have been working with industry groups to promote awareness of good management practices for reducing nonpoint source pollution. Although a voluntary program of management practice implementation has been adopted, preliminary indications are that the program is meeting with much success.

The HRWQA has assembled descriptions of good management practices, and the State Water Control Board has prepared handbooks for these activities. Other organizations also have prepared handbooks and field manuals for nonpoint pollution control. These materials provide detailed descriptions of practices and procedures; no adequate review of these practices can be given within the scope of this report. Simply stated good management practices should be applied and before applying any practice, it should be ascertained that the practice is appropriate for the soils, slopes and other conditions encountered in the Northwest River basin.

Implement Nonpoint Source Pollution Control

For most land uses management practices exist which will reduce the pollutant loads leaving a given parcel of land. As stated in the previous paragraph, several organizations have compiled descriptions of these practices and field manuals to guide persons designing or inspecting installations. It would not be fruitful to go into the details of specific practices in this report. However, two general goals can be stated for nonpoint source control measures:

1) reduce overland runoff and increase infiltration,

2) reduce the amount of pollutants leaving a unit area of land.

It has been stated previously in this report that aquisition of adequate water supplies has been a challenging goal for Tidewater localities. For the case at hand, the Dismal Swamp acts as a giant sponge soaking up water during wet periods and releasing it slowly during dry periods. Management practices should be selected which enhance this process by retarding overland flow and providing greater opportunity for runoff to infiltrate the ground. This recommendation goes against some long standing policies and practices which have been adopted because most people object to standing water. Drainage ditches and channelization do alleviate that problem but sometimes at the expense of water quality. The water quality considerations should be made an explicit factor in any future decisions regarding conveyance of stormwaters.

All reasonable efforts should be made to reduce nonpoint pollution loads to the Northwest River because the river has very limited assimilation capacity. Special efforts should be made to insure that any new development incorporates good practices in the design of the project since costs are greatly reduced if that approach is followed. Existing development should be assessed to determine if and where control structures or practices could be implemented. Participation in federal cost-sharing programs, such as the Rural Clean Water Program, should be encouraged when possible or available. If water quality further deteriorates, the city might find it attractive to implement some local programs of cost-sharing in order to get landowners to install control structures and to adopt new management practices.

Summary

The Northwest River shares a number of attributes with other swampy systems. Swamp water is not the ideal drinking water source, but economically and technically viable alternatives were not available. Consequently, efforts are needed to protect this water source. A number of general recommendations have been made. If these can be implemented, it is likely that the projected trend of deteriorating water quality can be at least ameliorated and if all goes well, some water quality enhancement could occur.

REFERENCES

Division of Water Resources "City of Chesapeake - Northwest River and Dismal Swamp Water Supply Project" A Staff Report, Richmond, Virginia, November 10, 1970.

Duda, Alfred M., "Municipal Point Source and Agricultural Nonpoint Source Contributions to Coastal Eutrophication". Water Resources Bulletin, Vol. 18, No. 3, June, 1982. pp. 397-407.

Kuo, Albert Y., Bruce J. Neilson and Paul V. Hyer. "A Water Quality Study of the Northwest River, Virginia". A report to the Hampton Roads Water Quality Agency. September, 1982. VIMS, Gloucester Point, Virginia.

National Academy of Sciences-National Academy of Engineering. "Water Quality Criteria 1972". Washington, D.C. 1972.

Southeastern Virginia Planning District Commission. "Physical Features Inventory". A report to the Hampton Roads Water Quality Agency. Virginia Beach, Virginia. March, 1978.

Southeastern Virginia Planning District Commission. Letter from Mr. John M. Carlock to Mr. Paul E. Fisher dated January 15, 1981.

State Water Control Board, "Water Quality Standards". Richmond, Virginia. November, 1974.

State Water Control Board, "Water Quality Standards". Publication No. RB-1-80. Richmond, Virginia. April, 1982.