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ABSTRACT

YAMAGATA, HISASHI. Protection of Streamflow in the Eno River. (Under the direction of DR. RICHARD N.L. ANDREWS).

Lack of sufficient flow in the Eno River has caused several serious problems within its river basin, including water shortage during dry periods, deteriorated water quality, impaired scenic and aesthetic beauty of the stream, loss of recreational opportunities, and adverse effects on aquatic life forms. Because of rapid urban development within the river basin, increased water demand and adverse effects associated with urbanization are expected to make these problems more serious. In order to acquire and protect streamflows in the Eno River, five approaches are proposed: to increase the river's streamflow during dry seasons; to enhance water availability; to minimize adverse effects associated with urban development on the water resources; to legally acquire and protect streamflows in the river; and to obtain public support for streamflow protection. Integrating protection of the riverine environment into general community development is recommended in order to change public negative perceptions about protecting streamflow. Both planning and regulatory measures are necessary for effective protection of streamflows in the Eno River.

INTRODUCTION

As the public has become interested in better quality of life and environment as well as amenity landscapes and recreational resources, demands for maintaining certain flows in rivers and streams have increased. Responding to these demands, governmental measures have been adopted to protect streamflows. Commonly, these measures take the form of requirements that streamflows be maintained at levels that will sustain a variety of instream needs, such as protecting fish life and aquatic habitat, ensuring a certain water quality, and protecting recreational and scenic amenities along the river.

However, these attempts by governments have often resulted in intensified competition over limited amounts of water resources as well as additional conflict among a variety of water users within a watershed. Since the idea of streamflow protection is rarely raised until flows in streams actually disappear or are significantly reduced, it tends to happen that available water supply is already short of its demand when the need for streamflow protection occurs. In such cases, streamflows may not be protected until existing demands of traditional uses is fully satisfied. Therefore, some precautionary administrative measures are required for protecting streamflows.

However, these precautionary measures are often unavailable or, even if provided, they cannot attain the intended purpose. This seems especially true in eastern states where water laws have largely been dependent on the common law riparian doctrine, which is based on "reasonable use" of water by each private riparian landowner. Many of these states have not established appropriate measures to protect streamflows or even to deal appropriately with problem of water shortage. The idea of maintaining streamflows is rarely incorporated into existing administrative measures for water quantity and quality management programs. Traditional water quantity management has tried to meet all demands for water by engineering capacity extension or by augmenting new water supply. The idea of resolving competition on water uses through regulating behaviors of customers has seldom been applied except for emergency situations. It is apparent that this approach cannot be dependable when potentially available water supply sources have already been consumed or cannot be developed because of economic or engineering infeasibility or environmental concerns. Under this situation, simply providing regulatory measures to control existing water uses and to protect streamflows would only produce additional conflicts and frustration among water users.

Decreased flows in streams significantly affect their capacity to dilute discharged pollution. However, in the area of water quality control adequate attention has not been put on this important relationship between quality and quantity of streamflows; the emphasis has always been on the control of pollutant discharges from point sources. Therefore, at present protection of streamflows cannot be assured through water quality control methods.

Since riparian doctrine itself recognizes the rights of private riparians to adequate flows in a stream for their reasonable use, it seems possible to protect streamflows by claiming these riparian rights. However, several difficulties arise in applying the riparian doctrine for streamflow protection. First, since the idea of protecting streamflow has emerged quite recently as a public demand for water rights rather than private riparian rights, riparian doctrine, which has served to protect private riparians' rights, does not provide an adequate mechanism. The riparian doctrine may not work unless a riparian land owner himself claims the rights. However, even when such a riparian land owner decides to protect streamflows, in order to claim such rights he has to file a suit against those who may have infringed his riparian rights. Then, the riparian needs to prove that he has suffered actual injuries from the defendant's water withdrawal as well as that the defendant's water use was unreasonable. These litigation procedures are surely a time-consuming and cumbersome process. Third, since the court, not the administrative agency, decides what reasonable use of water is in each litigation, taking into consideration specific situations of each case, one cannot make sure that streamflows are actually protected until the court delivers its decision. In addition, it is difficult to place economic values on instream uses to be compared to other water uses; it is also difficult to accurately quantify minimum flows necessary for protecting these values (Morandi and Lazarus, 1982). These factors would further render court decisions unpredictable.

Even when the court upholds the riparian landowner's rights to streamflows, because of the rule of "reasonable use," riparian doctrine does not ensure the original, natural flows to be maintained in the stream; the doctrine merely protects the flow levels below which injury to riparian rights occurs. Thus, the common law riparian doctrine, in spite of its provisions of streamflow protection for riparian land owners, may not be an effective means for streamflow protection.

Another concern is public attitudes towards protecting streamflows. Even where water resources are abundant and governmental measures are provided for the protection of streamflows, intervention by the government may not be welcomed by people within a watershed. People tend to consider that streamflow protection is only for recreational and aesthetic purposes. Little attention is paid to other important aspects of maintaining streamflows, such as water quality control, protection of water rights of downstream users, and preservation of valuable aquatic ecosystems. Consequently, streamflow protection is considered as a waste of a precious water resource by merely letting it flow in a stream without using it for beneficial purposes. Unless this negative understanding of streamflow protection is modified, efforts to protect flows in streams cannot succeed.

The Eno River, which is located in northern Orange County and flows through the town of Hillsborough into Durham County, illustrates the problems mentioned above. Because of severe water shortage during dry periods, lack of appropriate measures for streamflow protection, insufficient general water resource management, and public inclination toward the development of the Eno River watershed, attempts to protect the river's streamflow have not been successful. In this paper I try to identify possible policy measures to protect streamflows in the Eno River. First, the current water resources situation in the Eno River Basin is reviewed, followed by the identification and analysis of existing problems associated with the lack of flows in the Eno River. Since communities within the Eno River watershed are experiencing rapid urban growth, possible impacts from urban development on water resources within the watershed are identified and examined through a review of empirical studies of other watersheds.[1] Then, the paper considers the possibility of protecting streamflows in the Eno River by identifying obstacles as well as exploring some approaches to attain it. Governmental measures are indispensable for protection of streamflow; relevant federal and state statutes are reviewed and evaluated. Finally, a recommendation is made to protect and maintain streamflows in the Eno River.

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1. Most of the Eno River Basin is non-urban, and therefore, the effects of activities taking place in this area should be considered. However, this paper sets its major focus on urban activities which are occurring in a limited area of the basin but are considered to have significant effects on the Eno River and its watershed.

I. WATER RESOURCES SITUATION IN THE ENO RIVER BASIN

A. Surface and Groundwater Hydrology

Surface Water Hydrology

Data describing the Eno River hydrology are available from streamflow records collected at two U.S. Geological Survey (USGS) gaging stations. The most upstream gage is located at Hillsborough with records from October 1929 to October 1972 and from October 1985 to date. Another gage is located further downstream at the U.S. Highway 501 bridge in Durham and has been in operation since 1963.

The data obtained from these two streamflow gages exhibit two distinctive features of the Eno River's flow: continuous decline in its base flow and wide seasonal fluctuations in streamflow level. The unadjusted 7days 10 year low flow (7Q10[1]) at Hillsborough gage is 0.62 cfs (cubic feet per second) for the period of record. Since flows at this gage have been subject to regulation by upstream diversions, the 7Q10 flow which does not take into account these diversions has been decreased over the period of record. For the period from 1931 to 1941, the unadjusted 7Q10 is estimated to have been 1.78 cfs; this

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[1]. 7Q10 is defined as the minimum average flow fro a period of seven consecutive days that have an average recurrence of once in ten years (G.S.143-215.48.).

was reduced to 0.62 cfs during the period of 1931 to 1971 (NRCD, 1987). The North Carolina Department of Narural Resources and Community Development (NRCD) (1987) concludes that increased demands, including water diversions placed on the Eno River over the years, have caused a reduction in low flow levels. This decline in low flow level of the Eno River implies a decrease in the river's base flow which could be sustained year around including dry periods.

The cumulative flow of the Eno River at Durham gage exhibits wide seasonal fluctuations of the Eno River. For water year 1986 (October 1985 through September 1986), approximately 80% of of the 35,000 cfs-days of water that passed that gaging point in the river occurred during a five month high-flow period (November 1985 through March 1986), averaging 187 cfs during this period (NRCD,1987). As a result, during the summer and fall of 1986 predominantly low flows occurred.

At Hillsborough gage, the Eno River recorded minimum flow of zero (July 21 and 28, 1986) and maximum flow of 11,000 cfs (September 18, 1945), respectively (DWR, 1986; OWAR, 1973). No flow was also reported in July, 1979, when a minor drought occurred; in this case, however, the Eno River was without any flow over the dam of Lake Ben Jonston for approximately eight weeks (OCC, 1986). It is important to note that maximum flow occurred in September when lower precipitation is expected to occur. Data on previous streamflow show that annual minimimum flows tend to occur in September, October and November, the dry season of the year (OWAR, 1973). It is conceivable that the minimum flows occurr during this dry period. The fact that the maximum flows also occurred during this period seems to reveal that flows of the Eno River are under direct influence of climatic conditions of the area. Thus, usual fluctuations in seasonal precipitation as well as unusual changes in precipitation, such as those that may occur as a result of hurricanes, cause significant change in the river's streamflow. These wide variations in streamflow of the Eno River also reflect a lack of significant storage capacity of the river's flows during wet seasons. While the USGS Hillsborough gage has recorded an average of 39.5MGD (million gallons per day) for the 45 year period of record, only approximately 9% of this flow can be captured by thye existing reservoirs along the river (NRCD, 1987).

Three water supply impoundments have been constructed in the Eno River drainage area. They are, from upstream to downstream, Lake Orange, Corporation Lake, and Lake Ben Jonston. Their current storage capacities are 42.7MGD, 18.6MGD (originally 28.7MGD) and 19.6MGD (originally 27.1MGD), respectively. However, due to their geographical location and their interrelation, Corporation Lake and Lake Ben Jonston have only 5% of the water supply storage of Lake Orange under present operating procedures and pumping constraints (DWR, 1987). Therefore, while simple calculation of total safe yield of these three reservoirs is 3.43MGD, the potentially sustained yield of these three reservoirs is reduced to about 2.60MGD with the application of the Orange County water conservation measures (NRCD, 1987). When one-foot flash boards are added at Lake Orange, this yield is raised up to 3.2MGD (NRCD, 1987). These yield estimates will decline over time due to reservoir sedimentation.

Additional storage is provided in the Eno River Basin by a significant number of small ponds scattered in the headwater areas of the basin. These ponds are primarily used for irrigation and raising livestock. However, no detailed survey of these ponds nor quantitative estimates of their effects on runoff or streamflow has been done. As small as each of these ponds is, they might as a whole have significant effects on the hydrology of the Eno River Basin. Especially during drought periods when evaporation rates and water usage are high, water levels in these farm ponds and reservoirs will decrease and natural downstream discharge can be severely curtailed.

Groundwater Hydrology

The hydrogeology of the Eno River watershed is similar to that found in other areas of the Piedmont; because of impervious rocs strata which has a low filtration rate and storage capacity, groundwater provides little base flow to the Eno River (NRCD, 1987). It is estimated that 9MGD of groundwater is available for water supply from a 90 square mile area below Lake Ben Jonston where extensive groundwater development would not jeopardize water supply from groundwater to the three existing reservoirs (NRCD, 1987). Theoretically, about 15MGD of groundwater could be developed if extensive groundwater development could occur within the river's entire watershed.

The total groundwater use for the Eno River area in 1986 is estimated to have averaged 1.24MGD (NRCD, 1987). Since this estimated groundwater use is much lower than the theoretically availabile rate of 9MGD, groundwater could be developed for conjunctive use with existing surface water supplies (NRCD, 1987). However, this sustained yield from groundwater development is influenced to a large extent by the density and spacing of wells, well construction, and changes in groundwater infiltration and recharge.

B. Water Use Situation

Currently, daily average water use in the Eno River Basin is 4.86MGD in total, consisting of 1.24 MGD from groundwater sources and 3.35MGD from surface sources, and 0.27MGD from conjunctive surface and groundwater sources (NRCD, 1987). However, this figure may rise up 13.80MGD when the maximum daily watger use form each source is added together (NRCD, 1987). Major water uses within the Eno River Basin are public water systems along the river and irrigations located in the headwater area of the river.

Public Water Systems

Among three public water systems in Orange County, the Town of Hillsborough and Orange Alamance Water System withdraw water from the Eno River. Hillsborough's annual average withdrawal is approximately 1.35MGD, which, however, has recently increased to 2.14MGD. Orange Alamance withdraws a yearly average of about 0.59MGD and maximum daily use of 0.99MGD. In the Durham County portion of the basin, the City of Durham maintains an intake on the Eno River which can supply the City up to 4.82MGD. A yearly average withdrawal by the city is about 0.70MGD (NRCD, 1987).

All of the water withdrawn from the Eno River has not been utilized by these water systems; before reaching their customers, some treated water has been lost, presumably by leakage. In 1986 there was average annual water loss of 4.94MGD which was unaccountable by the above three water systems and Orange Water and Sewer Authority (OWASA) in the Eno River Basin (NRCD, 1987). This amount is approximately equal to the average annual withdrawals from the entire Eno River Basin. Among these four systems, Hillsborough has the highest rate of water loss; 21% of the water treated (0.35MGD) was lost in 1986. This is followed by Durham which has 17% loss (3.9MGD).

Even when water reaches customers and is used, not all used water is returned to the stream from which the water is originally withdrawn. In addition to the necessary consumption of water related to each water use, two major water uses have resulted in significant water loss in the Eno River Basin; large consumptive use of water in Hillsborough; and interbasin water transfer mainly by Orange Alamance Water System. In Hillsborough where septic tanks are widely used, only about 18% of the town's water use is served by the sewer system while approximately 60% of the average daily water use is accounted for by sewered customers (TRJCG, 1977). As a result, 40 - 50% of the water withdrawn by the town is not returned to the Eno River (OCC, 1986).

Several water systems within and around the Eno River Basin arw connected with pipelines. These connections lie between Hillsborough and OWASA, Durham and OWASA, Burlington and Orange Alamancd via the Graham-Mebane System. Some of these connections are used for emergency use; ouwever, others are for ordinary use and result in inter-basin water transfers. Currently, Orange Alamance withdraws about 1MGD of water from the Eno River which belongs to the Neuse River Basin, while the majority of its water use and discharge is in the Cape Fear River Basin. Also, OWASA, when purchasing water from Durham or Hillsborough, is withdrawing water from the Neuse River Basin and discharging wastewater into the Cape Fear River Basin. These transfers represent a consumptive loss to the Neuse River Basin.

Other Water Users

Several surface water withdrawals for industrial use exist along the Eno River, accounting for 0.36MGD as yearly average and 0.85MGD for maximum daily use. Since all of these withdrawals are located downstream of Lake Ben Jonston, the most downstream reservoir of the three impoundments in the river basin, these withdrawals do not affect those reservoirs' water levels, although they could affect the lower Eno River's flow level.

Another major type of water use is agricultural irrigation, withdrawing water either directly from the Eno River or through storage ponds. The average water use by agricultural irrigation is about 0.12MGD, but the maximum daily use rises up to 1.34MGD. Another type of irrigation which withdraws water from both groundwater and surface water sources, including three golf courses, amounts 0.27MGD for yearly average and 2.13MGD for maximum daily use (NRCD, 1987).

While each of these irrigation activities may be small compared to other larger users, as a whole these irrigations seem to have a substantial impact on the ground and surface water resources in the Eno River Basin. First, since irrigation is seasonal and subject to cropping patters and prevailing climatic conditions, under certain conditions irrigation can be the largest consumptive water user, particularly in June and July when precipitation diminishes and demand for water increases. Second, all of these irrigations but one are located further upstream of lake Orange, the most upstream reservoir, within headwater area of the Eno River. Therefore, these withdrawals of totaling 0.32MGD as yearly average, which may rise up to 3.35MGD, have more significant impact on the river compared to other withdrawals of similar amount but located further downstream.

In addition to these off-stream water and groundwater uses, there are instream flow needs for downstream users, water quality control recreational activities and aesthetic purposes, and protection of aquatic habitat. The State has determined the amount of flow to be maintained for stream water quality control in conjunction with the issuance of NPDES[2] permits to major wastewater discharges. NPDES permits for Hillsborough and Durham wastewater treatment plants are based on a minimum design flow in the Eno River

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[2]. National Pollution Discharge Elimination System: The main federal water pollution control program.

of 1.7cfs (1.1MGD) and 2.6cfs (1.7MGD), respectively. Since these figures are simply statistically determined, they do not necessarily represent desired flow for aquatic habitat protection or for other water uses (NRCD, 1987).

C. Future Trend in Water Use

Since 1950 both Durham and Orange counties have grown more rapidly that the State, recording 59% and 139%, respectively compared to 54% of the State as a whole (NRCD, 1987). While the margin between the county and state rate has declined since 1960, it is considered that growth of both counties in the next 20 years would be significantly higher that it was in the last 20 years (NRCD, 1987). Because of the existence of the Research Triangle Park (RTP), State Government and a variety of service sectors, so-called Research Triangle Park area which includes Raleigh, Durham, Chapel Hill and surrounding communities, has had a relatively strong economy and greater employment growth than most of the areas of the State. Since these industries have also acted as a desirable base around which new industries has and will develop, it is expected that this region will continue as a growth leader.

These expected population increase and economic growth in the RTP area would also affect those of the Eno River area which is located northwest of the RTP area.

Particularly, rapid growth in population and economic activity is expected in the Town of Hillsborough and Orange Alamance's service area because of the improved accessibility to the RTP area and Burlington with the completion of I-40 and its connection with I-85. This expected growth will lead to the rapid and substantial increase in demand of water for residential and commercial purposes in the Eno River area. According to NRCD's water use projection, water uses of Hillsborough and Orange Alamance will increase to 2.16MGD and 0.91MGD in 1990, 3.29MGD and 1.81MGD in 2000, and 6.54MGD and 4.75MGD in 2020, respectively (NRCD, 1987). When other water uses and state-mandated instream flow of 1.1MGD are included, total water use in upper Eno River Basin would be 3.60MGD in 1990, 7.03MGD in 2000, and 13.79MGD in 1920.

II. PROBLEMS CAUSED BY LACK OF STREAMFLOW

Because the Eno River watershed is located within the headwater areas of the Neuse River Basin, water resources are limited, making it difficult to accommodate new water users. In addition, because of the impervious nature of the geology underlying the watershed, the amount of the river's base flow is generally low (NRCD, 1987). This has caused serious problems within the Eno River watershed.

A. Lack of Sufficient Water Supply

Portions of the Eno River Basin are served by three major public water systems: the City of Durham, the Town of Hillsborough, and Orange Alamance Water System. The existing water supply situation in the Eno River Basin is such that these systems still have excess capacity during above average rainfall years. Currently, however, existing demand for water is about to exceed the surface water supply in the Eno River Basin; dry years place a great deal of stress on the water supply systems and conservation measures must be employed (NRCD, 1987). For example, in 1986 in Orange Alamance and Hillsborough service areas, voluntary water conservation was in effect from June 4 to October 7, 1986 (126 days in total); mandatory conservation was in effect from October 7 to December 29, 1986 (84 days in total) (DWR, 1987). Thus, for 1986 there were 210 days, or 58% of the year, that customers in those areas were asked to restrict their use of water. The City of Durham's emergency water intake on the Eno River was used to withdraw approximately 72 MG of water in 1986. In Durham voluntary water conservation was in effect from June 25 to July 9, 1986 and moderate mandatory conservation was from July 9 to August 21, 1986 (DWR, 1987). For 1986 customers in this area were restricted on their water use for 57 days (approximately 15% of the year). This insufficient water supply also affected other private users within the Eno River Basin who were threatened with having to shut down their economic activities due to lack of water (NRCD, 1987).

B. Water Quality Problems

The quality of stream water of the Eno River is important to various water uses in the river basin; but the river's water quality is also vital to water users outside of the watershed. The Eno River flows into Falls Lake upon which the City of Raleigh depends as a drinking water supply source. The water quality in most parts of the Eno River is evaluated as sufficient to support intended uses of the water in terms of its physical, chemical and biological characteristics (NRCD, 1987). However, when streamflow is reduced during dry periods, this decreased flow severely limits surface water yields and volumes necessary for assimilating effluent discharges from point as well as nonpoint sources, resulting in severe deterioration of water quality of the stream.

Deterioration of stream water quality during low flow periods is not a new problem within the Eno River Basin. As early as 1954, during dry periods of that year, monitors recorded almost depleted dissolved oxygen level and increased coliform count and biochemical oxygen demand level, all of which were well outside acceptable values, from the stream water samples taken immediately upstream and downstream of Hillsborough (NER, 1963).

At present 13 NPDES point discharges exist in the Eno River Basin. Hillsborough Wastewater Treatment Plant and Durham Wastewater Treatment Plant are major dischargers; they have design flows of 3.0 MGD and 1.5 MGD with assumed minimum design flow levels (7Q10) under NPDES permit system of 1.7 cfs and 2.6 cfs, respectively. These wastewater treatment plants occasionally caused violations of stream water quality standards during droughts such as the one in 1986 (NRCD, 1987). Especially, downstream of Hillsborough Wastewater Treatment Plant water quality of the river substantially declines, because in addition to the discharge from the plant, streamflow downstream of the town is significantly reduced during low flow periods due to upstream water withdrawal. Water quality of the stream could be worse and prolonged if the base flow of the stream were further lowered or if more pollutants were discharged into the stream.

Currently, the 7Q10 low flow in the Eno River has been estimated to be 0.62 cfs for both Hillsborough and Durham wastewater treatment plants. This figure is much lower than the NPDES design flow levels for both plants, it is easily imagined that severe deterioration in water quality would occur not only during unusual drought periods but also during normal dry seasons of the year. In addition, some of those NPDES discharges have continual problems of meeting their permit limits (NRCD, 1987). Therefore, water quality of the stream could further be worsened.

The City of Durham is planning to increase the capacity of its wastewater treatment plant from its present capacity of 2.5 to 10.0 MGD (NRCD, 1987). If this project is realized, increased wastewater discharge will adversely affect water quality of the Eno River. Since the entire Eno River is classified as Nutrient Sensitive Waters[1], the increase of waste discharge from the treatment plant, in addition to extended periods of low flow condition, would

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[1]. Nutrient Sensitive Waters is waters which, under the determination of the Environmental Management Commission, require limitations on nutrient inputs (N.C.A.C. 15:02B.0101.)

produce a significant impact on these waters sensitive to nutrient enrichment from nitrogen and phosphorus. This may result in eutrophication and excessive growth of algae and aquatic plants downstream in Falls Lake.

Other concerns about the Eno River's water quality are increases in nonpoint source pollution. They include increases in runoff discharge resulting from urban development in the Hillsborough and Durham areas, and surface as well as groundwater contamination from septic tank failures (NRCD, 1987).

C. Insufficient Flow for Instream Needs

In addition to off-stream water uses and water quality problems, there exist instream needs for recreational and aesthetic purposes and aquatic life forms as well as downstream users. Insufficient streamflows in the river also affect the quality of life of residents along the river.

The Eno River and its surrounding lands provide a diversity of water-related recreational opportunities; hiking and camping, canoeing and kayaking, swimming and fishing are among popular activities. Since most of these recreational activities are centered on the stretch of the Eno River below Hillsborough, the amount of streamflow as well as its quality has a significant impact on the quality of those activities. Water-based recreation depends almost entirely on river flow, and any decrease in streamflow directly affects these activities. In 1986 when the Eno River's streamflows were much lower than natural and were significantly lower than 1985 flow, the number of boaters decreased from approximately 2,000 in 1985 to 1,200 in 1986, and no boaters were observed during August and September of 1986 (NRCD, 1987).

The Eno River and its adjacent lands, from upstream of Hillsborough to Falls Lake downstream from Durham, are extremely scenic because of a variety of vegetative communities along the stream (DPR, 1979). The Eno River State Park was established to protect the aesthetics of the area of approximately 2,000 acres along a 12 mile corridor of the river as well as to provide recreational opportunities (NRCD, 1987). The amount of flow in the river is as much a its part of aesthetic beauty as the forested banks, hillsides and wildflowers. The decreased flow will make more of the channel dry and exposed, and will result in unpleasant odor, darkened color of water, and poor condition of vegetation along the river, causing the reduction of aesthetic appeals of the State Park. The effect of low streamflows on the Eno River State Park during 1986 drought is shown decrease of 11% in overall attendance to the Park, 40% in canoeing and rafting activities, 18% in hiking, and 7% in fishing as compared to the year before (DWR, 1987).

The Eno River is listed as one of the best sport fishing streams in the Neuse River Basin (DPR, 1979). Reduction in the streamflow affects these game fish as well as other aquatic life forms. Decreased streamflow reduces the depth, velocity, width and volume of the flow and increases the flow temperature and concentrations of constituents and pollutants in stream water. In the Eno River steady deterioration of aquatic ecology exhibited by disappearing, suffering, or dying fish and wildlife was reported (DWR, 1987). From the results of a simulation model to evaluate the effects of flow reduction on the aquatic organisms in the Eno River, it was revealed that the existing low flow situation of the river is continuing to result in habitat losses of target species which are significantly larger than those due to natural conditions (NRCD, 1987).

Some people, such as riparian land owners and recreationalists, have enjoyed aesthetics and recreational resources of the Eno River; other people recognize that the river contains significant cultural and historic values. For these people lack of streamflow in the river means the destruction of those intrinsic values and amenities attached to the river and may result in the degradation of their quality of life.

D. Analysis of the Problems

Currently the Eno River's total water supply is about to be exceeded by the total water demand within the river basin; during droughts, or even dry seasons, water supply runs short of its demand (NRCD, 1987). Two major factors are responsible for having caused this situation: physical characteristics of the Eno River Basin, and human factors, that is, the way in which people have utilized the water resources in the river basin.

Located within the headwater area of the Neuse River Basin, the Eno River originally lacks ample flows in the channel. The river's streamflows are determined by the amount of surface water runoff, reservoir releases, and discharge from groundwater through springs, seeps, and well water withdrawals. Since groundwater discharge is stable compared to surface water discharges, generally water from groundwater determines base flow of a stream. However, in the Eno River Basin because of low infiltration rate and low storage capacity of the underlying rock strata, groundwater provides little flow to the river. Therefore, in the Eno River Basin, not only does the river have little base flow but also its flow level is largely determined by surface water runoff and reservoir releases.

The capacity of the Eno River watershed to absorb and store surface water is a major factor in overall water availability. Surface runoff, unless captured and stored in impoundments, flows quickly downstream, in the case of the Eno River, into Falls Lake. Unless it is effectively stored, surface runoff cannot provide stable water to a stream, and streamflows become very sensitive to climatic conditions; little flow exists during dry seasons.

In spite of the facts given above, water resources development and management within the Eno River Basin do not seem to have been conducted with close attention to the river's distinctive hydrologic characteristics. The importance of the Eno River to the communities in the river basin, especially to the Town of Hillsborough, was recognized as early as 1968 (OCC, 1986). Since the Eno River contains the entire planning area of the town, the river and its immediate tributaries must serve as the town's long-term basic water resource; at the same time, since all drainage within the town's planning area flows down to the Eno River, the river must also serve as the major means of disposing of sewage effluent and street runoff. Thus, even 20 years ago it was emphasized that the low flow of the Eno River is a very critical factor for water supply and waste disposal consideration and that maintaining streamflows in the Eno River is important. The necessity of impoundments was also suggested in order to overcome the limited capacity of the Eno River as a water supply resource (OCC, 1986). However, water supply development has not been properly carried out. In the 1930s and 40s the Soil Conservation Service and the Corps of Engineers identified a number of potential reservoir sites available in Orange County. However, most of these areas were not protected or reserved, and they became no longer available as reservoir sites (OCC, 1986). And the water resource of the Eno River has simply been exploited. The problem of water shortage in Hillsborough was manifested as early as the summer of 1977 when there was a minor drought; no flow over Lake Ben Jonston was recorded for approximately eight weeks, and Lake Orange was estimated to be drawn down to 50% without any significant upstream water withdrawals (OCC, 1986). In spite of this fact, heavy dependence on unstable flows of the Eno River has continued within the entire Eno River Basin, as has interbasin water transfer by Orange Alamance System and large consumptive use of water in Hillsborough; and the three existing reservoirs, because of their insufficient water storage capacities, cannot effectively collect increased streamflows during wet seasons. All seem to have resulted from the lack of sound water resources management and development programs within the Eno River watershed. These human factors have further affected the Eno River so that it has become more vulnerable to climatic conditions as well as human activities within the river basin.

III. EFFECTS OF URBANIZATION ON STREAMFLOW: REVIEW OF EMPIRICAL STUDIES

Of all land uses urbanization has by far the most forceful impact on the hydrology of an area; urbanization fundamentally changes the hydrology of a watershed (Anderson, 1970; Carter, 1961; Kibler et al., 1981; Leopold, 1968). However, the effect of urbanization on the watershed is not limited to the alteration of hydrology. Impacts of urbanization on a watershed are categorized into four groups: changes in streamflow characteristics; deterioration in stream water quality; alteration in stream geomorphology; and impacts on aquatic life forms and aesthetic values associated with a stream.

Since rapid urban development has taken place within the Eno River Basin, it is necessary to identify possible effects of urbanization on the river and its watershed in order to protect water resources of the watershed from further deterioration.

A. Changes in Streamflow Characteristics

Leopold (1968) identifies two principal factors governing flow regime: the percentage of surface water running into a stream without infiltrating into the ground, and lag time[1], the rate at which surface water is transmitted across the land to stream channels.

The volume of runoff, water running over land surfaces, is primarily governed by infiltration characteristics of the ground (Leopold, 1968). While related to land slope and soil type as well as the type of vegetation cover, these infiltration characteristics are directly affected by the percentage of impervious surface area (Leopold, 1968). Increase in impervious surface area causes decrease in infiltration rate of the surface, resulting in increased surface runoff which directly runs into a stream. Since suburbanization and urbanization accompanied by construction of houses, streets and parking lots, substantially increase the percentage of impervious surface area, this results in significant increases in the magnitude of streamflow which collects increased runoff.

Increase in impervious area causes another impact on streamflow characteristics. Since water runs off faster into a stream from streets and roofs than from naturally vegetated areas, less time is required for surface water to reach a stream. In addition, urbanized areas generally provided with surface water collection systems which effectively collect surface runoff and immediately

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[1] Lag time is a factor describing the relation between the storm and the runoff. It is defined as the time interval between the center of mass of the storm precipitation and the center of the mass of the resultant hydrograph (Leopold, 1968).

discharge it into a stream. The channel characteristics of these runoff collection and discharge systems also substantially decrease the lag time of a watershed (Graf, 1976b). As new streets and drains are constructed, the total number of channel links increases, resulting in an increase in the total length of the channels and a commensurate change in drainage density. Dramatic increases in drainage density have profound effects on streamflow attributes, for a dense channel network insures rapid collection of runoff and discharge into a receiving stream (Graf, 1976b). Because of the increase in effective impervious area and in density of artificial channel networks within a watershed, lag time significantly decreases (Graf, 1976b). Increases in impervious surface areas and in channel network density caused by urbanization results in a situation in which more water form given precipitation is discharged into a stream within a much shorter period of time than it did before urbanization took place within a watershed.

Basin development factors, such as the percentage of effective impervious area and channel improvements, significantly influence runoff volume, peak discharge, and flood volume (Brabets, 1987; Sherwood, 1986; Pope and Bevans, 1986; Howard et al., 1979; Leopold, 1973, 1968). For example, Leopold (1968) reports that for unsewered areas the difference between 0 and 100% of the impervious surface increases peak discharge on the average of 2.5 times, and that for 100% sewered areas, peak discharge for 0% impervious areas will be about 1.7 times the mean annual flood and the ratio increases to 8 for 100% impervious areas.

Increased runoff discharge and heightened peak flow result in increased volume of streamflows during wet, especially storm, periods (Carter, 1961). Therefore, urbanization is expected to increase flood potential. In a given basin urbanization tends to increase the numbers of floods per unit time which exceed channel capacity (Sherwood, 1986; Leopold, 1973, 1968).

While urbanization causes a problem of flooding during wet periods, it also produces a serious problem of an opposite nature during dry periods. Increased runoff in urbanized area affects the low flows of a stream. Because in any series of storms a larger percentage of water resulting from precipitation goes into a stream, a smaller amount of water is available for soil moisture replacement and for groundwater storage which is generally a major supply of water for streams (Leopold, 1986). Therefore, an increase in total runoff from a given series of storms as a result of increased imperviousness results in decreased groundwater recharge, and this may decrease base flows in a stream. Simmons and Reynolds (1982) report that in urban areas with storm water sewage systems, base flow was reduced 20% of the total streamflow mainly because of sanitary sewage systems while in urbanized but unsewered areas base flow was reduced 84% of the total annual flow.

In brief, urbanization, by causing reduction in the base flow in a stream, makes streamflow more sensitive to variations in precipitation or makes streams "flashy" - that is, subject to wide variations in discharge in a relatively short period of time. Before urbanization taking place, yearly fluctuation in precipitation did not have a significant effect on the percentage of total streamflow occurring as base flow as indicated by a relatively constant percent base flow of the rivers during drought periods. In contrast, urbanization causes not only a general downward trend in percent base flow from year to year, but wide fluctuation in this ratio as well. These fluctuations probably result from the loss of groundwater recharge, caused by increased impervious surface areas and the density of channel networks, and the increased amount of surface runoff.

B. Deterioration of Stream Water Quality

As urban development within a watershed proceeds, water quality of a stream flowing through the watershed decreases. Leopold (1968) identifies two principal effects of urbanization on water quality of a stream. First, urbanization produces a huge influx of a variety of substances from point as well as nonpoint sources. These discharged substances tend to increase dissolved solid contents and decrease the dissolved oxygen content necessary for aquatic life forms (Leopold, 1968). Second, urbanization makes flow regime "flashier" in that flows during flood periods are higher and flows during non-storm periods are lower. Decreased base flow often lacks enough capacity to dilute increased concentrations of substances, resulting in substantial deterioration in stream water quality during dry periods. Increased flow during flood periods may cause another problem relevant to water quality of a stream. While increased flow dilutes and washes off some pollutants discharged into a stream, its increased capacity of eroding materials on the banks and the channel bottom can cause significant increases in the concentration of other substances such as suspended sediments (Leopold, 1968).

Influx of Substances

Three major categories of human activities relevant to urbanization determine the types of substances running into a stream: construction activities during the transitional period from a rural to urban watershed, a variety of water uses necessary for producing goods and services, and general urban activities within a watershed which affect the quality of water.

With all other factors remaining constant, sediment discharge will change with land use (Keller, 1962). The principal effect of land use change on sediment comes from the exposure of the soil to stream runoff during construction. Thus, when building sites are denuded for construction, excavations are made, and dirt is piled without cover or protection near the sites, the sediment movement as a rill or stream channel becomes very large in terms of tons per year immediately downhill from the construction sites (Wolman and Schick, 1967). Especially during the transition period from rural to urban land, erosion of denuded areas increases the sediment discharged to receiving streams. Keller (1962) reported nearly six-fold increases in suspended sediment discharge, 2 to 5 times higher suspended sediment concentrations, and longer persistence in water in an urban growth area. Imposition of large quantities of sediment on streams causes serious problems. They include deposition of channel bar, obstruction of flow and increased flooding as a result of deposition within the channel, shifting configuration of channel bottom, blanketing of bottom dwelling flora and fauna, alteration of the flora and fauna due to changes in light transmission and abrasive effects of sediments, and alteration of species of fish due to changes produced in the flora and fauna upon which fish depend (Wolman and Schick, 1967)

High loads of suspended sediment are, however, not the only discharge from construction sites. Kappel et al., (1985) report that at housing-construction sites, loads of nutrients and heavy metals are as high as those from highly density residential sites in addition to loads of suspended sediment which were 10 times greater than at any other monitoring sites.

One of the effects of urban development on streams is the introduction of effluent from point sources such as factories and municipal waste water treatment plants, and often discharges of raw sewage into channels. Raw sewage obviously degrades water quality, but even treated effluent contains dissolved minerals which are not extracted by sewage treatment (Leopold, 1968). These minerals act as nutrients and promote algae and plankton growth in a stream. This growth in turn alters the balance in the stream biota.

Based on an analysis of 17-year chemical and streamflow data, Anderson and Faust (1965) show a general increase in the content of dissolved solids per volume of water and a 20% decrease in dissolved oxygen content. Especially during the period of the greatest population growth, dissolved solid content increased 40%. Since these trends occurred during all months of the year, and not only during low flow periods, the deterioration of the quality of water was attributed to the disposal of increasing volumes of municipal and industrial waste water in the river basin (Anderson and Faust, 1965).

Urbanization of a watershed significantly alters stream water quality even in the absence of direct waste discharge from point sources (Jones and Clark, 1987). This results mainly from increased street runoff which collects various substances from the land surface on its way running into a stream. Even in heavily polluted and industrialized areas as well as in heavily urbanized areas, urban runoff contributes a significant percentage of the total loads of substances such as nutrients, heavy metals and oxygen demanding materials (Kappel et al., 1985; Clark and Jones, 1984; Ellis et al., 1984; Fisher and Katz, 1984; Water Planning Division, 1983; Whipple and Hunter, 1979).

Suspended sediment is still a major substance found in urban streams which have experienced major rural-urban transition periods. Suspended sediment loads from urban watersheds tend to be an order of magnitude greater than those from forested watersheds (Burton et al., 1977; Randell et al., 1978). Pitt (1985) suggests that these suspended sediments originate mostly from back and front yards in residential areas as well as from construction sites.

Hampson (1986) identifies four categories of environmentally significant substances found in urban runoff: heavy metals, nutrients, organics, and oxygen-demanding substances. Heavy metals that have been identified as the most environmentally significant from a water-pollution standpoint are lead, zinc, nickel, chromium, strontium, titanium and zirconium (Pitt and Bozeman, 1983). When these metals associated with stream runoff are compared to the metal content of sanitary sewage, most of the runoff metals are 10 to 100 times greater than the sewage metals on a concentration basis (Pitt and Bozeman, 1983). While street surfaces account for most of the heavy metals, zinc concentration from roof tops make up one quarter of total zinc discharges (Pitt, 1985).

Primary nutrients found in urban runoff are compounds or constituents containing nitrogen, phosphorus and other elements that are essential for plant growth (Hampson, 1986). Amounts of nutrients in urban land use are generally higher compared to non-urban land uses. Street surfaces, driveways and parking lots are considered to be major sources of these nutrients (Pitt, 1985). Nutrient losses from urbanized watersheds may be two to ten times greater than those from forested watershed (Burton et al., 1977; Grizzard et al., 1978). These nutrients may stimulate algal growth in well-lit sections of urban streams, leading to possible alteration of aquatic food webs.

Organic material is most often found on street surface in such forms as cellulose, tannins, lignins, grease and oil, hydrocarbons from automobile exhaust, carbon hydrates and animal droppings (Hampson, 1986). Of these substances grease and oil are the most major constituent runoff, and their primary impact is the exertion of oxygen demand on receiving waters (Pitt, 1985).

Chemical and biochemical oxygen demand on an aquatic system may be exerted by the various constituents previously mentioned. The primary impact of excessive oxygen-demanding materials is the depression of dissolved oxygen availability in receiving waters, which adversely stress aquatic organisms and may also cause noxious odors (Hampson, 1986).

Meteorological factors significantly affect the attributes of urban runoff; contributions of street dirt to urban runoff discharge depends on the ability of the rain to loosen and wash particulates form the street surfaces (Pitt, 1985). Thus, in a given area intensity and volume of rainfall have a significant influence on the volume and type of substances drained into a stream (Mustard et al., 1985; Wiiliams et al, 1980). In addition, the relative contributions of pollutants from various sources are different from the contribution of runoff flows. During very small rains most of the urban runoff and pollution discharges are associated with the directly connected impervious areas. As the rain total increases, the pervious areas become much more important (Pitt, 1985). During dry weather concentrations of major constituents of streamflow, such as major ions and total solids, are slightly greater in both urban and non-urban reaches. While the rain and resulting runoff diluted the concentrations of these constituents in the stream during wet weather, the concentrations of major pollutants from nonpoint sources are found greater during wet season than during dry weather. While similar differences between wet and dry weather are noted for both urban and non-urban areas, the wet weather concentrations were typically much higher in the urban than non-urban areas (Brabets, 1987; Pitt and Bozeman, 1983). Brabets (1987) states that even where water quality at base-flow conditions meets water quality standards, rainfall runoff periods show increased concentrations exceeding the standards of suspended sediment, heavy metals, nutrients and fecal coliform bacteria.

Highways are another significant source of pollution (Pope and Bevans, 1986; Clark and Jones, 1984; William et al., 1980). During snow-melting periods, high concentrations of substances used for deicing on highways are found in streams draining these highways. The application and subsequent transport in snow-melt runoff of deicing material such as salt and sand from streets and highways cause significant change in water quality of these streams. Pope and Bevans (1986) report that median concentration of dissolved sodium, chloride and solids in snow-melt streamflow at all study sites averaged 218% greater for dissolved sodium, 296% for dissolved chloride, and 71% for dissolved solids relative to median concentrations in dry weather streamflow.

Changes in Flow Regime

Changes in streamflow regime caused by urbanization also significantly affect stream water quality. Since the discharge of pollutants into a stream substantially increases as a result of urbanization, reduction in the base flow of a stream further affects its capacity to dilute increased concentrations of pollutants. If a channel contains little water except during storms, there is no chance for transporting or diluting these substances.

Increase in streamflow during wet seasons produces another problem relevant to stream water quality. While construction activities in the early urbanization stage is a major source of suspended sediment discharge into a stream, increased flow of flood stream as a result of urbanization causes another rise in sediment content of a stream. As urbanization proceeds, the number of high flows above bankfull stage increases materially; because of this the erodible material of the banks and beds of a channel will not remain stable, rather the channel will enlarge through erosion, substantially increasing sediment content of streamflow. Thus, the urbanization through the increase in peak flow produces large amounts of sediment through channel enlargement processes. As a result, sediment discharge from urban growth continues for a long period from the early stage of construction until all major areas of construction are stabilized and the stream channels have adjusted to the more frequent high flows.

C. Changes in Stream Channel Geomorphology

Change in streamflow regime as a result of urbanization also causes significant changes in fluvial systems. Typically, resultant physical changes in stream channels are larger flood plains and larger free faces.[2] During the construction phase of suburban development, surface materials are mobilized and storm runoff entrains large quantities of sediment, resulting in new and enlarged sedimentary structures (Graf, 1975; Leopold, 1973; Hammer, 1972). Graf (1975) reports that during the construction period the total area of flood plain was increased by 270% through creation of new flood plains and enlargement of old ones by increased sediment production which was recorded as much as 30 times over the pre-development period.

An expansion of flood plains is followed by

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[2] free face is the exposed surface of a mass of rock (McGraw-Hill Dictionary of Scientific and Technical Terms, 2nd ed. 1978).

down-cutting of streams and channel enlargement by increased streamflow during high flow periods (Hammer, 1972; Whipple et al., 1981). Increased amounts of impervious surfaces cause increases in runoff but reduce the sediment load, which in turn causes the stream to erode through the newly accumulated deposits. Further, as the area of suburbanization increases, greater percentages of stream length are dominated by sediment transport and lesser percentages are dominated by erosion and deposition. Stream channels become larger to handle larger, more frequent flood peaks (Hammer, 1972). Large channel enlargement effects are especially found for sewered streets and areas of major impervious parcels such as parking lots (Hammer, 1972).

Increases in free faces and flood plains have serious implications for the development of the drainage basin because the growth of slopes destroys valuable property. Large quantities of sediment-produced disruption of the surface would choke small valleys with marshy flood plains (Graf, 1976a). These physical changes also cause a serious reduction in the aesthetic and recreational values of the stream (Hammer, 1972).

D. Impacts on Aquatic Life Forms and Amenities

It is easily imagined that the effects of urbanization on flow characteristics, water quality and channel structure of a stream would cause tremendous impacts on aquatic organisms dwelling in the stream. Since some pollutants such as heavy metals have been shown to be deposited in the stream bed, benthic fauna and flora also receive significant impacts (Brabet, 1987).

Impacts of urbanization on aquatic life forms is shown as a decline in the diversity of species and families of organisms without significant decrease in the total numbers of organisms (Jones and Clark, 1987; Clark and Jones, 1984; Pitt and Bozeman, 1983; Duda et al., 1982; Benke et al., 1981; DiGiano et al., 1975). Thus, changes in aquatic habitat cause substantial decreases in many pollution-sensitive groups and pronounced increases in relatively few pollution-resistant groups, while causing little change in the total number of aquatic forms.

Deterioration of stream water quality is blamed as a main cause for the decline of a diversity of aquatic organisms (Jones and Clark, 1987; DiGiano et al., 1975). However, changes in the flow regime such as in base flow level and flow temperature as well as in the physical environment of a stream should also have an adverse impact on those aquatic life forms.

Amenity values associated with a streamflow and its flow channel are also adversely affected by those changes in a stream caused by urbanization. A channel which is enlarged due to increased floods tends to have unstable and unvegetated banks, scoured or muddy channel beds, and unusual debris accumulations (Leopold, 1968). The addition of pollutants such as nutrients and oxygen demanding substances disrupts the balance in the stream biota. Nutrients also would bring the growth of unwanted plants, increased turbidity, and the development of obstructive odors.

The accumulation of artifacts of civilization in the channel and on the flood plains also deteriorates amenity values of the stream (Leopold, 1968).

E. Possibility for Protecting Streamflow in the Eno River

Among various problems which might be caused by watershed urbanization, an extended condition of extremely low flow during dry seasons seems likely to occur in the Eno River Basin. Since the Eno River originally has a tendency to fluctuate its flow seasonally, urbanization in the watershed would severely affect the river's low flow condition during dry period by decreasing in the base flow as well as by increasing water demand.

Another concern is the deterioration of water quality of the Eno River. Urbanization within the watershed would surely affect the quality of the stream through increased urban runoff and waste discharge from point sources. Since the Eno River is the only major stream running through the Town of Hillsborough which has a large potential of urban development, discharges from most of the town's development and resulting urban activities run into the Eno River and affect its water quality. Increase in surface runoff from highways is also likely to occur after I-40 is connected to I-85 at Hillsborough if runoff from these highways runs into the Eno River.

Because the notion of streamflow protection does not directly relate to the notion of individual's beneficial use of water, the idea of streamflow protection tends to be least visible, if not totally overlooked, or it receives a lower priority compared to other water uses, even if recognized. Therefore, for the protection of streamflows, governmental measures are necessary. First, it should be determined whether such measures are available for protecting streamflows in the Eno River. However, even when governmental measures are provided, they may not be effective until all the other demands for water have been satisfied or until strong interest in streamflow protection is raised among the public. At this moment little water can be allocated for instream values in the Eno River because of existing demand excesses and supply scarcities within the river basin. Consequently, some engineering approaches may be required in order to create additional water supply sources. Also, it is necessary to control existing water uses in order to enhance the limited availability of water resources within the Eno River Basin. Further, precautionary measures may be required to prevent or to minimize the impact to be brought by coming urban development on the water resources within the watershed; otherwise, urban development would further bring an adverse effect on the original flow characteristics and stream water quality of the Eno River. Because of the sense of scarcity of water resources as well as the inclination toward economic development rather than the protection of the river's environment among communities within the Eno River Basin, streamflow protection may be perceived as the waste of a valuable resource by letting it flow in the stream without putting it on economically beneficial uses. Even when administrative and engineering measures are well prepared for streamflow protection, without adequate support from public and community leaders, flows in the stream may not successfully be protected. There need also to be social-psychological measures to obtain agreement and support from the community on streamflow protection.

IV. FEDERAL AND STATE STATUTES FOR STREAMFLOW PROTECTION

The necessity of depending on some governmental measures for the protection of streamflows has been suggested. Several Federal and State statutes may be applied to protect streamflows in the Eno River. These statutes include the Federal Wild and Scenic Rivers Act; the North Carolina Natural and Scenic River Act of 1971; the Water Use Act of 1967; the North Carolina Clean Water Act; the Dam Safety Law; and the Right of Withdrawal of Impounded Water Act.

A. Review of Federal and State Statutes.

Federal Statutes

There is no federal agency or law which has the words "instream flow protection" in its title, nor federal program which has instream flow protection as its principal mission. However, several federal statutes provide measures to protect the environment, including instream flow. Some of these federal statutes have a provision requiring federal agencies to take into consideration the effects of federal projects or licensing actions on the environment: the Clean Water Act (33 U.S.C.A. 1251-1376), the Fish and Wildlife Coordination Act (16 U.S.C.A. 661-666c), the Federal Power Act (16 U.S.C.A. 791-825r), and the National Environmental Policy Act (42 U.S.C.A. 4321-4347). Other statutes, such as the Endangered Species Act (16 U.S.C.A. 1531-1542) and the Wild and Scenic Rivers Act (16 U.S.C.A. 1271-1287) attempt to protect streamflows in order to preserve endangered species or distinctive beauty of streams in the nation. Among these federal statutes the Federal Wild and Scenic Rivers Act seems to have some possibility to be applied in the protection of instream flow in the Eno River.

The Federal Wild and Scenic Rivers Act (16 U.S.C.A. 1271-87)

The Federal Wild and Scenic Rivers Act recognizes the values of free-flowing streams and has provided the Wild and Scenic River System to fulfill the purpose of the Act of preserving those streams for the benefit and enjoyment of present and future generations (16 U.S.C.A. 1271).

The Wild and Scenic Rivers System contains three categories of river areas: wild, scenic, and recreational river areas (16 U.S.C.A. 1272(b)). When included, the overall character of a river or river segment determines its classification (16 U.S.C.A. 1273(b)). Classification, then, delineates regulatory provisions, land use limitations, and water use controls applicable to the component (16 U.S.C.A. 1278-79).

These regulations are most stringent for the wild river areas. Wild rivers are inaccessible to the public except by path or trail, and no development is permitted in order to maintain topographic and sylvan setting within the areas (16 U.S.C.A. 1273(b)(1)). In scenic river areas, natural setting is also emphasized to the greatest degree possible although limited forms of development are allowed within this area (16 U.S.C.A. 1273(b)(2)). Among the three river areas, restrictions are least stringent in recreational river areas. Various types of pre-existing development encumber shores of these areas, and water ways may have some impoundments (16 U.S.C.A. 1273(b)(3)). The emphasis in the recreational river area is primarily on providing vacation facilities for large numbers of people (Goodell, 1978). In brief, the three types of river areas provide varying degrees of protection for rivers included in the national system while all regulations are geared toward preserving the beauty of the rivers and adjoining land by controlling permissible land uses.

One important aspect of the Act is that it recognizes that state participation in the system is critical to the effective preservation of waterways (Goodell, 1978). Therefore, the Act encourages the states to take a prominent role in the development and administration of the Wild and Scenic River System. State participation under the Act includes proposing a river to be included in the system (16 U.S.C.A. 1273(a)(ii)), carrying out the study of rivers for inclusion in the national system (16 U.S.C.A. 1276(c)), and cooperating with federal agencies to administer and maintain river areas (16 U.S.C.A. 1281(e)).

Since the main purpose of the Wild and Scenic Rivers Act is to identify, preserve and protect existing untouched streams of precious value, the Act authorizes the Secretary of the Interior and the Secretary of Agriculture to acquire lands and interests in land within the boundaries of the system by condemnation (16 U.S.C.A. 1277(a)). Also, the Act contains provisions prohibiting or regulating future water development projects in the designated river segment (16 U.S.C.A. 1278). Even when such lands are located within an inhabited area, condemnation can be applied if existing zoning ordinances applicable to the area do not prohibit new commercial or industrial uses which are inconsistent with the purpose of the Act or do not protect the bank lands by means of acreage, frontage, and setback requirements on development (16 U.S.C.A. 1277(c)). While the Act requires federal and state governments to cooperate for purpose of "eliminating or diminishing the water pollution of the rivers," because of its purpose the Act does not provide any measures to regulate existing water uses along the streams in order to enhance their existing conditions. Also, the Act is unlikely to protect those streams whose free-flowing feature and pristine quality have already been spoiled from further deterioration through regulation of existing water uses along their stretches.

State statutes

The North Carolina Natural and Scenic Rivers Act of 1971 (G.S. 113A.30-43.)

When Congress passed the 1968 Wild and Scenic Rivers Act in order to prevent the continued decay of free-flowing rivers, many states responded to this federal legislation (Goodell, 1978). North Carolina's Natural and Scenic River Act of 1971 is one of those state statutes that followed the federal counterpart.

The Act recognizes the multiplicity of values associated with some rivers in the State and declares a policy of maintaining a "rational balance between the conduct of man and the preservation of natural beauty along those rivers" (G.S.113A-31). Further, the Act asserts that it is a beneficial public purpose to preserve certain rivers or segments of a river in their natural and scenic conditions by maintaining them in a "free-flowing" state (G.S.113A-31). The Act defines a "free-flowing" state as "existing or flowing in natural condition without substantial impoundment, diversion, straightening, rip-rapping, or other modification of the waterway"

(G.S.113A-33.(2)).

To carry out this policy, the Act enables the State to designate certain qualifying river sections as segments of the North Carolina Natural and Scenic Rivers System (G.S.113A-32). This Natural and Scenic Rivers System contains two types of scenic rivers: natural river areas (class I) and scenic river areas (class II) (G.S.113A-34). Natural rivers are in a free-flowing state and their adjacent lands exist in natural condition; scenic rivers are largely free of impoundments, with the lands within the boundaries largely primitive and largely undeveloped, but accessible in places by roads (G.S.113A-34).

Water flow is one of the major criteria for including any river or segment of river in the System. The Act states that the stream must be sufficient to assure a continuous flow and not subjected to withdrawal or regulation to the extent of substantially altering the natural ecology of the stream (G.S.113A-35.(4)). It seems clear from these provisions that those streams included in the system should continuously have either totally natural flow or one close to that level required to protect the natural ecology of the streams.

Like the Federal Wild and Scenic Rivers Act, a major concern of the State Natural and Scenic Rivers Act is to identify and designate streams of distinctive values and to protect their undeveloped scenic and pastoral features through regulating future water resource developments. The Act cannot cover nor protect from further deterioration those streams where their free-flowing feature has been stained by existing water uses.

Thus, like other similar wild and scenic river programs, the effectiveness of the Act is limited by its emphasis upon relatively undeveloped areas and may not provide protections to streams in the greatest danger of depletion (Dixon and Cox, 1985).

The Water Use Act of 1967 (G.S.143-215.11-22.)

Among several North Carolina statutes relevant to stream flow protection, the Water Use Act of 1967 seems to offer the most effective method for protecting instream flows if the Act is actually applied. The purpose of the Act is to put the water resources of the State to "beneficial use to the fullest extent" for the general welfare and public interest (G.S.143-215.12). To attain these purposes, the Act gives the Environmental Management Commission (EMC) limited authority to regulate the use of water in areas designated as "capacity use areas" (CUAs), where in the judgment of the EMC water shortage or conflicts among water uses exist or are impending (G.S.143-215.13(b)). Thus, the Act basically contemplates that henceforth some waters might be subject to quantity controls established by the EMC. Under the Act a CUA could apply to any body or accumulation of water, surface or underground, public or private, natural or artificial, which exists within the jurisdiction of the State once designated.

The Water Use Act established a three-step process for controlling state waters: (1) the declaration of a CUA (G.S.143-215.13.(a)); (2) development of regulations addressed to the needs of the area (G.S.143-215.14.); and (3) the imposition of a permit system to carry out the objectives of the legislation (G.S.143-215.15).

The first step in implementing the Act is the EMC's declaration of a CUA. The Act defines a CUA as one where the EMC finds that the aggregate uses of water resources may require coordination and regulation, or may exceed, threaten or impair the renewal or replenishment of such water resources (G.S.143-215.13.(b)). When the EMC finds that the use of water resources require coordination and limited regulation "for protection of the interests and rights of residents or property owners of such areas or of the public," the Commission designates these areas as CUAs (G.S.143-215.13.(a)).

The EMC is authorized to declare a CUA provided it follows specific and detailed procedures outlined in the Act, which includes public hearings (G.S.143-215.13.(c)(1) -(7)). If the EMC believes that a capacity use situation exists or is emerging, it will direct the Department of

Natural Resources and Community Development (NRCD) to investigate the area (G.S.143-215.13.(c)(1)). NRCD will file a written report with recommendations to the EMC whether such a area should be declared as CUA or not (G.S.143-215.13.(c)(2)). If the EMC then contemplates issuing an order declaring a CUA, it must give notice and hold one or more hearings before issuing a final order (G.S.143-215.13(3) and (4)).

After a CUA has been designated, the EMC may proceed to formulate rules concerning water use in the area in order to protect against or abate unreasonable adverse effects on other water users within the area, including adverse effects on public use (G.S.143-215.14).

Any water users in a CUA are required to secure permits from the EMC in all instances where use is in excess of 100,000 gallons per day, 0.1 MGD (G.S.143-25.15.(a)). If such a water use is consumptive, a permit for use in excess of 0.1 MGD may be denied when the proposed use is contrary to the pubic interest (G.S.143-215.15.(b)). In other cases, the EMC may grant for such a large consumptive use a permit with conditions, a temporary permit, or a modified permit (G.S.143-215.15.(c)). If the use is non-consumptive, the EMC can issue a permit without a hearing or conditions provided for a consumptive use (G.S.143-215.15.(b)).

Water users within a CUA who do not use in excess of

0.1 MGD are not required to secure a permit; nevertheless, they are required to comply with procedures established to protect and manage the water resources of the designated area (G.S.143-215. 16.(c)). Individual domestic water users are exempted from this requirement (G.S.143-215. 16.(c)).

When the EMC decides not to use a CUA designation as a measures for controlling water uses, the Commission may adopt alternative measures recommended by NRCD (G.S.143-215.13.(2)).

G.S.143-215.13.(d), which was added to the Act by a 1973 Amendment, authorizes the EMC to provide temporary regulation pending establishment of CUAs (Heath et al., 1978). When the EMC determines that an increase in withdrawal or waste discharge within an area will impair the availability or fitness for use of such water resources and will cause injury to the public health, safety or welfare, the Commission, after a public hearing, may issue a rule to regulate large-scale water withdrawals and waste discharges as well as new or increased withdrawals or waste discharges which may exceed the established rates (G.S.143-215.13.(d)).

G.S.143-215.17. provides for enforcement procedures. Any person who violates any provision of the Act is guilty of a misdemeanor and is liable for penalties specified in the Act (G.S.143-215.17.(a)). Civil penalties could also be applied to those who violated any provision of the Act, order or rule pursuant to the Act (G.S.143-215.17.(b)). In addition, for those violators the Secretary of NRCD may, either before or after the institution of proceedings for the collecting of the penalty, request the Attorney General to institute a civil action in the Supreme Court for injunctive relief to restrain the violation (G.S.143-215.17.(c)).

Finally, the Act states that any provisions of the Act do not change or modify existing common law with respect to the riparian rights of landowners concerning the use of surface water (G.S.143-215.22). There are some claims against this provision. Heath et al. (1978) assert that this provision leaves some unresolved ambiguities in the interpretation of the Act and may raise questions about the impact of the Act if it is applied to surface water. The National Water Commission (1970) also recommends that the rule of the riparian law should specifically be abolished because it hinders effective water resources management which pursues the economically most efficient use of the resource by allocating water to the highest and best economic use. However, in the absence of minimum flow provisions which are specifically defined to serve as measures for the protection of interests in stream flows of riparian landowners as well as the general public, this provision seems to be the only available measure to protect their interests in stream flows.

In addition to the provision of protecting riparian rights, several questions about the Act have been raised. They include the limited scope of the Act, which only deals with current and emerging problems; lack of provisions which set priorities on water allocation among different types of water uses during emergency as well as normal situations; and inadequate consideration to the question of due process and just compensation in a case where a user must reduce or discontinue withdrawal (Heath et al., 1978).

Article 21. Water and Air Resources: the North Carolina Clean Water Act (G.S.143-211., 143-215.9.)

While the main mission of the N.C. Clean Water Act is water quality control of the State's streams through regulating major point source waste discharges, the Act provides for protection of minimum flow in the streams so that the water quality of these streams should not deteriorate because of lack of flow in the streams. Thus, on the development and adoption of water quality classifications and effluent standards for each classification, the Act requires the EMC to use rate of flow as one of the criteria in assigning to each identified water the appropriate classification (G.S.143-214.1. (d)(1)).

Pursuant to this provision, the Commission has adopted a statistical estimate of stream flows, the 7Q10 low, on which the State's water quality standards are based (N.C.A.C. T15:02B.0206). Thus, in order to meet water quality standards except toxic substances, at least the 7Q10 flow should always remain in the streams covered by the Act (N.C.A.C. T15:02B.0206. (a)(1)). This statistical rate is also applied to determine waste load allocations for toxic substances water quality standard (N.C.A.C. T15:02B 0206 (a)(3)). N.C.A.C. T15:02B 0206 (a)(4) states that the governing flow for all water quality standards should be the instantaneous minimum instream flow or an alternative flow deemed appropriate by the EMC. This flow is typically close in volume to the 7Q10 flow, although it may be significantly greater or less (NRCD, 1984). Therefore, theoretically, in a stream with these NPDES permittees along its watercourse, stream flow should be equal to or greater than the 7Q10 flow in order to protect these effluent standards.

The Act specifically prohibits the discharge of waste materials by any person until an NPDES permit is secured and forbids any person to discharge any waste to the waters in violation of any effluent standards or limitations established for any point source (G.S.143-215.1.(a)). However, the Act itself does not explicitly refer to the violation of the 7Q10 flow.

The Dam Safety Law (G.S.143-215.23-37.)

The Dam Safety Law, which regulates the safety of the design, construction and operation of dams, could be another candidate for protecting instream flows. One of its stated purposes is to ensure "maintenance of minimum stream flows" below dams of adequate quantity and quality (G.S.143-215.24). The Law defines minimum streamflows as those flows of a quantity and quality sufficient in the judgment of NRCD to meet and maintain stream classifications and water quality standards established under North Carolina Clean Water Act (G.S.143-215.25.(4)). Thus, the Law requires all dams subject to the Law to maintain minimum stream flows, that is the 7Q10 flows, necessary to sustain stream classification and water quality standards. (G.S.143-215.25.(4)).

In order to ensure that minimum streamflow requirements as well as water quality standards are met and maintained, the Dam Safety Law gives the EMC broad powers and supervision over the application for certifications of a dam (G.S.143-215.28.); certification of final approval (G.S.143-215.30.(C)); and maintenance and operation of a dam (G.S.143-215.31). Also, the Law authorizes NRCD to impose conditions and requirements on the operation of dams to satisfy minimum streamflow requirements (G.S.143-215. 25.(4)).

There are significant restrictions on the scope and reach of the Law, however. Since it exempts federally owned, subsidized and licensed dams as well as certain small ones from its scope of regulation, the Law applies only to limited numbers of privately built dams (G.S.143-215.25.(2)). Also, while the Law requires the 7Q10 flow to be maintained in the streams below those dams, it does not take into consideration the effects of existing and future water uses downstream of the dams which may significantly affect the quantity and quality of the streams. Since there are no regulatory measures to control these downstream water uses to preserve the 7Q10 flows, it is not certain that below those regulated dams such a minimum stream flow would be maintained.

The Right of Withdrawal of Impounded Water Act (The "Impounded Water Act", G.S.143-215.44-50.)

The Impounded Water Act is designed to protect the interests of those who impound streams in withdrawing and using the water they have impounded. It gives the impounder a statutory "right of withdrawal" to withdraw excessive volumes of water that are equivalent to the volumes they have impounded by storage reservoirs (G.S.143-215.44.(a)). These rights to withdraw excessive volumes of water may be exercised either by making withdrawals directly from the storage reservoir or from the stream below the reservoir (G.S.143-215.46). However, while recognizing impounders' right of withdrawal, the Act defines "excess volume" as that which may be removed without foreseeably reducing the rate of flow of the watercourse if the impoundment did not exist (G.S.143-215.44.(c)). Thus, the Act contains a provision safeguarding from excessive water withdrawal normal stream flows that would prevail in the absence of an impoundment (Heath, 1985).

The Impounded Water Act does not directly affect the maintenance ofinstream flows, but it does encourage the building of storage reservoirs by clarifying the legal rights of impounders. It may tend thereby to encourage the kinds of water supply arrangements that involve more storage reservoirs and less direct withdrawals from the natural streamflow.

Another aspect of the Act is that it provides a guideline to determine a streamflow level when the rate that would exist in the absence of an impoundment is an issue (G.S.143-215.48.(a)). The Act authorizes the EMC to determine the flow rate, either 7Q10 or alternative rates which if introduced could more closely approximate the flow rate without the impoundment (G.S.143- 215.48.(a)).

B. Examination of Federal and State Statutes for Protecting Streamflows in the Eno River.

In the Eno River, the Eno River State Park seems to have served as a barrier for the river from development of the designated area and protected its undeveloped natural features as well as cultural and historic sites along the river. The Park was established and has been expanded along the river in response to proposals of development the watershed resulting in the destruction of the river's free-flowing nature (DPR, 1970). It is clear from the configuration of the Park, which has a long stretch of the river corridor as a main park feature, that the Park is intended to protect the free-flowing nature of the river, its natural and historic features, and water-related recreational facilities along its stretch.

Thus far, the State Park has been successful to some degree in protecting the natural and historic environment within its boundaries. On the other hand, the Eno River's free-flowing state and quality of stream water have deteriorated because of increased amounts of withdrawal and waste discharge along the river upstream of the Park. The control of the North Carolina State Park Act, which has created the Eno River State Park, is limited to water uses by those who visit the park; no regulation is provided to protect the river from the impact of upstream water use.

The Federal and State Wild and Scenic Rivers Acts

One of the possible ways to protect the Eno River's streamflow is to designate some segment of the river within the Eno River State Park as a recreational river area under the Federal Wild and Scenic Rivers Act or as a scenic river area under the North Carolina Natural and Scenic River Act. Because of the provisions of these Acts, the maximum protection of streamflow of the river, that is maintenance of free-flowing state of the stream, could be attained through the designation. Especially, the Eno River's various features seem to make the river qualified to be in the State Natural and Scenic Rivers System and to benefit from its protective features.

The first thing to be considered is whether the Eno River could be qualified as either a recreational river under the Federal statute or a scenic river under the State act. For inclusion of recreational river area, the Federal Wild and Scenic Rivers Act requires that a stream has a free-flowing state and "one or more of the environmental values" to be protected by the Congress while providing recreational facilities along the stream (16 U.S.C.A. 1273(b)).

For including a river in the Natural and Scenic River System under the State Natural and Scenic Rivers Act, the Act specifically defines scenic river areas as those rivers or segments of rivers that are largely free of impoundments, with land within the boundaries largely primitive and undeveloped, but accessible in places by roads" (G.S.113A-34). G.S.113A-35 provides specific criteria for including rivers or their segments to the system: river segment length must be no less than one mile; water quality shall not be less than that required for class "C" water as established by the EMC; and flow shall be sufficient to assure a continuous flow and shall not be subject to withdrawal or regulation to the extent of substantially altering the natural ecology of the stream (G.S.113A-34). In addition, N.C.A.C. T15:12F.0202. provides more detailed criteria for a river to qualify as either natural or scenic river. The code states that a river segment should be long enough to provide a rewarding experience and to encompass a sufficient portion of those features and processes that make the segment worthy of consideration (N.C.A.C. T15:12F.0202.(a)(1)). The natural features and forces necessary for the maintenance of high quality riverine resources must be identified (N.C.A.C. T15:12F.0202.(a)(2)). Also, the code provides additional criteria for designation of a river as a scenic river: (1) on environmental quality, scenic river areas are more amenable to multiple use than natural river areas and are more suited for active and intensive recreational uses; and (2) scenic river shorelines and adjacent lands shall be largely free of structures and forested landscapes mixed with dispersed agricultural uses and rural dwellings or settlements (N.C.A.C. T15:F12.0202.(c)(B)).

An apparent obstacle stands before the designation of the Eno River under the Acts. Both statutes require a river to be in a free-flowing state, which means that flows should be "sufficient to assure a continuous flow" and "not subjected to withdrawal or regulation to the extent of substantially altering the natural ecology of the stream" (G.S.113A-35.(4)). The situation of the Eno River during previous summers has clearly showed that the river lacked such sufficient streamflow. Therefore, because of the nature of these statutes of general emphasis on the preservation of undeveloped streams, there is uncertainty on the applicability of these wild and scenic river statutes to those streams like the Eno River which are in greatest danger of development (Dixon and Cox, 1985).

Even if the Eno River were included in either one of these scenic river systems, another uncertainty exists concerning the actual ability of these Acts to protect the free-flowing state of designated streams. Because of their implicit assumption that only untouched streams in remote areas could be qualified for inclusion in the system, these statutes are structured so as to emphasize the identification, designation and preservation of the rivers of distinctive beauty as they are. Therefore, available protection measures for these Acts are the provisions regulating future development along the designated streams in order to maintain existing situations. Few measures are provided to deal with existing water uses which may affect the quality and quantity of the streams.

Mather (1984) raises additional problems with the Federal Wild and Scenic Rivers Act. First, while designated wild and scenic river does receive considerable protection against federal developments, it is not well protected from private activities. Further, these limitations only apply to the portion of the river designated as "wild and scenic"; such developments either up- or downstream from the designated portion of the river are permitted. Second, the area of the river system to be protected by the Act is limited to just 320 acres per mile - essentially 1/4 mile on each side of the river. The Act is unable to protect the river or basin from private development outside this narrow corridor although it is quite clear that such development, if uncontrolled, could result in considerable degradation of the river (Mather, 1984).

There is a problem of political feasibility in applying the Federal or State Wild and Scenic Rivers Acts to the Eno River. Since severe competition over water resources has occurred among water users in the Eno River Basin, it may be impracticable for the State to designate or propose the river to be included in the State or Federal Scenic Rivers system simply for the purpose of instream flow protection.

The N.C. Clean Water Act, the Dam Safety Law, and the Right of Withdrawal of Impounded Water Act

While these statutes provide some provisions requiring that certain amounts of streamflow should be maintained, they lack practical measures to attain the purpose of instream flow protection. Therefore, these statutes by themselves cannot stand as substantial means for this purpose. However, they seem to be able to serve as a statutory basis for the EMC under the Water Use Act to adopt rules and regulations to provide some protection of instream flow at the 7Q10 flow level.

C. Streamflow Protection under the Water Use Act

So far, no federal nor state statute has been shown to be an effective measure to protect streamflows in the Eno River. However, the Water Use Act may have greater potential to attain this purpose. The Act has two major provisions to be used for protection of streamflow.[1] One provision of the Act authorizes the EMC to require large water users within a CUA to seek a water use permit

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1. Since the Water Use Act does not define the kind of water use which it protects or regulates, it is not certain whether instream uses are under the protection of the Act. However, the Act guarantees that it does not change riparian landowners' rights to surface waters which, in North Carolina, include the right to sufficient flow of a stream (G.S. 143-215.22.). Therefore, it is possible to consider that the Act protects instream uses.

(G.S.143-215.15(a)); the other directs the EMC to adopt rules and regulations in a CUA (G.S.143-215.14). Examination of these two provisions helps us to understand the Act's potential for protecting streamflow.

<u>Permit System of the Water Use Act</u>

The Water Use Act provides a water use permit system for any area designated as a CUA. While the Act is designed to control general water use and not particularly to protect instream flow values and uses, the permit system of the Act may have a potential to be used for streamflow protection.

The National Water Commission (NWC) has provided a model water use permit system for the regulation of withdrawals of water in a riparian jurisdiction. One of the most significant characteristics of the NWC's permit system is that while regulating water withdrawals, the system simultaneously provides a scheme for protecting instream values and uses within it (NWC, 1970). When compared with the Commission's permit system, the permit system of the Water Use Act exhibits several drawbacks as an effective measure for streamflow protection as well as for general water use control.

One apparent drawback of the permit system of the Water Use Act is that it does not directly provide for protecting instream flows. In order to protect instream flows the NWC (1970) recommends that such an act should have a provision to authorize an administrative agency to establish minimum flow for surface streams and that the water remaining should be subject to development for use and in providing goods and services.

A significant difference is also evident in the range water users covered. The NWC (1970) recommends that permits should be required for all withdrawals, both before and after enactment of the statute, except for inconsequential amounts of water uses such as domestic uses. Under the Water Use Act only users who withdraw water exceeding 0.1 MGD are required to obtain permits (G.S.143-215.15.(a)). Among those large users, however, permits with conditions are required only for those who make "consumptive uses" of water that may cause substantial impairment of quality or quantity of water (G.S.143-215. 15.(c)). Thus, even if a water withdrawal exceeds 0.1 MGD, unless the EMC decides that such water use is "consumptive," a permit is unconditionally given to water users without a hearing or any conditions on withdrawals or uses of water (G.S.143-215.15.(b)). Consequently, only those who withdraw water more than 0.1 MGD and use it consumptively are held under the control of the EMC's permit system. Those who withdraw water less than 0.1 MGD are free from the consideration of permit requirement although they are required to comply with procedures established to protect and manage water resources in the area (G.S.143-215.14.(a)).

Another concern in dealing with a permittee is that the Water Use Act does not establish any guidelines about granting or denying a permit except for the amount of water withdrawn. There is no provision stating what types of water uses are covered by the Act or are necessary in order to secure a permit. Nor are there criteria for setting priorities in granting permits among different types of water users. Without such a priority list, there might be confusion and conflicts in granting permits, especially when availability of the resource is limited. Since the Act does not specifically mention instream flow protection, it could be expected that water for this purpose might be put aside until all other demands are met.

The lack of guidelines except for 0.1 MGD criterion about granting water use permits may cause a problem in determining who is covered by the permit system in the Eno River Basin. Most of irrigational water users in the river basin withdraw less than 0.1 MGD of water on the yearly average; however, the maximum daily use of more than half of these irrigators exceeds 0.1 MGD limitation. Since these irrigational water use is quantitatively consumptive, that is, most of the water withdrawn for this purpose is not return to the stream, irrigational withdrawal may have tremendous effects on the river's streamflow during dry periods. However, in the irrigational water use, such withdrawals as to exceed 0.1 MGD happen for only limited time of the year, different from industrial use and public water supply which have water withdrawal constantly exceeding the limit. In addition, for irrigational users lack of sufficient water during dry periods severely affect their economic activities. Therefore, requiring irrigators water use permits only because their water use exceeds 0.1 MGD may not be an effective way to protect water resources in the Eno River Basin and may cause an adverse effect on agricultural activities in the area.

To furnish adequate data for water resource development and management is one of the important purposes of a water use permit system (NWC, 1970). Since water demand and supply, for both groundwater and surface water, vary from basin to basin, accurate information for the supply side and the demand side is necessary. If permits cover all withdrawals, the aggregate information provided by the permits gives a reasonably full picture of the demand side of the supply-demand equation. It is particularly important under the permit system to determine the amount of consumptive use, and the amount of return flow, so that certain flows can always be maintained in the stream when the permit is issued. This information also becomes important when the permit is transferred, for ordinarily only the consumptive use will be transferable, since other areas may depend on return flow (NWC, 1970).

While the Water Use Act requires permit applicants to furnish information on their proposed water withdrawal (G.S.143-215.16.(c)), compared to the permit system suggested by the NWC, this information is not sufficient. Since only a limited number of large water users are required to apply for a permit under the Act, aggregate of information before the EMC may be insufficient for the Commission to comprehend the total water demand situation. Without comprehensive information on water demand within the watershed, the EMC may have difficulty in deciding and limiting the amount of water to be withdrawn by each user as well as in allocating certain water for instream flow maintenance. Lack of sound information to justify the agency's decisions may also expose its decision-making procedures to judicial review.

Another significant disadvantage of the Water Use Act is that it does not provide for cancellation of permits for nonuse or for reduction in the quantities permitted to be withdrawn where there has been an extended period of underuse. The NWC (1970) believes that these provisions promote effective resource allocation by eliminating paper rights from the record.[2]

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2. To deal with this problem, the EMC may apply G.S.143-155(k) which allows NRCD to request any water user to furnish his water use information. Such information includes withdrawal rate, measured in gallons per minutes, and total amount of water withdrawn for a month (G.S.143-

A serious drawback is also observed in the point that the Water Use Act is only written in terms of permitting uses that exist at the time of designation of a CUA (Heath et al., 1978). No guidance or standards are provided for determining priorities among competing uses or for resolving conflicts that arise from current users in times of emergency or drought. Nor does the Act provide guidelines for preventing or solving future water use conflicts that will arise as a result of increased water use in the future. Providing statutory schemes for allocating water in periods of shortage which take instream flow protection into consideration is particularly important for the protection of instream uses and values.

While the Water Use Act states that permits, the rights to water, are transferable with the approval of the EMC (G.S.143-215.16(b)), the Act does not provide any guidelines for conducting the transactions of transferring permits or for restricting the transfers in order to protect other permittees and to prevent infringement of desirable minimum flow in the public interest. Since the Act does not change common low riparian rights (G.S.143-215.22), this provision could serve for protecting riparian rights to the flow of the stream when permits are transferred. However, it also could be an obstacle to the effective permit transfer, for the rule of riparian law

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155.(k)).

strictly limits use of water to riparian land and forbids the sale of water rights separately from riparian land. In order to overcome this dilemma, the NWC (1970) recommends the annulment of the riparian rule and the adoption of minimum flow provisions; the former ensures the accomplishment of economically efficient water resources allocation while the latter serves as a measures for the protection of interests in streamflows of riparian landowners and of the general public.

Shortcomings of the Water Use Act's permit system as a measure for water use control and streamflow protection are summarized as follows;

(1) lack of authority to set the minimum flow levels;

(2) failure to cover all consequential water users;

(3) lack of provisions for cancellation of permits, for reduction of water to be used, and for allocation of water during shortage periods; and

(4) lack of standards or guidelines for granting temporary permits, renewing permits, transferring permits, and type of water uses which are applicable to the law.

At present the permit system of the Water Use Act by itself may be an inadequate measure for streamflow protection as well as a general water use control.

<u>Rules and Regulations adopted under the Water Use Act</u>

Another possible measure for protecting streamflow under the Water Use Act is the EMC's adoption of rules and regulations within the capacity use areas and the ones of near-capacity situation.

The only capacity use area that has been designated is the phosphate mining region of eastern North Carolina, where pumping of groundwater threatened the integrity of the region's principal water course (Heath et al., 1978). The regulations adopted by the EMC in the permit system for the area include:

(1) maximum total daily water withdrawal and time of withdrawals;

(2) maximum withdrawal rates from individual wells or surface-intakes;

(3) maximum drawdown levels, that is, the lowest water level that may be produced in any well or wells;

(4) a requirement to determine and implement reasonable and practical methods or processes to conserve and protect the water resources; and

(5) setting of monitoring devices that will provide a continuous record of withdrawals (N.C.A.C. T15. 02E.0202).

While these provisions are for withdrawal of groundwater, it is reasonably anticipated that similar types of regulations would be contained in permits for surface water withdrawals when surface water areas are designated. Since maximum drawdown levels were determined for groundwater withdrawal, it is expected that minimum streamflow levels could be determined for surface water withdrawal.

The next question is whether the Act can provide some measures to protect instream flows even when the EMC decides not to use CUA designation but to adopt alternative measures. There is a case in which the EMC adopted regulations on surface water withdrawals instead of using CUA designation. When a power company planned to construct a nuclear power plant on the Yadkin River, the company proposed to withdraw 72 MGD of water from the river for the operation of the proposed plant. Reflecting public concern over the environmental effects of the proposed water use, the EMC directed NRCD to investigate the possible effects of the proposed use on the stream and to prepare a recommendation as to whether all or part of the Yadkin River should be declared as a CUA. Following NRCD's investigation and its recommendation discarding CUA designation, the EMC decided that measures short of declaring a CUA would be sufficient to conserve and protect water resources and to satisfy the needs of present and potential future uses of the river (High Rock Lake Ass'n v. N.C. Env. Mgt., 1979 and High Rock Lake v. N.C. Environ. Management, 1981). Then, the EMC adopted regulations on the company's water withdrawal from the river. Although there is no provision in these regulations that specifically mentions the amount of flow to be protected in the river, the regulations do prohibit withdrawals that would remove more than 1,000 cfs (45 MGD) and limit withdrawals that would remove more than 25% of the streamflow or exceed 1,000 cfs (N.C.A.C. T15:02E.0105.(1) and (2)). In addition, the regulations limit the company's maximum daily consumptive use of water and require the company to monitor and report its water withdrawals and water releases (N.C.A.C. T15:02E.0105.(3) and (4)). Therefore, if NRCD seriously considers the protection of streamflow and put the idea in its recommendation to the EMC with suggested streamflow levels, there is a possibility that certain amounts of streamflow could be protected.

While G.S.143-215.15 (h) provides a list of factors to be taken into consideration by the EMC in adopting those rules and regulations, this provision only loosely conditions the EMC. Important decisions on the rate, maximum amount, and time of withdrawing water, on the type of water uses to be regulated, and on the priorities in water withdrawal among different users, if the Commission would adopt them, are largely at its discretion.

Streamflow Protection under the Water Use Act: Conclusion

Notwithstanding the reservations expressed above, it is still possible that regulations can be applied within

CUAs and the areas of a near-capacity situation that provide some streamflow protection. In these areas the EMC is authorized to adopt regulations in order to protect against or abate unreasonable adverse effects on water uses, including public use, or to control competing water uses within the area (G.S.143-215.13.(c)(2) and 14.(a)).

It has been noted that broad discretion was granted to the EMC in its adoption of alternative measures or regulations within those critical areas. This is due to the fact that the Water Use Act provides few specific standards or guidelines for the Commission's decision making. On the one hand, this has caused differing interpretations of the Act, misunderstanding as to what it allows, and a concern that a CUA subjects the allocation of water to interest group pressures and potential litigation in case of conflicts (Heath et al., 1978). On the other hand, however, the fact that the Act grants the EMC considerable discretion could mean that the Commission could supplement the Act, such as the absence of specific provisions or gaps in instream flow protection, in its discretion. Therefore, the EMC's discretion becomes one of very important factors to determine the nature of the rules and regulations in the Act.

In determining whether the EMC appropriately applied its discretion during its decision-making process, or acted arbitrarily or capriciously, the North Carolina Court of

Appeals in Yadkin River case has applied the "whole record test" as a standard of judicial review of the Commission's actions (<u>High Rock Lake v. N.C. Environ. Management</u>, 1981). The Court explained the test as one which "takes into account the specialized agency's expertise, thus not allowing reviewing court to substitute its judgment for that of agency; the test, however, requires that a reviewing court take into account evidence in the record which fairly detracts from the weight of evidence that the agency relied upon to make its decision" (<u>High Rock Lake v. N.C. Environ. Management</u>, 1981). In this case, riparian property owners downstream of the proposed plant sought judicial review of the EMC's decision that rejected declaring a CUA. While recognizing the fact that the proposed plant would cause adverse effects on the environment of the river, the Appeals Court, after reviewing the entire record and taking in view the conditions to be imposed on the plant for withdrawing water from the river, concluded that the EMC's "judgment was supported by competent, material and substantial evidence and was neither arbitrary nor capricious" (<u>High Rock Lake v. N.C. Environ. Management</u>, 1981). Therefore, it might be possible that the EMC could adopt such regulations which set aside flow for streamflow protection or that take into account this idea.

When a stream is covered under either the N.C. Clean

Water Act, the Dam Safety Law, or the Right of Withdrawal of Impounded Water Act, at least the EMC can adopt rules and regulations to protect the 7Q10 flow in the stream in order to comply with the requirements of these statutes. However, if the EMC adopts rules and regulations which protect the streamflow greater than the 7Q10 flow, such regulations may have to survive judicial review by the courts to justify the EMC's decision-making process. In order to survive judicial review the EMC should provide evidence showing the existence of strong concern over instream flow protection among the public; evidence that maintenance of certain streamflows is the most effective way to protect rights and interests of riparian landowners and of public; evidence which would prove that the preservation of the stream flows would not cause significant adverse effects on or inconvenience to other water users; and rigid scientific methodology and hard data which could provide for determining appropriate streamflow levels.

V. APPROACHES TO THE PROTECTION OF STREAMFLOW IN THE ENO RIVER

It is desirable flows which would preserve most if not all instream values be maintained in the Eno River. Currently, it is impossible to obtain such flows in the river without causing strong conflict with existing water uses or forcing them to give away their shares to use the water. In order to protect streamflows in the Eno River, four major issues must be addressed: to acquire enough water resources to satisfy various demands including instream needs; to prevent and/or minimize adverse effects on water resources from existing and future water and land uses within the watershed; to justifiably obtain and protect enough flows for preserving instream values; and to modify people's perception on streamflow protection so that it could be positively understood in the context of community development.

A. Acquisition of Water for Current and Future Demands

It is very difficult, if not impossible, to maintain sufficient streamflows in a watercourse without satisfying demand of existing water uses. Within the Eno River Basin the demand is about to exceed the supply, and during drought periods this limited supply cannot meet increased demand (NRCD, 1987). In this situation, even where there exist governmental measures and public demand for streamflow protection, water may not be allocated in a stream unless existing demands of other private uses are satisfactorily fulfilled.

The first thing to be done for streamflow protection in the Eno River is to increase flows in the river during dry periods without sacrificing existing water uses. Two approaches seem available to attain this objective. One is to store water during high flow periods and to use it during low flow seasons; the other is to control surface runoff discharge into the river and to enhance groundwater discharge.

Amelioration of Flow Fluctuation and Use of Excess Water

Large seasonal flow fluctuations of the Eno River have been noted. These fluctuations have resulted in the situation in the river basin where the supply becomes extremely reduced as the demand rapidly increases during dry periods. One measure to resolve this problem is to retain and reserve those excess streamflows during high flow periods so that this stored water can be used to meet increased demand during dry periods. First, existing water storage systems should be re-evaluated in terms of their storage capacity and their operating policies. The three major surface water reservoirs within the river basin should be examined in order to optimize their beneficial use. Some uniform policy may be necessary for operating numerous small irrigation ponds in the river's headwater area, so that their effect on reduced streamflows during dry periods could be minimized. These irrigation ponds, if managed effectively, might play a significant role to ameliorate the flow fluctuations in the Eno River; these ponds could also reserve excess water during wet periods and release it during dry periods.

Re-examination of regional water systems connected with pipelines may also bring some solutions for seasonally available excess water. Currently, eight water systems within and outside of the Eno River Basin are directly or indirectly connected to each other (NRCD, 1987). It might be possible to transfer excess water from one water system to another through existing pipelines among these water systems. For example, OWASA may be in a position to furnish water to Hillsborough when the Cane Creek reservoir is completed (NRCD, 1987). It is also possible to transport water from one river basin to another where the water is stored and to return it to the original basin when water shortage occurs. In order to facilitate this regional cooperation on water resource management, political as well as engineering feasibility to conduct such operations should carefully be examined.

To increase the storage capacity of existing reservoirs and/or to construct new surface reservoirs is another means of reducing high flows and increasing low flows. NRCD (1987) provides several possible reservoir sites within and outside of the Eno River Basin. Because of existing pipelines connecting water systems within and around the river basin, it might be possible to build a reservoir between two watersheds where water is conveyed through pipelines connecting these watersheds.

Another possibility is to store excess water in underground storage systems. Underground water storage has several advantages over surface water storage. Since less water will be lost to evaporation in underground storage, this results in improvement of quantity and quality of water (Ku and Simmons, 1986). Underground storage not only prevents subsidence and salt water intrusion but also saves surface space allowing more economic land uses (Agthe, 1986). Underground storage systems can be constructed in a community experiencing urban growth where developers are required to provide underground storage facilities when they develop large properties, such as shopping malls and parking lots.

Control of Surface Runoff and Increase in Infiltration Capacity

In essence, increased imperviousness within urban areas means decreased storage capacity of rainwater which in turn facilitates increased and rapid runoff of storm waters (Lazaro, 1979). Alternatively, if one wishes to reverse this process, i.e., to decrease the rate or volume of runoff, one must increase the storage factor. In the Eno River Basin, the groundwater and surface water resources are closely interrelated. Groundwater within the basin originates from local recharge through infiltration from rainfall; excess groundwater discharges through springs and seeps to the stream in the basin, forming the base flow component of stream flow (NRCD, 1987). Consequently, increase in groundwater recharge directly affect groundwater discharge into the Eno River. Because of low groundwater discharge, surface runoff is the major source for stream flows in the Eno River. Therefore, control of surface runoff, combined with enhancement of infiltration capacity and groundwater recharge within the river basin, may directly result in substantially stable as well as increased base flow in the Eno River. Thus, urban runoff control to reduce high flows during flood periods may also bring low flow increases as a beneficial "spinoff" in the Eno River Basin.

Roofs make up a large proportion of the impervious area within an urban region; more than 50% of the impervious area in a city is occupied by roofs (Chiang, 1971). If one were to design roofs to retain rainwater, a considerable amount of water could be held in storage and slowly released after the storm passed or could be infiltrated into the ground. Since roofs are not subject to littering as are urban streets, the quality of rainwater is very good, depending on air pollutants (Chiang, 1971). Chiang (1971) suggests that instead of using a roof as a drainage device as we are doing now, one should employ it as a control and regulating device and a conservation measure. Design requirements would not be cost-prohibitive; roofs are commonly built to hold 8 inches of water (40 pound/square feet), and an additional 4 inches, which make roofs retain rainwater up to a foot deep, would not significantly increase construction costs because the cost of a roof is a small fraction of the total cost of the majority of urban structures (Chiang, 1971). Perhaps the most significant economic factor is that the detention of rainwater by roofs could considerably reduce the size of the community's storm sewage system (Chiang, 1971).

Another possible measure to reduce surface runoff and to increase groundwater recharge is the application of porous pavement. Porous pavement has advantages of alleviating flash flooding and preserving natural drainage patterns and improving surface runoff water quality by reducing the number of shock loadings (Thelen et al., 1972). Thelen et al. (1972) report that an open-grated asphalt concrete was the most suitable material for porous pavement; the porous asphalt, containing relatively small amounts of fine particles, exhibited superior physical characteristics, was low in cost, and could be laid by conventional paving equipment. Another significant advantage of this porous asphalt surface is that the cost of installation and maintenance of this asphalt is equal to or cheaper than the cost of conventional pavement with storm or combined sewer facilities (Thelen et al., 1972). Since groundwater within the Eno River Basin does not have a basin-wide structure but has site-specific features, these porous pavement and small scale rainwater collection and infiltration system in buildings and homes might be effective in filling locally existing fracture zones.

B. Prevention and Minimization of the Adverse Effects of Water and Land Uses on Water Resources

While to acquire additional water supply through engineering measures is one way to solve water shortage in the Eno River Basin, to enhance availability of a limited amount of water resource through the practice of more efficient water use is another way to attain the same purpose. It is also important to prevent or minimize additional deterioration of surface and groundwater resources from future land and water uses within the river basin. Since land use change associated with urban development has a significant effect on the water resources in a watershed, for the communities within the Eno River Basin which have begun experiencing urban growth, it is necessary to prevent or minimize the impact of urbanization on water resources.

Enhancement of the Availability of Water Resource

Two major types of water use within the Eno River Basin are irrigation and public water supplies. No specific management plan has been implemented to control withdrawal of surface water and groundwater for irrigation in the Eno River Basin. Nor has the provision of the Impounded Water Act which requires maintenance of 7Q10 flows downstream of surface impoundments been fully applied to these impoundments. Although the amount of water used by each irrigation may be negligent, because of their location within the Eno River's headwater area and their water use patterns which substantially increase during dry periods, the aggregate use of water by these irrigations may have significantly affected the river's streamflows. It is reasonable and necessary to focus on the water use of these irrigations to accomplish efficient use of limited water resources in the river basin.

To make an accurate inventory of these irrigations in terms of their storage capacity, the amount of withdrawal and general water use patterns in wet and dry seasons is first needed in order to assess the effect on the streamflows of the water uses attributable to these irrigations. The Water Use Act may provide effective measures to control water uses by irrigators in order to prevent excessive water withdrawal during dry periods. However, it may be more effective and efficient on reducing excessive water withdrawals during dry periods to apply technical assistance by state and local governments in the management of irrigation ponds and pumping as well as in actual water uses by irrigators, for irrigational water use varies seasonally, and the availability of sufficient water for limited time is very critical for growing agricultural products. Adopting of regulations simply prohibiting water withdrawal by irrigators may result in damaging their economic activities.

Public water systems within the Eno River Basin also seem to have some room for improvement as to their water management. Several problems have been raised on the operation and management of these water systems. They include interbasin water transfer by Orange Alamance Water System; large consumptive use of water by Hillsborough; and considerable water loss attributed to leakage in their distribution systems. To solve these problems seems to be the first step to enhance the availability of water resource in the Eno River basin. It may be difficult to solve the problem of interbasin water transfer because political and legal as well as engineering problems are involved in this issue. However, if downstream communities would suffer restrictions on their water use because of lack of water supply caused by water transfer by upstream a community, this problem should be focused upon, and reasonable agreement should be attained between upstream and downstream communities. Reduction in water loss through accurate metering, leak detection, and water loss audit could aid in conserving existing supplies and making a water system more economical and efficient (NRCD, 1987).

Water use patterns of each customer should also be modified to conserve water and to use it more efficiently. Since public water supply shares a large part of the water supply of the Eno River, aggregate reduction in each residential customer's water use would increase the availability of the river's water resource. Further, in terms of overall urban water supply efficiency, a reduction in peak use may result in lower water costs and a diminished need of water supply and treatment capacity. Berk et al. (1981) strongly recommends the application of a proper price system which would reflect marginal cost of the water resource in order to successfully modify each customer's water use pattern. This approach might work effectively for the customers in the Hillsborough and Orange Alamance Water Systems. Because the water rate charge of these public water systems is either a flat rate or decreases as consumption increases, these rate structures provide little incentive for the conservation of water during normal conditions, and more importantly, during periods of scarcity (NRCD, 1987). Also, water connection fees for both water systems are unreasonably low; these fees do not even recover the unit cost of constructing new facilities to supply raw and finished water for new users (NRCD, 1987). According to the marginal cost theory, it follows that too much water is consumed in the Eno River Basin. In order to prevent excessive water use as well as to run the water system in economically sound condition, the water rates of these water systems should be revised and raised.

Plumbing and building code changes can result in future reductions in domestic and commercial water use, with the size of these reductions dependent on the percentage of new construction (Morandi and Lazarus, 1982). Since these measures do not usually cause the controversy associated with water pricing increases and pricing structure change, they are more easily adopted.

Adoption of water-saving devices through education, or even free distribution of those devices to residential consumers, is effective for water conservation. Effectiveness of these devices depends on the percentage of households that actually install the devices and do not have any subsequent problems which either render the devices less useful or cause residents to remove them (Morandi and Lazarus, 1982). Berk et al. (1981) note that adoption of proper water rate would also let consumers be more highly motivated to introduce water-saving technology and use water more efficiently.

Application of economic incentives for voluntary water-saving measures and techniques to new homes is a possible measure to restrain increasing water use. Agthe et al. (1986) reported the implementation of a voluntary water development fee program to encourage new home builders and owners to adopt water saving desert landscaping.

An educational campaign is an important measure for water resource protection and conservation. Lamb and Lovrich (1987) note a consistent positive effect attributable to being well informed in the protection of water resources. Public education can provide customers with accurate information on the existing water resource situation in a watershed and can increase their awareness on water conservation. Berk et al. (1981) point out the importance of social-psychological factors on conducting effective conservation programs. These conservation programs will be more effective:

1) when consumers can be convinced that a genuine shortage exists, and that it constitutes a problem for a group(s) with which consumers identify;

2) when appeals are made to moral principles, stressing the need to make a "fair" contribution to group welfare;

3) when consumers are convinced that their individual efforts can make a difference for collective welfare;

4) when consumers can be convinced that the individual costs and inconveniences stemming from their conservation efforts will not be great (assuming it is true); and

5) when consumers are convinced that all members of the relevant group(s) are also making sincere efforts to conserve (Berk et al., 1981).

In order to provide customers with these psychological influences and thus to conduct effectively conservation programs, public education is necessary. People can also obtain accurate information on various water-conservation techniques and measures through education.

Minimization of the Effects of Urban Growth on Surface Waters

It has been noted that urban development significantly changes flow characteristics and the quality of stream water, causing adverse effects on public health and aquatic environment. As the communities within the Eno River Basin experience urban development, similar problems are expected to take place. However, urbanization of these communities might have much more severe effects on the Eno River because of the river's original flow characteristics which exhibit generally low flows around the year and large seasonal flow fluctuations.

In addition to engineering approaches to improve existing water resource situation and administrative measures to deal with present water users, it is necessary to handle possible problems which occur as a result of urban development within the Eno River Basin. First, it is important to understand the profile of the watershed in terms of its physical characteristics and human activities taking place within the watershed. Through the accurate understanding of the physical profile of the watershed, one can distinguish areas which are suitable for or tolerant to urban development from other areas which are more sensitive in terms of environmental and/or water resources protection. Recognizing the geographical distributions and intensities of different types of human activities and population within a watershed is useful for estimating the impacts of human activities on water resources. For example, in determining eventual water consumption, the distribution, not the size, of the population and the type of the industry, not the increase in employment, may be more important (Romm, 1977).

After determining where growth should occur based on the physical profile and existing land uses within a watershed, comprehensive land use controls are required to define the course of events in the watershed, especially on the way that land and waterways are used. The Water Use Act, while it provides measures to regulate existing water uses within the watershed, may not be able to cover those emerging problems caused by urban growth; the Act may not provide adequate control over future water uses or those activities which do not directly withdraw water from the river but may affect the quality and quantity of the stream flows.

Miller et al. (1981) suggest two basic approaches for the management of urbanized watershed: one is control of the location of land uses within a watershed and the other is site-level design requirements. A major purpose of locational measures is to prevent the disturbance of land which is environmentally sensitive and/or important for water quality protection. Thus, these locational measures protect areas where growth would occur by providing services and land use controls which would enable these areas to develop without adversely affecting the surface and ground water resources. At the same time, these measures foster development in the areas where disturbance of the land does not have significant effects on the stream or the environment (Miller et al., 1981).

One of the first actions taken is to impose moratoriums to slow or stop new development in the watershed or part of the watershed until a planning process has been completed and a scheme of permanent controls has been devised and implemented (Burby et al., 1983). One major purpose of moratoriums is to provide communities time to undertake a technical planning process and learn from desirable public debate about watershed management and to formulate and implement land use control measures (Miller et al., 1981). Moratoriums are also effective to prevent development that will be contrary to the eventual watershed management program from taking place before the program becomes operational (Burby et al., 1983).

Zoning is used to implement comprehensive land use plans. Zoning divides a political jurisdiction into districts or zones, each of which places different restrictions, such as on the type of land use allowed there and the density of development. By controlling and regulating the use of private property, zoning seeks to coordinate private and public development and to avoid undesirable side effects of development by separating incompatible uses, grouping compatible uses and maintaining adequate standards for individual uses (Miller et al., 1981). For example, locations of large water users and major pollution dischargers can be regulated by zoning to assign land uses to sites which have the most suitable environmental characteristics for those uses so that adverse environmental effects will be minimized.

Another location-control measure is capital investment. This is an indirect method of land use control which schedules new roads, water and sewer lines and other facilities in locations where development will not degrade water quality or the environment. Capital investment also assures that public services do not become overburdened by too much growth (Miller et al., 1981; Burby et al., 1983).

Site-level measures are useful for taking care of those problems that could not be eliminated using land use controls. These problems include treatment of point source pollution, storm water/erosion control, and agricultural management. In watersheds which are experiencing rapid urban growth, storm water/erosion control seems the most relevant; urban development within a watershed results in increased impervious surface areas and discharge of vast amounts of sediment load from construction sites into streams. Therefore, storm water/erosion control should be focused on controlling runoff from streets, parking lots, and other impervious areas and on minimizing erosion from construction activities.

C. Acquisition and Protection of Streamflow for Instream Needs

It has been noted that the Water Use Act might be able to protect instream flows through the provisions of rule making and water use permit requirements. The Impounded Water Act, the Dam Safety Law and the North Carolina Clean Water Act provide statutory bases for the EMC to set aside the 7Q10 flows in streams in the State. However, this 7Q10 flow level is merely a statistically-derived value and does not reflect the actual flows required for the protection of instream values. Therefore, based on these statutory provisions alone, the EMC may not be able to protect and maintain enough flows in the State's streams. In addition to these statutes, three legal measures might support allowing the EMC to obtain and protect sufficient streamflows to attain instream flow protection. They are the common law riparian doctrine, the public trust doctrine, and the environmental provision in the State Constitution.

The Common Law Riparian Doctrine

The common law riparian doctrine states that "a riparian proprietor is entitled to the natural flow of a stream running through or along his land in its accustomed channel, undiminished in quantity and impaired in quality, except as may be occasioned by the reasonable use of the water by other proprietors" (Smith v. Town of Morganton, 1924). Therefore, the riparian doctrine is in principle a legal guarantee that sufficient water will remain in a stream for all reasonable uses, including flows necessary to meet instream flow purposes (Morandi and Lazarus, 1982).

The concept of reasonable use, as a means of protecting instream uses in private litigations, may emerge in instances where diminutions of the flow would result in injury to the rights of riparians (Dixon and Cox, 1985). Under North Carolina law a riparian landowner has a right to the recreational and scenic use and enjoyment of a stream as well as to fishing in the stream, all of which may be impaired by diminishing flows (Springer v. Joseph Schlitz Brewing Company, 1975). However, in order to claim these rights in a litigation, a plaintiff needs to prove that a defendant's use of water has caused actual injury to the plaintiff's riparian rights. The importance of proving actual injury is illustrated by the case of Dunlap v. Carolina Power & Light Co. (1938). The plaintiff, a downstream riparian owner, was unable to prove that lowered streamflows resulting from upstream impoundment by the defendant were injurious to his riparian rights. Therefore, the court ruled that the plaintiff's claim to natural levels of flow unreasonable. In addition, it is important to note that such rights do not extend to the entire natural flow of a river but to the level below which actual injury would occur to the right of downstream riparians.

Protection of property values provides another approach through which the principles of reasonable use may be invoked to preserve levels of flow that sustain instream needs (Dixon and Cox, 1985). In those cases where investment in private property is made in reliance upon a natural or minimum level of streamflow, the riparian owner may be held to have a right to flows sufficient to protect such investment. However, as in the case of other damage to riparian rights, a claimant must be able to show actual injury resulting from lowered flows (Dixon and Cox, 1985). In Dunlap v. Carolina Power & Light Co., the court noted that if the lower landowner's property was being damaged as a result of actions by an upstream user, then the upstream user is indebted to the downstream user for the reasonable value of the land taken, or the damage so done, without regard to the reasonableness of the use it is making of the stream.

Physical damage caused by artificial manipulation of stream flow regimes constitutes only one aspect of injury to property value that may be prohibited by means of common law principles. Aesthetic enjoyment and recreational pleasure are also values inherent in the maintenance of an acceptable level of streamflow, and where investments are made based upon such values, the theory of reasonable use dictates that these rights be protected (Dixon and Cox, 1985). On the Eno River canoe and kayak classes are taught by private outfitters and a canoe club (NRCD, 1987). Low flows may cause cancellation of clinics and these outfitters could realize an economic loss. Since the court appears to regard property values as paramount to the right of the upstream proprietor to make reasonable use of the water, more flows could be maintained by claiming the protection of property values of riparian owners (Dunlap V. Carolina Power & Light Co., 1938).

The Water Use Act has a provision to protect the rights of riparian landowners (G.S.143-215.22.). Under this provision the EMC may be able to adopt some measures to protect flow levels in a stream below which injury to the riparian rights or the investments to their property would occur. It is reasonably anticipated that these flow levels are higher than those of statistical 7Q10 flows. However, it is important to note that instream flow protection under the reasonable use theory is not being given to a natural or "normal level" of water but rather to a level below which unreasonable interference would be inflicted on riparian proprietors. This suggests that the riparian doctrine's reasonable use concept cannot by relied upon to protect natural flows or instream values where actual injury to the rights of riparian owners is nonexistent or difficult to prove (Dixon and Cox, 1985).

Public Trust Doctrine: Public Right to Navigate in Navigable Waters

The essence of the public trust is that the public has rights to navigation and fishing in all navigable waters located within a state, and that it is the duty of the state to protect watercourses for public purposes. In North Carolina the public rights are defined as those rights held in trust by the State for the use and benefit of the people of the State in common (G.S.1- 45-1.). The North Carolina courts have long acknowledged the public right to navigate and fish in the navigable waters of the state and to have those waters kept free from obstructions (Lewis v. Keeling, 1854 and Davis v. Jerkins, 1858). Further, the General Assembly has expanded this public right so that it includes "the right to swim, hunt, ..., and enjoy all recreational activities in the watercourses of the State" (G.S.1-45-1.).

The public trust doctrine is "more than an affirmation of state power to use public property for public purposes"; "[i]t is an affirmation of the duty of the state to protect the people's common heritage of streams, ..., surrendering that right of protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust" (Nat. Audubon Soc. v. Super. Ct. of Alpine Cty., 1983). Therefore, it might be possible to use the public trust doctrine as a basis for the state to challenge abuses of navigable waters and as a source of constitutional authority to justify legislation protecting navigable waters (Heath, 1978). Thus, through claiming this public right in navigable waters, it might be argued that it is public nuisance to divert water from navigable waters in such a quantity that results in an obstruction to navigation or other public activities in these navigable watercourses. Consequently, in order to prevent such public nuisances and to protect its rights in navigable waters, the state may be able to allocate flows to satisfy these rights. Further, it might be possible for the State to prohibit diversion of water from navigable waters where such withdrawal may result in obstruction of navigation and hindrance to the enjoyment of public rights.

Whether one can claim obstruction of navigation due to a specific action in a certain watercourse depends upon the test of navigability; the test takes into consideration the navigability in law and some other conditions in which a certain action is to be claimed as an obstruction of navigation. The North Carolina General Statutes provide one definition of navigability in the watercourses of the State: "'[n]avigable water' means all waters which are navigable in fact" (G.S.146-64(4)). However, this definition seems functionally useless because it makes no reference to the kind of craft, the seasons, and other important factors which determine navigability in a watercourse.

Existing court cases on obstruction of navigation in North Carolina provide more specific definitions of navigability in the State's watercourses. From the beginning the North Carolina courts did not rely on the common law rule of navigability, the ebb-and-flow test, for determining the navigability of watercourses in obstruction-of-navigation cases. In early cases, the courts adopted as a fact that the principle that a watercourse was navigable in fact by sea-vessels. For example, in 1859 State v. Glen held that any waters which are "wide enough and deep enough for the navigation of sea-vessels, are navigable water." However, Broadnax v. Baker (1886) held more broadly that any waters capable of floating boats used as instruments of commerce are navigable. In 1888 State v. Narrows Island Club took a position as similar to the Broadnax case, stating that "the waters navigable in fact are navigable in law, to that extent and for that purpose, publici juris." But the court also introduced "the capacity for substantial use" as the test of navigability of a particular body of waters. In this case the court claimed that if the land was covered by waters of sufficient depth for the passage of "skiffs, canoes, schooners, fishing boats, hunting boats and batter boats," the public had the right to use the water as a public highway although the title of the land beneath the water belonged to individuals; however, the court limited the purpose of using these waters to transportation, not extending to others such as fishing and hunting.

The purpose of navigation under the navigable-in-fact rule was expanded in 1901 when the court held that a watercourse which was used by the public for fishing and hunting, as well as passing and repassing in their boats, was navigable (State v. Baum, 1901). The court stated that "the public has the right to the unobstructed navigation as a public highway for all purposes of pleasure or profit, of all watercourses, whether tidal or inland, that are in their natural condition capable of such use...." It is important to note that the court recognized that the public have the right to navigate on those watercourses for pleasure purposes in their natural condition capable of such use if these watercourses have been "used by the public when unrestrained." However, three years later State v. Twiford (1904) adopted the most liberal test of all; "the capability of being used for purposes of trade and travel in the usual and ordinary modes is the test and not the extent and manner of such use." The court summarized its opinion by quoting the court opinion in Attorney General v. Woods (1871): "[i]f water is navigable for pleasure boating it must be regarded as navigable water though no craft has ever been put upon it for the purpose of trade or agriculture. The purpose of navigation is not the subject of inquiry, but the fact of the capacity of the water for use in navigation." Since no case has been reported on obstruction-of-navigation since State v. Twiford, the test of the navigability of a watercourse in North Carolina is whether the watercourse has the capacity for the use of navigation by any kind of vessel, without depending on the purpose of navigation, in its natural condition.

Whether diversion of flow from a navigable watercourse constitutes an obstruction of navigation is another issue to be considered. So far all of obstruction of navigation cases in North Carolina have dealt with constructing obstacles in a watercourse, such as bridges, fisheries, milldams and iron pipes, which literally obstructed the navigation in streams. There has been no case that artificial changes in the flow of a watercourse constituted obstruction of navigation in navigable waters in the State. Therefore, in North Carolina it is still not certain that such diversion of water from a navigable watercourse - which may obstruct navigation or prohibit the public's enjoyment of the flow in the watercourse - would be regarded as an obstruction of navigation. However, in other jurisdictions, the courts have held diversions of water as an obstruction of navigation. California has long held that diversion of flows from a navigable watercourse in such amount that destroys navigation and other public trust use in the watercourse may be enjoined as a public nuisance (People v. Russ, 1901). In a recent case the California court ruled that the public trust doctrine protects navigable waters from harm caused by diversion of nonnavigable tributaries (Nat. Audubon Soc. v. Super. Ct. of Alpine Cty., 1983). It would not be impossible for the North Carolina courts to hold that diversion of water from navigable watercourses is an obstruction of navigation in any appropriate case.

Along the Eno River a variety of activities take place; they include canoeing, kayaking, rafting, bathing, swimming, and fishing. Under the current navigability test, the Eno River is a navigable watercourse where the public has rights to enjoy water-based recreation as well as navigation of the stream. Therefore, the pubic trust doctrine might provide some support for the EMC to adopt rules under the Water Use Act to maintain sufficient flows to ensure these public rights.

Environmental Provision of the State Constitution

Although the environmental provision of the state constitution does not provide direct mechanisms of regulation or enforcement, it creates standards by which government action or inaction can be measured (Dixon and Cox, 1985). Since there is widespread agreement that a constitutional environmental declaration can set goals and provide guidelines for state agencies, these declarations could be considered a call for all state agencies to consider the impact of their decisions on the environment (Tobin, 1974). Therefore, minimum flow protection could become part of a constitutionally encouraged conservation effort where harm to instream values is considered damaging to the environment (Dixon and Cox, 1985).

North Carolina is one of those states that have adopted an Environmental "Bill of Rights." The Constitution of the State does not specifically state that the public has the right to a decent environment. But the Constitution clearly declares a general state policy "to conserve and protect its land and waters for the benefits of all its citizenry." To accomplish this policy the Constitution requires the State and local governments "to acquire and preserve park, recreational, and scenic areas, to control and limit the pollution of ... water...." This provision, like the public trust doctrine, might provide some support for allowing a state agency to adopt measures to protect streamflows of such levels as to provide the public with the opportunity of enjoying water-related recreation as well as to sufficiently assimilate or dilute discharged waste and maintain water quality.[1] However, it is uncertain that this environmental

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[1]. The Constitution states that it is a proper function for the State to preserve its lands and waters as a part of the common heritage of the State. The reference

provision of the State Constitution serves to define any specific level of flows to be maintained in the river because of the lack of a specific provision for protecting flows in streams in the State.

Riparian doctrine, public trust doctrine, and the environmental provision of the State Constitution seem to provide some support for the EMC to justify its actions to protect flows in streams of the State. The State Constitution could allow the agency to take actions for protecting streamflows as one of the measures for environmental protection. Riparian doctrine and public trust doctrine might also authorize the EMC to set specific flow levels that would protect the rights of riparian landowners, and public rights to enjoy streamflows and to navigate, respectively. Since the Water Use Act contains a provision to protect riparian rights, even if the EMC did not apply public trust doctrine, riparian doctrine could be available for stream flow protection under the Act.

D. Changing the Perception about Streamflow Protecton

Thus far the possibility to protect instream flows of the Eno River has been discussed. With the help of

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of "common heritage " overtones of the public trust concept. In fact, its early version of the bill that became the Environmental Bill of Rights referred to the public trust (Heath, 1985b).

engineering approaches to enhance availability of water resource within the river basin, legal and administrative measures may be able to protect streamflows in the Eno River. However, without the support of citizens as well as community leaders and developers, these mechanisms may not successfully attain their objective of protecting the Eno River's streamflows. This is particularly true where these programs are perceived by the community as not meeting or hampering its interests. Therefore, it is strongly recommended that, before adopting conventional techniques to regulate or restrict people's water and land use activities, some efforts should be made in order to change the negative view about streamflow protection. Then, appropriate government measures should be applied to protect streamflows and prevent their further deterioration.

In most instances, the idea of streamflow protection has been neglected or, if recognized, it has been perceived as inevitably conflicting with the interests of water users and as obstructing or restricting the economic growth of a community. This is mainly due to a perception that streamflow protection would serve for only a limited number of people who are interested in instream values; and that most of these instream values are of recreational or aesthetic characteristics which, in many cases, do not produce any economic benefits to the community. This perception leads to an idea that streamflow protection is not for the public purpose and should be inferior to other traditional water uses which are directly connected to people's economic activities. As long as this negative image of streamflow protection predominates in the community, efforts to protect streamflows neither are not appreciated nor may be able to attain their intended objectives.

Conflict occurs when people believe that they have mutually incompatible goals (Boulding, 1963). It is necessary to provide people an opportunity to reconsider the idea of streamflow protection and recognize that this idea may not be incompatible with their interests and that it could rather be beneficial or even indispensable to the community's economic development and quality of life. One possible approach is to integrate the protection and development of a riverine environment into a general development of a community as one of its major features. Thus, regarded as a center of the community development, the stream could become the main focus of commercial and tourist attraction as well as the aesthetic and recreational fabric of urban life. For a short-term perspective, retaining streamflows in a river without using it seems like a waste of the water resource and against community development; for a long-term perspective, however, preserving the river's environment would benefit the more harmonized development of the community. San Antonio's (Texas) Paseo del Rivor, "River Walk," is one of those successful cases where the community integrated a river corridor into the aesthetic and recreational fabric of urban life as well as the commercial center of the community (Lamb and Lovrich, 1987). There is a substantial literature of other similar cases as well.

This idea of integrating the protection and development of a river corridor into general development of a community merits consideration by the Town of Hillsborough through which the Eno River runs. Fortunately, the Eno River State Park still maintains plenty of undeveloped natural resources along the river; the Park can serve as a green buffer against continued urban sprawl in the RTP area, providing recreational amenities for the people of the State. Hillsborough, which is located at what was once the juncture of the Indian Trading Path, the high road through the Piedmont, and the Eno River, is rich in historic resources (Nygard, 1973). More than 100 late eighteenth and early nineteenth century buildings have been preserved and/or restored in and around the town (Hillsborough Historic Society, 1960). If Hillsborough could integrate these natural and recreational resources of the Eno River and the town's historic values into its development plan, the town could become a very unique and attractive town community many residential centers around the RTP. Since the town is located at the junction of I-85 and I-40, it is strongly recommended that the town utilizes its locational advantage and features its tourist and aesthetic attraction as well as its commercial and residential opportunity. Hillsborough's current concerns with water resources are to obtain adequate water supply to meet public health needs and to support the anticipated growth in the town in the future as well as to preserve adequate flow in the Eno River to protect ecological system and to meet certain water quality standards (DWR, 1987). In order to meet these interests on public health and environmental protection, sufficient flows should be maintained in the Eno River; however, the water resource of the Eno River needs to be utilized for the development of the town. These conflicting interests could best be resolved by integrating streamflow protection into the town's development scheme rather than considering them as separate issues. If the people in the town would consider that the flow protection of the Eno River would benefit the town's economic activity and its quality of life, legal and administrative as well as engineering measures to protect and maintain streamflow in the river could more easily be accepted by the community.

E. Planning and Environmental Regulation Programs for Protecting Streamflow in the Eno River

For the actual protection of streamflows, two approaches are available. One is planning measures to protect critical areas of a watershed, or to ameliorate their impaired condition so that these areas can provide stable or increased water into a stream. The other is regulatory measures to protect streamflow by regulating human activities which may significantly affect the quantity and/or quality of streamflow. One proposal has been to protect environmentally critical areas through a combination of land use planning and environmental protection techniques. This idea also seems appropriate for protecting streamflows in the Eno River.

Because of rapid progress of urban development within the Eno River Basin, planning measures are necessary to minimize unreasonable destruction of the environment which results in decreased availability of water resources in the basin. Planning is also important for increasing the availability of water resources and enhancing its maximized use within the basin. Further, in order to improve the environment of the Eno River and its surrounding area, planning techniques are absolutely needed.

In theory, almost everything sought by environmentalists could be achieved through land use planning and regulation. In practice, however, this has not happened and is unlikely happen on any significant scale. Heath (1985c) raises several reasons for this:

1) Land use planning in practice is still largely an implement of commercial development, not of environmental amenities.
2) Truly comprehensive land use planning, which has territorial jurisdiction over undeveloped area where environmental protection is best able to achieve its objective, has not yet existed.
3) Land use regulation and planning are especially vulnerable to city-county jurisdictional strife in transitional areas where environmental objectives can be achieved before sunk investments make economical and effective protection that much harder.
4) The pool of technical experts in environmental specialties is not large enough to staff all the local planning organization at prices they are willing and able to pay.

For all these reasons, environmental protection has not been effectively achieved through planning programs.

In addition, it has become extremely difficult for local governments to adopt strict land use control measures because of the recent decision of the United States Supreme Court. In First English Evangelical Lutheran Church of Glendale v. County of Los Angeles case, the Court held that the remedy of monetary damages is available in cases where government regulations amount to a "temporary taking" of property. Ordinances which deprive the owner of all use of property have always been subject to invalidation as an unconstitutional taking without just compensation. The government unit then has the choice of repealing the regulation or revising it to make it constitutional, or condemning the property with compensation to the owner. The significance of this Supreme Court decision is that it requires the government to compensate the owner for the period during which the unconstitutional ordinance is in effect (Hankins, 1987). Thus, private landowners will be entitled to an award of compensatory damages for the interim period if they can establish a taking in the constitutional sense.

Hankins (1987) identifies the following land use controls as ones that should be reconsidered: the "extortionary" type (such as those requiring dedication of greenways or park land before development approval will be given); zoning of property for open space or conservation without compensation or solid public safety justification; and moratorium ordinances which impose a complete ban on development or construction while a study is underway. Because of the Supreme Court decision in the Lutheran Church case, local governments cannot easily adopt these land use control measures. Since they are very effective in terms of protecting undeveloped area from uncontrolled development, where these measures are not available some other approaches need to take their place in order to achieve the intended objectives.

Another concern is that in protecting streamflow, planning techniques by themselves cannot provide measures which directly protect and maintain flows in a stream. A major objective of streamflow protection is to preserve certain flows in a stream for instream, or passive, water users who utilize the water without taking it out of the stream. Given the physical condition of the stream and meteorological factors, quantity and quality of the streamflow are entirely determined by out-of-stream, or active, users who withdraw the water from the stream and/or discharge wastes there. While some types of land uses which significantly affect streamflows can be regulated by planning measures, they cannot define specific streamflow levels to be sustained or regulate water uses. If there are no measures to ensure maintaining certain flows in a stream and, for this purpose, to regulate active water uses, streamflows may be depleted and water quality may be severely deteriorated. Therefore, in order to protect streamflows actively, regulations are necessary.

Present water supply and demand in the Eno River Basin clearly demonstrate the necessity of adopting regulatory measures against current water users. These regulations are needed to eliminate excessive water uses and to facilitate more effective use of the limited amount of water resources within the river basin.

Both planning and regulatory approaches are necessary in order to protect streamflows in the Eno River, because both measures play different roles which are indispensable for protecting streamflow. Since existing water supply is not enough to meet its demand including water for streamflow protection under current statutes, planning should provide land use control measures to deal with urban development in order to minimize its adverse effects on water resources as well as to prevent additional decrease in water availability. Also, engineering measures are essential for ameliorating flow fluctuation in the Eno River and for increasing water availability in the basin. Simultaneously, programs to reduce inefficient water uses and water losses should be adopted through planning and regulatory approaches. Finally, measures which define the minimum streamflow levels and regulate water uses should be adopted.

CONCLUSION

In order to protect streamflows in the Eno River, five approaches are proposed:

(1) increase flows in the Eno River during dry periods;

(2) enhance availability of water resources;

(3) prevent or reduce adverse effects on water resources associated with urban development in the watershed;

(4) legally protect and maintain sufficient flows in the Eno River; and

(5) increase public approval and support for streamflow protection.

The main issue in the protection of streamflows in the Eno River is, first, to acquire water resource for satisfying the demand of various uses including streamflow protection. It is very difficult, if not impossible, to maintain sufficient streamflow in the river without meeting the demand of water for other purposes. Therefore, engineering approaches should be applied to increase streamflows in the Eno River as well as to satisfy increasing water demand. One possible objective of these measures is to even out large seasonal fluctuations in the river's streamflows. Storing excess water during wet seasons in new surface reservoirs and groundwater storage systems might be possible. Regional cooperation on water resource management may also provide some solutions to this problem.

Second, enhancement of the availability of water through water use control needs to be emphasized. Measures should be taken to regulate or control water uses for irrigation within the headwater area of the Eno River and public water systems along the river. For irrigation, in addition to regulations to prevent excessive water withdrawal, technological assistance in the management and operation of irrigation ponds and pumping wells as well as actual water usage seem effective for reducing water use without adversely affecting users' economic activities. For public water systems, existing problems such as large water loss in their distribution systems and underpriced water rates should first be resolved; then, the more difficult problems such as interbasin water transfer and large consumptive use of water through septic tank use should be addressed. To change customers' behavior on water use through education, application of economic incentives and water saving devices is also important. Especially, water rates for these water systems need to be assessed and modified for the purposes of stimulating water conservation among customers as well as managing these water systems in economically sound condition.

Third, urban development taking place within the Eno River basin should be controlled. Urban development significantly changes flow characteristics and deteriorates stream water quality, causing adverse effects on public health and on the aquatic environment. However, urbanization within the Eno River Basin might have much more severe effects on the river because of its original flow characteristics exhibiting generally low flows around the year and large seasonal flow fluctuations. It is necessary to handle possible problems which occur as a result of urbanization within the basin. First, the profile of the Eno River watershed should be understood in terms of its physical characteristics and human activities taking place within the watershed; this enables us to distinguish ares suitable for or tolerant to urban development from other areas sensitive in terms of environmental and/or water resources protection as well as to estimate the impacts of human activities on water resources within the watershed. Finally, regulatory measures for land use control and site-level design requirements should be applied to minimize the effects of each human activity on water resources.

Fourth, legal or administrative measures should be applied to acquire and protect the water for streamflows. The State Water Use Act might be applied to protect adequate flows in the Eno River if the EMC could apply the riparian doctrine, the public trust doctrine and/or the environmental provision in the State Constitution as legal bases for the Commission's action to protect and maintain flows in the Eno River.

Finally, people's negative perceptions of flow protection must be modified. Without the affirmative support from the public as well as community leaders and developers, engineering and administrative measures may not successfully protect flows in the Eno River. While engineering and regulatory approaches are important to ensure that ample flows are actually running in the river, the social-psychological factor would determine the success of the others to accomplish their intended objectives. Water resources planning and management has long adopted engineering solutions to given problems. As limited availability of water resources has become apparent, legal and administrative measures were introduced to protect the quality and quantity of the streamflows as well as to resolve conflicts among users. However, the present situation of increasing scarcity of water resources is expected to become severe as population and economic activities grow within a watershed. Further, without taking any precautionary measures, urbanization within a watershed would substantially affect the water resources and the environment within the watershed. Under this strained situation on water resources, simply putting additional restrictions on users' activities would merely increase frustration and conflicts among those regulated. What is needed is to change the perspectives of those who are regulating as well as regulated on the issue and to search for a better solution to attain the intended objectives. The idea of streamflow protection has been regarded as serving only for recreational and aesthetic purposes and having no relation to beneficial use of water.

One showing recommendation of this paper is to integrate the protection of streamflows into the Hillsborough community development plan. The purpose of the recommendation is to define the protection of the river environment as a main focus of the community's tourist and commercial attraction as well as a symbol of the quality of life of the community. This idea merits consideration by the Town of Hillsborough which is rich in both historic resources and the natural and recreational opportunities provided by the Eno River running through the town. If Hillsborough could integrate these natural, recreational, and historic resources into its economic development plan, the town would be one of the distinctively attractive communities in the RTP area.

If changing public perception about streamflow protection is successful, measures to protect streamflow will more easily attain their mission. Planning measures are essential in order to ameliorate flow fluctuation, to control urban development and to enhance water availability. Only after adopting these planning measures will water be available for streamflow protection in the Eno River. Then, regulatory approaches are required in order to protect streamflows, through specifying minimum flow levels which would satisfy most of instream uses, and through regulating water uses so that it is ensured that water which is once acquired for streamflow protection can be protected.

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