ABSTRACT

WENDY FUSCOE. Regional Water Mnaagement.
(Under the direction of DR. DANIEL A. OKUN)

A major problem associated with water supply systems in the United States in water quality, especially for small water supplies. The establishment of regional water authorities in England and Wales has clearly shown the advantages of regional water management; they provide water of good quality efficiently and economically.

In North Carolina, there are almost 3,000 public water supply systems and only 2% of these systems serve over 10,000 people. Most of the systems in the state (79%) serve fewer than 500 people. The North Carolina Department of Natural Resources has reported that quite afew systems in North Carolina are deficient in quantity, quality and/or operation and maintenance. The report examines regional water management in one county to assess the possibility of regionalization in North Carolina.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

Early in 1984, representatives of water utilities, government and academia were asked what they thought were the most critical water issues the nation will face five years from now (Malcolm Pirnie, Inc., 1984). Over half of the respondents placed water quality issues at the top of their list; a majority believing the most severe problems existed with ground water supplies. The ability to provide an adequate supply to meet future demands, and the necessity of restructuring water financing were also cited as major issues. Surprisingly, enough participants agreed that small water systems were a major problem, that this issue was ranked third in degree of importance. The overall quality of operations and maintenance of small systems (defined as serving fewer than 10,000 people) was rated "inadequate" by 66% of the panel and "poor" by many. The report stated that "...almost all violations of the Safe Drinking Water Act are in small systems; about half do not comply with monitoring requirements, leaving many customers with potentially unsatisfactory drinking water."

There are several reasons for the poor performance of small systems. Often a lack of finances prohibits small communities from hiring a professional staff, or investing in the necessary equipment. But even if small communities could employ a full-time staff and incorporate state-of-the-art technology, it would be an inefficient use of skilled personnel, of capital investment, and of water (Street, 1966). The cost to the consumer would be high. Many respondents to the survey saw regionalization as a way to provide safe drinking water at a reasonable cost to everyone, even those in small communitites.

A special regionalization committee formed within AWWA defined regionalization (AWWA Committee Report, 1979) as:

"Regionalization of a water system is (1) a creation of an appropriate management or contractual administrative organization, or (2) a coordinated physical system plan of two or more community water systems in a geographical area for the purpose of utilizing common resources and facilities to the optimum advantage in planning, designing, constructing, operating and maintaining water supply systems that meet current minimum standards."

The committee cited four major benefits of a regional system:

1) Improved operation and maintenance
2) The ability to optimize the planning of water supply systems
3) A larger service area for the distribution of costs
4) Fewer systems to be monitored for compliance with water quality standards

The characteristic most frequently cited as a benefit of regionalization is the economy of scale associated with water supply systems.

Improved water quality may result from regionalization. Table 1 is the result of a 1969 Community Water Supply Survey (McCabe, 1970). The Bureau of Water Hygiene of the U.S. Public Health Service (USPH) wanted to determine if the American consumer's drinking water met USPH drinking water standards. These standards then applied only to interstate carriers and some states. A major conclusion of the study was that small systems (500 or fewer people served) had more water quality problems and facility deficiencies than large ones. The

Table 1

SUMMARY OF RESULTS OF COMMUNITY WATER SUPPLY SURVEY BY CATEGORY AS A PERCENTAGE

Item	Number of Systems	500 or less 446	500-100,000 501	Greater than 100,000 22	All Populations 969
Water quality evaluation	Met drinking water standards	50	67	73	59
	Exceeded recommended limits	26	22	27	25
	Exceeded mandatory limits	24	11	0	16
	Survey population in each group in thousands	88	4,552	14,463	18,203
Facility deficiencies	No major deficiencies	39	47	64	44
	some major deficiencies	61	53	36	56
Bacterio-logical survillenace	Met criteria	4	15	36	10
	Did not meet criteria	95	85	64	90

SOURCE: McCabe, E.J., et al., Survey of Community Water Supply Systems, JAWWA, 1970 principal investigators recommended merging the smaller systems with larger ones where institutional arrangements permitted.

The federal government is giving more of the responsibility for providing good quality water to the states and local governments. Federal funding for community water supply water projects has been falling steadily since 1978 (Snyder, 1984), with Farmers Home Administration (FmHA) tightening eligibility requirements for the grant program and raising interest rates for the loan program.

Unfortunately, the states do not appear to be interested in funding water projects. According to a 1982 survey (Snyder, 1984), over half of the states provide no financial assistance to local governments for funding water projects (Table 2).

Table 2 Number of States Providing Assistance to Local Governments for the Development of Water Supplies and Wastewater Treatment Facilities

	Grants & Loans	Grants	Loans	No Assistance
Water Supply	10	8	6	26
Wastewater Treatment	0	32	7	11

SOURCE: Snyder, 1984

With less federal money available and a minimum of state involvement, local communities may be forced to work together to provide water service, including both adequate quality and reliable, sufficient quantity. The advantages of larger water projects are numerous: higher quality personnel, more efficient development of water resources generally resulting in higher quality water, and a larger revenue base. Although many states do not provide any financial assistance, according to an ASCE survey, 68% of the states have policies favoring regionalization (Bell, 1976).

2. REGIONALIZATION IN NORTH CAROLINA

2.1 Size and Problems of North Carolina Water Systems

As of January 1985, there were 2,786 public community water supply systems in North Carolina. Figure 1 illustrates the size distribution of the systems in the state, with 98% of the systems serving under 10,000 people. These systems serve 38% of the total population. Figure 1 classifies systems according to source; groundwater or surface water. The 90% of the systems using groundwater serve only 29% of the population. Systems serving over 10,000 people using surface water serve over one-half of the population. Between February 1984 and February 1985, 128 systems had persistent violations (EPA defines persistent as 4 or more violations). All except 6 of these were water systems serving fewer than 500 persons.

The North Carolina Department of Natural Resources (NCDNRCD, 1978) stated that "quite a few" systems in NC were deficient in one or more of the following areas:

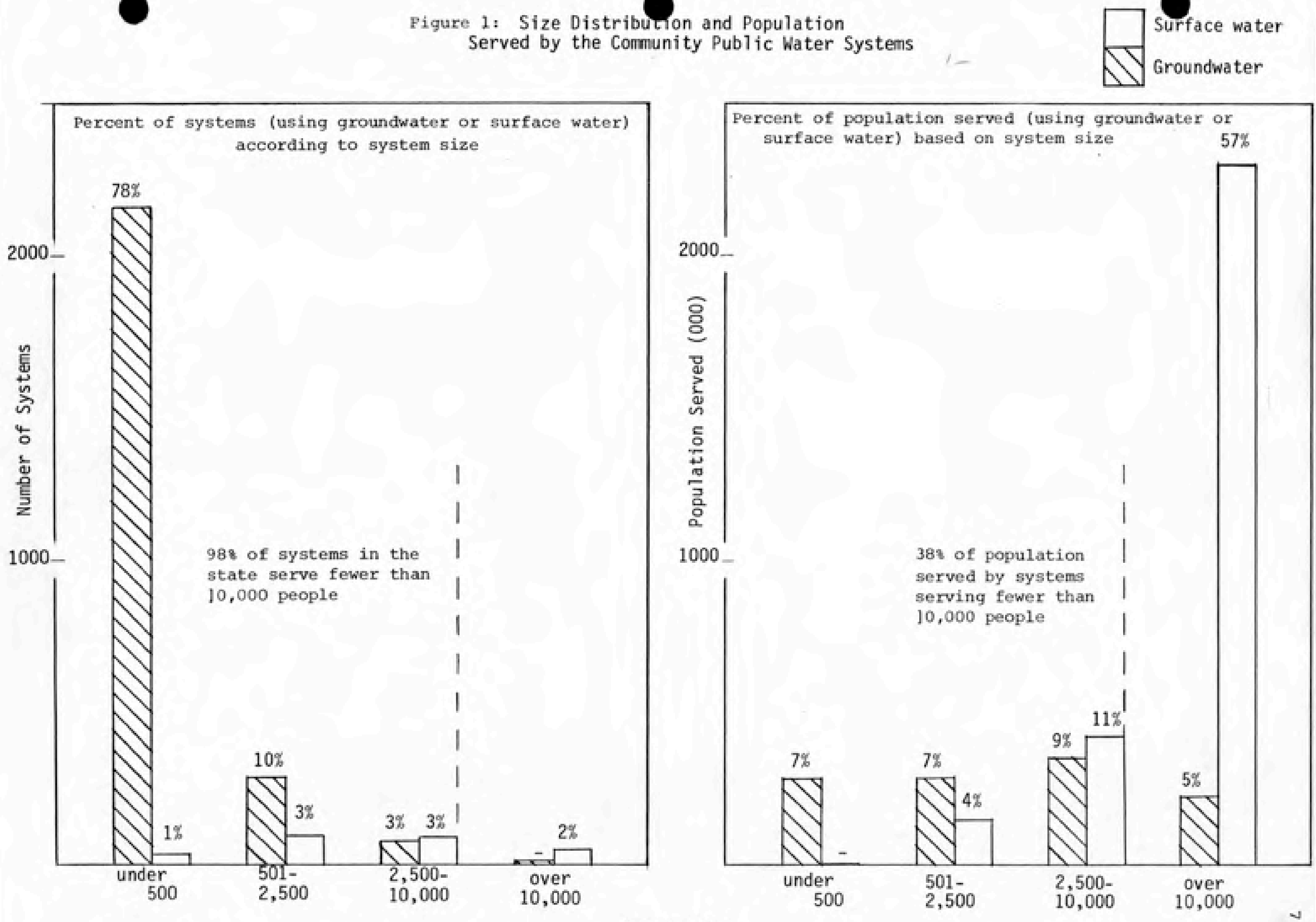
* quantity of source
* quality of source
* treatment and distribution system adequacy and maintenance
* system monitoring

For convenience, the last two categories are grouped together under the heading of system operation and maintenance.

2.1.1 Quantity of Sources

Some public water systems in NC do not have an adequate supply of water, usually because of inadequate long range planning. An example is the current situation facing Dare County. Located on the NC coast, Dare County encouraged

Figure 1: Size Distribution and Population Served by the Community Public Water Systems



SOURCE: N.C. Department of Human Resources development. In the past years, the Towns of Nags Head and Kill Devil Hill each used a water source known locally as Fresh Pond, each town having its own treatment plant. Use of this pond was suspended in 1980 when the county water system began pumping water not only to Nags Head and Kill Devil Hills, but several other communities as well. The pond has since been reactivated to use as an additional source, but the county can not expand its system. All available water is earmarked for current residents. The county is currently under contract with an engineering firm to sink wells at Kill Devil Hills and to analyze the quantity (and quality) of water available. The current plan is to build a desalination plant which would treat the water found in the test wells. Desalination is expensive. Other examples appear in the local media almost daily during most summers.

2.1.2 Quality of Source

The 10% of the public water supplies using surface water serve a majority of the population, making contamination of surface waters a concern. In many cases, sources are contaminated by municipal and industrial wastewaters, storm run-off or other pollution. Alexander County, which uses the South Yadkin River as its source, experiences problems of high turbidity, run-off debris, and difficulty in treating the water up to 40% of the operating time.

During low flow periods, wastewaters discharged to rivers are less diluted. The state Division of Environmental Management estimates that under low flow conditions, the Haw

River contains 96% effluent (Binata, 1986). In 1981, DEM reported 39 of 93 permitted dischargers into the Haw River in the regional division which includes Pittsboro, which takes water from the Haw, were not complying with State water quality regulations. These noncomplying dischargers coupled with urban and agricultural surface runoff affect water quality.

Accidental spills and leaching of contaminants are problems affecting groundwater supplies. About one-half of the state's households are not served by community sewer systems, depending on the traditional septic tank system or some other form of on-site wastewater disposal system to handle their sewage and other liquid wastes (Wicker, 1980). System failures and poor maintenance contribute to the contamination of groundwater. High iron concentrations appear to be a problem common to most groundwater supplies in North Carolina.

2.1.3 System Operation and Maintenance

The biggest problem facing small systems is poor operation. A 1977 survey showed that 48% of the systems surveyed in NC had inadequately trained operators (Gosnell, 1980). Inadequate design, lack of maintenance and poor operation all contribute to poor quality service. The majority of violations in NC are with systems failing to monitor water quality. Sometimes the only analysis is a once monthly bacteriological test and an annual chemical test. A report of bacteriological violators for the first quarter of 1985 show 283 systems in violation.

The sheer number of small systems makes it difficult to routinely inspect or even keep abreast of a system's O & M. The North Carolina Utilities Commission requires annual reports from every privately-owned public water supply system in the state. Last year they sent out over 100 letters requesting system owners to report to the commission office to explain delinquent reports. Only one owner showed up, but enforcing the submission of the other reports would require time and manpower the commission doesn't have. The large number of small systems precludes state engineers from making frequent inspections, and lack of day-to-day monitoring could permit the use of contaminated water for an extended of time (NCDNRCD, 1978).

2.2 Regionalization Programs in North Carolina

Whereas the English used legislative action to create their regional water authorities, North Carolina has used economic incentives to encourage the regionalization of water systems: the Regional Water Supply Planning Act of 1971 and the Clean Water Bond Act of 1977 (Okun, 1981). The funds available through these acts are administered by different agencies.

The Regional Water Supply Planning Act of 1971 was established under the control and direction of the Department of Administration. The objective of this act was "...to provide a framework for comprehensive planning of regional water supply systems, and for the orderly coordination of local actions relating to water supply, so as to make possible the most efficient use of water resources and to help realize economies of scale in water supply systems." A revolving account was set up such that the Department could make advances to units of government "...acting collectively or jointly as a regional water authority, for the purpose of meeting the cost of advance planning and engineering work necessary or desirable for the development of a comprehensive plan for a regional water supply system as defined in this Article." The revolving fund was designed so that the zero-interest loan would be paid back within six years or when construction of the regional system began. The money paid back would then be available to fund another project. Unfortunately, all available funding was committed to projects by 1974, and few communities paid back any money. No action was taken to make communities repay, and eventually the fund was depleted and not replenished by the legislature.

The Clean Water Bond Act of 1977 (initially started in 1971) is a state grant program providing financial aid for the construction of improvements to water and sewage systems within the state. A priority system is used to determine which projects are most worthy of funding. Those projects which are part of a regional system receive a higher priority for funding.

Both programs have assisted in creating several county-wide water systems, but success has been limited. According to Jon Arnold, project engineer with the Water Supply Grants Unit in the NC Division of Health Services, Department of Human Resources, another form of incentive is needed (Arnold, 1979). Currently, the Regional Water Supply Planning Act of 1971 is inactive, and the State grant program provides grants for capital construction but not for operation and manitenance.

Arnold cites the fear of operating a large system, assuming very high O&M costs as one reason small systems hesitate to become regional, opting to either expand or improve existing systems.

Not only are state programs limited in their success, but federal aid is decreasing as well (Snyder, 1984). Federal water supply aid programs are listed in Table 3 (NC Ad Hoc Group, 1978), with the Farmers Home Administration (FmHA) being the major contributor to small water suppliers. North Carolina had received more money for water supply and wastewater disposal projects from FmHA than all but two other states, so it more than most states will feel the effect of decreasing federal financial aid.

2.3 Reasons for Regionalized Systems in North Carolina

There are several reasons why a regional water system may be attractive to a county or community in North Carolina. Almost 40% of the population in the state is served by small systems, which for reasons cited earlier, are generally thought to be inferior to large (serving over 10,000 people) water supply systems. In rural areas, where it may be difficult to get groundwater, a county-wide system may be the only feasible option. This was the case in Montgomery County. Located in the southern half of the piedment, Montgomery County is rural, with only 15 public water supply systems in the entire county. People mostly have their own wells. However, once it became difficult to get water individually, the public petitioned for a county-wide system. A new plant is now in operation using water from Lake Tillery. Approximately 1,600 county users are served,

Table 3: MAJOR FEDERAL WATER RESOURCE PROGRAMS, CLASSIFIED BY MAJOR ELEMENTS AND AGENCY, SHOWING THE PRIMARY STATE AGENCY INVOLVED

Federal Programs	Primary State Cooperating Agency
1. Water Supply	
Farmers Home Administration	
Rural Water Supply planning & construction grants and construction loans to local agencies	Human Resources, Sanitary Engineering Section
Soil Conservation Service	
Water Supply in Small Watershed Projects	DNRCD, Land Resources Division
Corps of Engineers	
Water Supply in Multiple-Purpose Reservoirs--planning, construction, operation & maintenance	DNRCD, Office of Public Works
Economic Development Administration	
Water Supply Grants to local agencies	Human Resources, Sanitary Engineering Section
Environmental Protection Agency	
Regulation of domestic water supplies, Grants to State for management of State Regulatory Program	Human Resources, Sanitary Engineering Section
Dept. of Housing & Urban Development	
Community Development Grants to localities	Human Resources, Sanitary Engineering Section
Geological Survey	
Cooperative-Federal-State Basic Data Program, surface and ground water	DNRCD, Division of Environmental Management

SOURCE: NC Ad Hoc Group on Water Resources, Water Resources Management in NC 1978 and water is sold to the towns of Biscoe, Mt. Gilead, and Troy.

Quality problems, i.e., taste and odor problems, may be bad enough that consumers want to be part of a larger system which produces better quality water. Cleveland county is a case in point. Poor water quality led some residents to form the Upper Cleveland Sanitary District among themselves. This system is new, having only been in operation two years and is already expanding to reach additional counties.

Another incentive for a regional water project may be the potential of attracting industry to the area. There are also examples of industry becoming instrumental in instituting water projects. Classified as "economically depressed", Robeson county was able to participate in the EDA grant/loan program. About four years ago, Campbell Soup Company wanted to locate in the county and agreed to participate financially with the county in getting a county-wide water system. Because of poor local groundwater quality (excessive iron and manganese), a county system was well received by the public. Robeson county now has one of the fastest growing regional water systems in the State. According to Mr. Wallace Venrick, regional engineer for the Department of Human Resources in Winston-Salem, without such incentives, we would see very few regional systems.

2.4 Successful Regional Systems in the State

2.4.1 Anson

Located in central North Carolina on the NC-SC state line, Anson County has a successful regional water system. In 1966, Anson County received a combination revenue bond loan and grant of $4,000,000 from EDA. County voters then approved a $750,000 general obligation bond issue to add to EDA funds and the county was able to implement preliminary plans for a county-operated, county-wide water supply and distribution system (Wicker, 1979). Profit from the sale of water to other counties has enabled Anson County to expand water lines within the county. The county's decision to expand came about because neighboring counties wanted to purchase water. In 1971 the Anson County water system was completed, and they began selling water to Union County. EDA grant money was used to finance distribution lines from Anson to Union county. In 1977, Richmond county began buying water, and 1985 Anson began selling to the Chesterfield Rural Water Company in Chesterfield county, SC. Both Richmond and Chesterfield counties paid for their own distribution lines from Anson county. Anson county is currently selling more water outside the county (59%) than is used by county residents. According to the Anson county manager, customers would have to pay $0.38/1,000 gallons more for water if Anson county was not selling water, increasing the cost of water about 15%. To the extent that charges represent costs, this indicates that the regional supply is economically attractive.

2.4.2 <u>Davidson Water Inc.</u>

In 1965, a group of concerned citizens in the Welcome area of Davidson County recognized the need for a water system in the area. Individual wells were not reliable, and as there was not (and still isn't) a county sewer system, there was the added problem of putting in a septic tank. The group formed a private, non-profit corporation so as to receive Farmers Home Administration financing to construct a water system.

Having received a $3,680,000 loan (the maximum at the time was $4,000,000), North Davidson Water Inc., a private, non-profit corporation was formed to serve 3,650 customers. Unable to receive additional financing, the company could not expand its water lines but was able to supply more water. Between 1968 and 1969, four more non-profit corporations were started in Davidson County (financed by FmHA loans) to construct water lines. North Davidson Water Inc. furnished the water. In 1973, Congress removed the $4,000,000 ceiling, and the five systems consolidated into the Davidson Water Inc. The new board consists of three members from each of the five original systems.

The treatment plant has gone from 2 mgd capacity in 1968 to 12 mgd capacity which will be completed in 1987, when demand is estimated to be between 10 and 11 mgd. The plant operates at capacity, with expansions every several years. Located on the Yadkin River, the plant operates continuously. Installation of tube settlers has improved water quality, although finished water quality has always met standards.

The last five years of operation have been "break even" years. Revenues have paid for operation and maintenance, but not all necessary capital improvements. Over the past two years, the records show a profit. Because this is a non-profit corporation, customers will eventually be reimbursed or rates will be lowered. Water rates are based on what needs the board anticipates three to five years ahead, yet there is still the need for FmHA financing. This past plant expansion, from 8 mgd to 12 mgd required a $2,000,000 loan from FmHA, but system managers feel this may be the last of FmHA loan money.

Davidson Water Inc. is the largest non-profit rural water system in the nation, serving rural residents of Davidson and Randolph County. As the water system becomes more accepted (there are still residents preferring their own wells to the water system), more people will tie onto the system. According to loan guidelines, the company can spend up to $1000 per new connection. Problems arise when only one or two residents want to tie in, and other neighbors don't. But as new residents move into the area, these gaps in the system are closing.

Regionalization of water supply systems is encouraged through state legislation, but oppostion is experienced on the local level where the idea of regional water management is threatening to local governments. The provision of water is seen as a way to control the growth of a community, and local officials are not eager to share this power with other communities. Where consumers have been concerned with the quality or quantity of the water supply to the point of organizing or petitioning for a regional (usually a county) system, regionalization has been successful.

3. GASTON COUNTY: A CASE STUDY OF REGIONALIZATION

Regionalization within North Carolina has often resulted in better quality water at lower cost to consumers, but many counties in the state have no type of regional water system, neither physical nor organizational. An essentially rural state with many small communities and no large centers of population, NC has a clear need for regionalization (Okun, 1981).

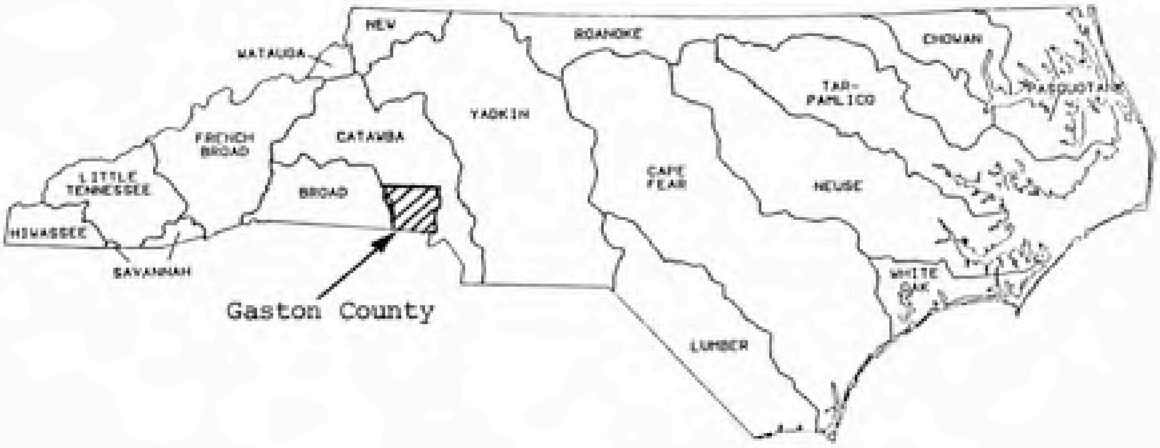
To the extent that one county can typify the State, Gaston County was chosen as a case study of regionaliztion in North Carolina. By examining various regional plans in one county, principles applied within this county may be applicable at the state level. Gaston county dosen't own or operate a water (or wastewater) system, but does own some transmission lines. There are over 200 small public water supply systems, all of which use groundwater, and several small municipal systems which use surface water.

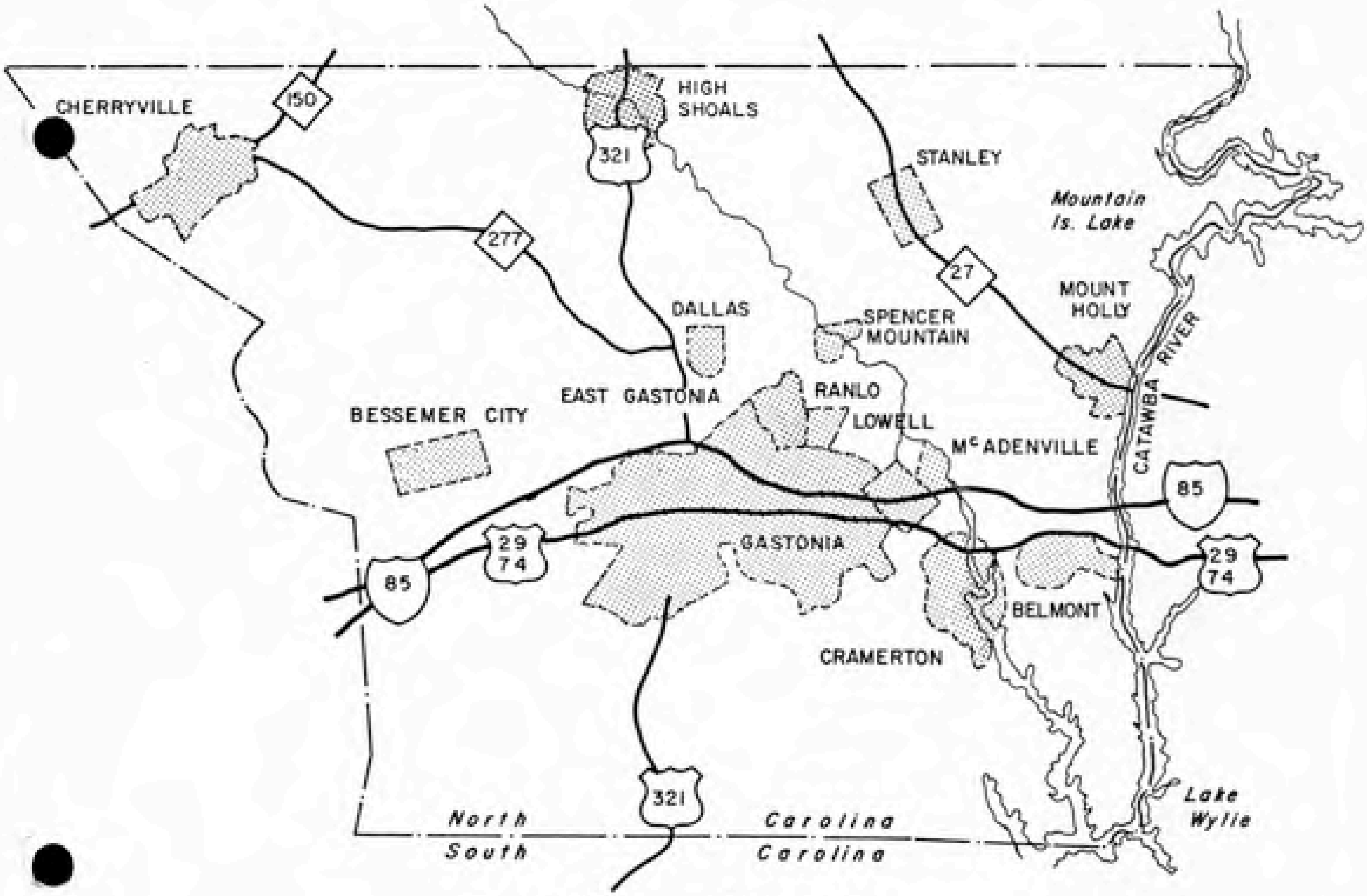
3.1 General information

Gaston County is located in the South-central part of the Piedmont region of North Carolina within the Lower Catawba River Basin, Figure 2.

There are 212 public water supply systems in Gaston County; one half of the systems in the county serve fewer than 100 people. Only sixteen systems serve more than 500 people (see Figure 3). Of these sixteen, four private companies, averaging 660 people each, use groundwater. Seven

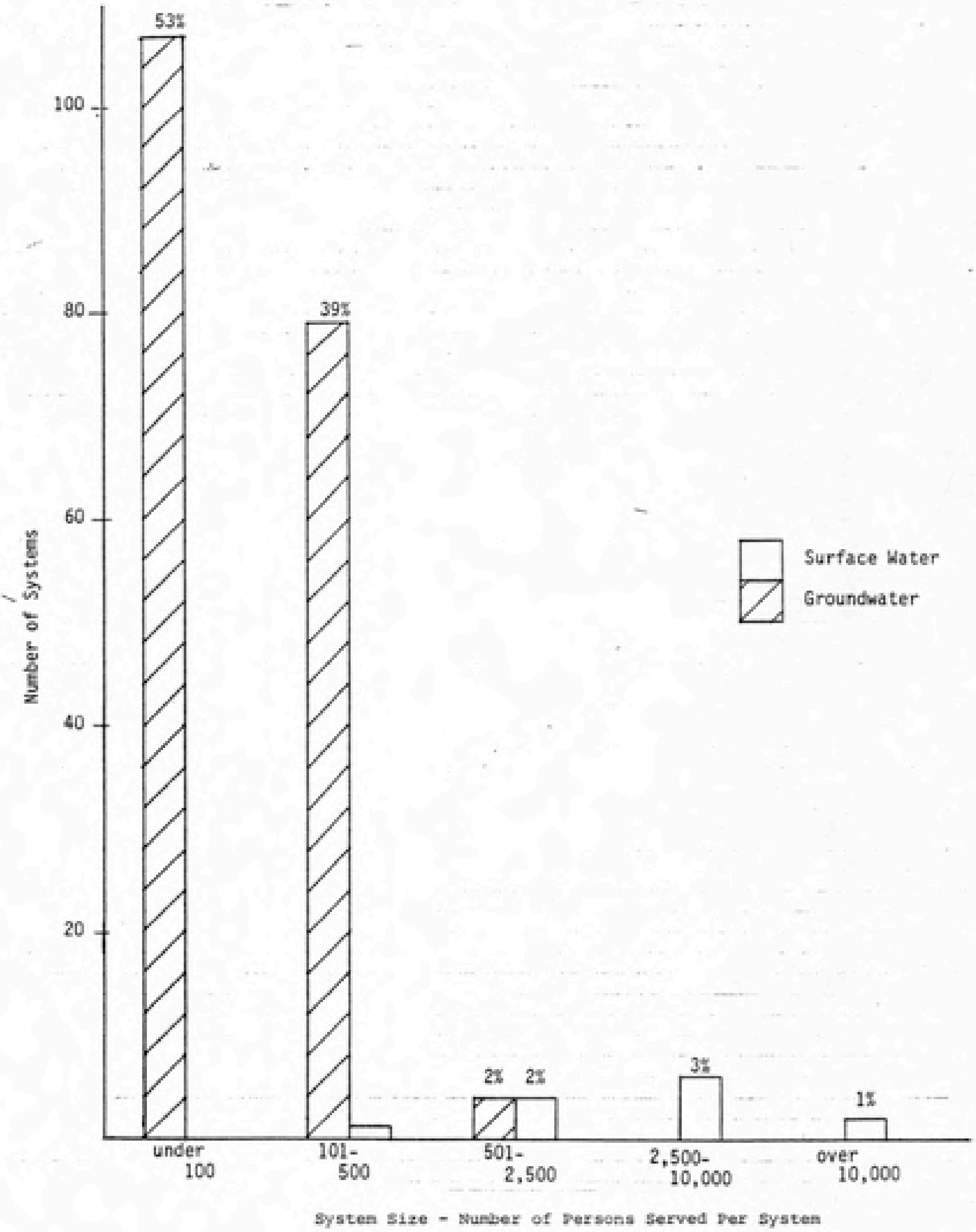
Figure 2: Gaston County





GASTON COUNTY

Figure 3: Size Distribution and Sources of Water of Gaston County Public Water Supply Systems



SOURCE: N.C. Department of Human Resources, 1985 municipalities including Gastonia use surface water, with five additional communities purchasing treated surface water from Gastonia, Table 4.

Table 4

System	Population	Source
Belmont	15,000	Catawba River
Bessemer City	6,000	Long Creek
Cherryville	4,900	Indian Creek
Gastonia	53,190	South Fork Catawba
Cramerton	1,842	*
Dallas	4,170	*
Lowell	3,300	*
McAdenville	970	*
Ranlo	1,774	*
High Shoals	700	South Fork Catawba
Mt. Holly	6,300	Catawba River
Stanley	3,000	Hoyles Creek

* Purchase treated water from Gastonia

The City of Gastonia is the largest water supplier in the county, serving approximately 65,000 people. Up to this point, there has been no contractual agreement between Gastonia and the five satellite communities that buy water from Gastonia, but the city is offering serveral alternatives to the "no contract" agreement. These satellite cities are discussed later.

3.2 Reasons for regional water management in Gaston County

If regionalization is to be initiated in North Carolina, it will be as a result of local initiative, with assistance from state agencies. Local self-interest was the driving force behind both the successful regional systems discussed earlier. Local constituencies of Gaston County have differing concerns over their water situation, and there are several reasons regional water management may be an attractive alternative to the current trend of individual ownership and operation of both small and large systems.

Gaston County officials are interested in forming a county water water system which would interconnect the municipal water systems not only for emerengcy use, but to serve rural residents of the county as well. With 212 public water supply systems, Gaston County has the highest number of public water systems in the state. The inherent problems of small systems (poor management, insufficient finances to hire qualified personnel, etc.) might be solved by incorporating these smaller systems into a larger system.

Not only is operation and maintenance of small systems a problem, but groundwater quality is a concern in the county. The Public Health officials are concerned because approximately 350 wells serving the community water supplies in Gaston County are not monitored routinely for inorganic chemicals. They estimate 27,000 people are being supplied water from groundwater sources that are not monitored bacteriologically or chemically. The proliferation of septic tank systems is a problem which affects water quality. Below is an excerpt from a paper written by the County Health Department (On-Site Sewage Treatment and Disposal, 1985):

"The failure rate of the total number of septic tank systems in the county is about 3 to 5% annually, with systems over 10 years old having a higher failure rate. It is therefore possible to have 500 to 1000 malfunctioning septic tank systems each year, which results in the flow of human waste onto the surface of the ground and into streams. Some of these malfunctioning systems go undetected or unreported and have the potential to produce sewage related diseases such as hookworm, hepatitis (which is high in Gaston County), dysentary and other enteric diseases".

The two large municipal suppliers in the county use surface water from large river systems used by many municipal and industrial dischargers. It may be possible to use a better quality source at an acceptable cost. The City of Gastonia has almost completed the final expansion of their existing plant and is investigating new plant sites as well as a new source. Two other systems must expand to meet the 20-year demand. It may not be necessary for all three systems to expand individually, joint ownership for two or more systems may be advantageous.

3.3 Regional approaches in Gaston County

Regionalization may refer to the physical water supply system or to the organizational arrangement used (Higgins, 1972). Three types of regional plans are evaluated which involve either physical or organizational arrangements: interconnections among municipal systems, service to the small systems (both municipal and private), and organizational arrangements consistent with water management in Gaston County.

Using a 20-year design period, potential interconnections between municipalities are determined by treatment plant capacity and the safe yield of the source. Prior to identifing possible interconnections, water quality of sources in the county are evaluated, so that alternatives can be compared on the basis of providing equal quality.

With no county-wide water system and increased development outside city limits, the number of small public water supply systems is increasing. Other means of serving these rural residents besides increasing the number of small systems may result in a better quality water service.

Based on practices of other counties in the state, several organizational arrangements may be feasible which could result in a larger governing unit providing service over a larger area.

4. WATER SUPPLY SOURCES IN GASTON COUNTY

4.1 Determination of mean annual flow

Located in the piedmont, Gaston County relies mainly on surface water to meet the county water demands. Although a large number of systems utilize groundwater (Figure 3), they serve only 20% of the population. Determination of mean annual flows was based on information from gaging stations within the area, and work done by F.E. Arteaga and E.F. Hubbard (Arteaga, 1975). The mean annual flows for streams in Gaston County are between 1.0 and 1.5 cfs per square mile as shown in Figure 4. Figure 5 shows the location of four gaging stations within the area. The mean annual flows at each of these stations are as follows:

Station	Drainage Area (sm)	MAF (cfs/sm)
02143500* (Indian Cr., Lincoln Co.)	69.2	1.32
02144000 (Long Cr., Gaston Co.)	31.8	1.13
02142900 (Long Cr., Mecklenburg Co.)	16.4	1.12
02145000 (S.F. Catawba, Gaston Co.)	628.0	1.28

* U.S.G.S. Station Number

These values are within the range suggested by the USGS in Figure 4 (Arteaga, 1975), and are used for estimating the safe yield of a source.

4.2 Safe Yield of Existing Sources in Gaston County

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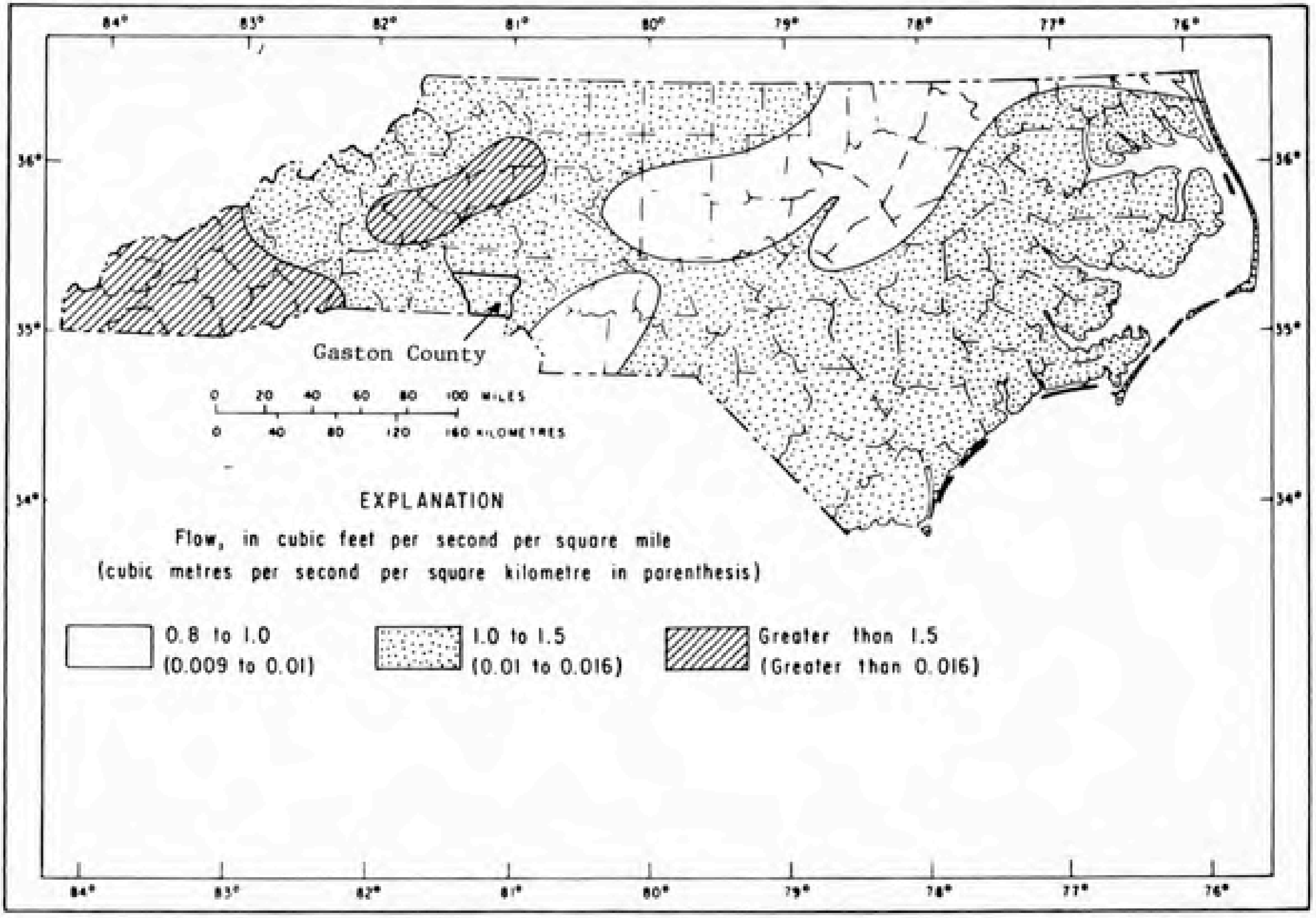
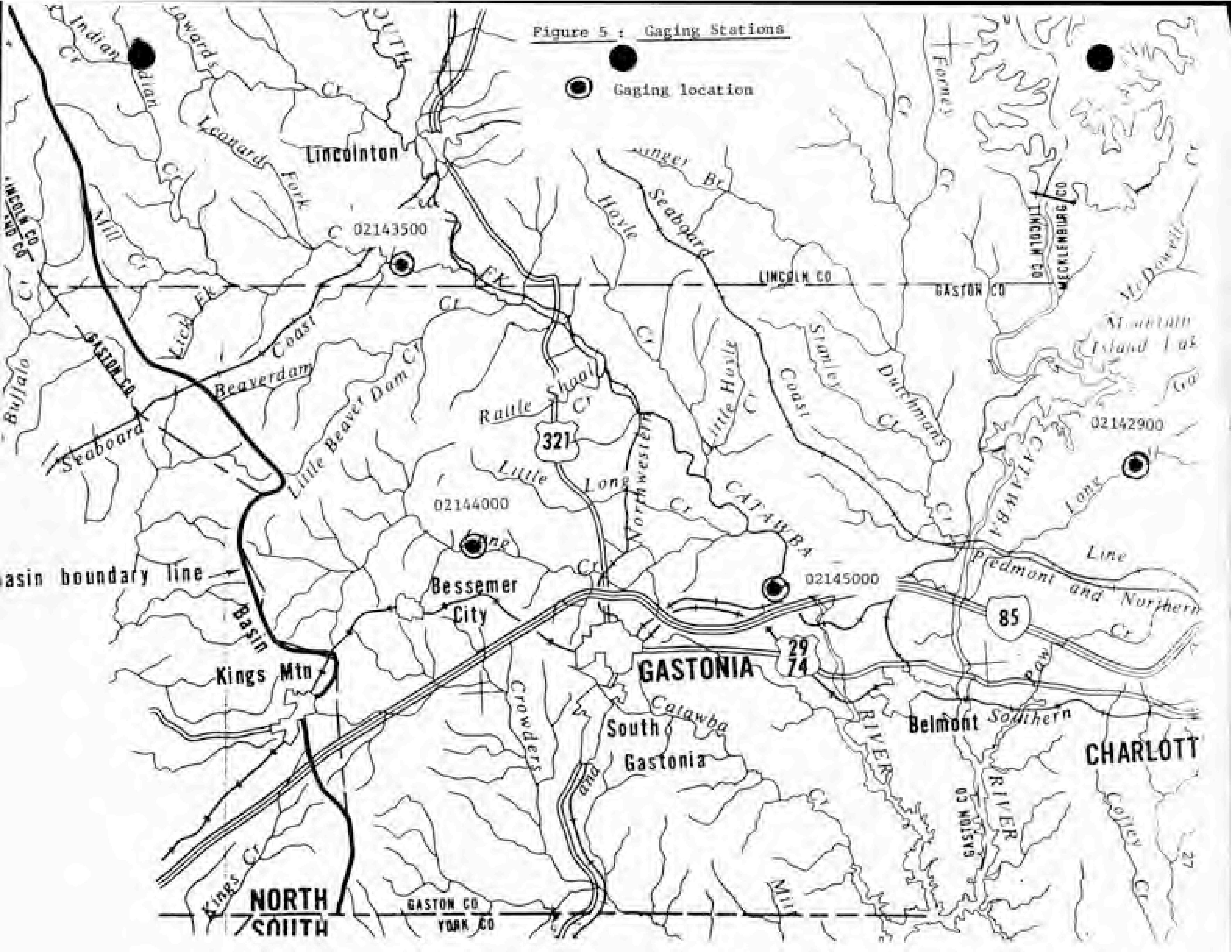


Figure 4 --Range in mean annual flow of streams in North Carolina.

Figure 5 : Gaging Stations



important to know how much water is available to each system, and whether the existing treatment plants are adequate in size. Assuming a 20-year design period, it is possible to evaluate alternatives for meeting the future demands of each system. Two systems in the county provide no raw water storage, withdrawing directly from either the South Fork of the Catawba or the Catawba River. The remaining systems take water from impoundments. Figure 6 shows the location and intake for each of the seven municipalities.

4.2.1 Safe Yield of River (no impoundments)

Two municipalities, Belmont and High Shoals, take water directly from the Catawba and South Fork Catawba Rivers respectively without storage. Gastonia is a special case in that water is piped directly from the South Fork of the Catawba to an impoundment on Long Creek. The drainage areas of the sources are shown below:

System	Source	Drainage Area (sm)
1) Gastonia	South Fork Catawba,	628
	Long Creek	35
2) High Shoals	South Fork Catawba	628
3) Belmont	Catawba	1,860

Where there are no impoundments, the safe yield is assumed to be approximately the minimum flow over the period of record. The instantaneous minimum flows for the four gaging stations are:

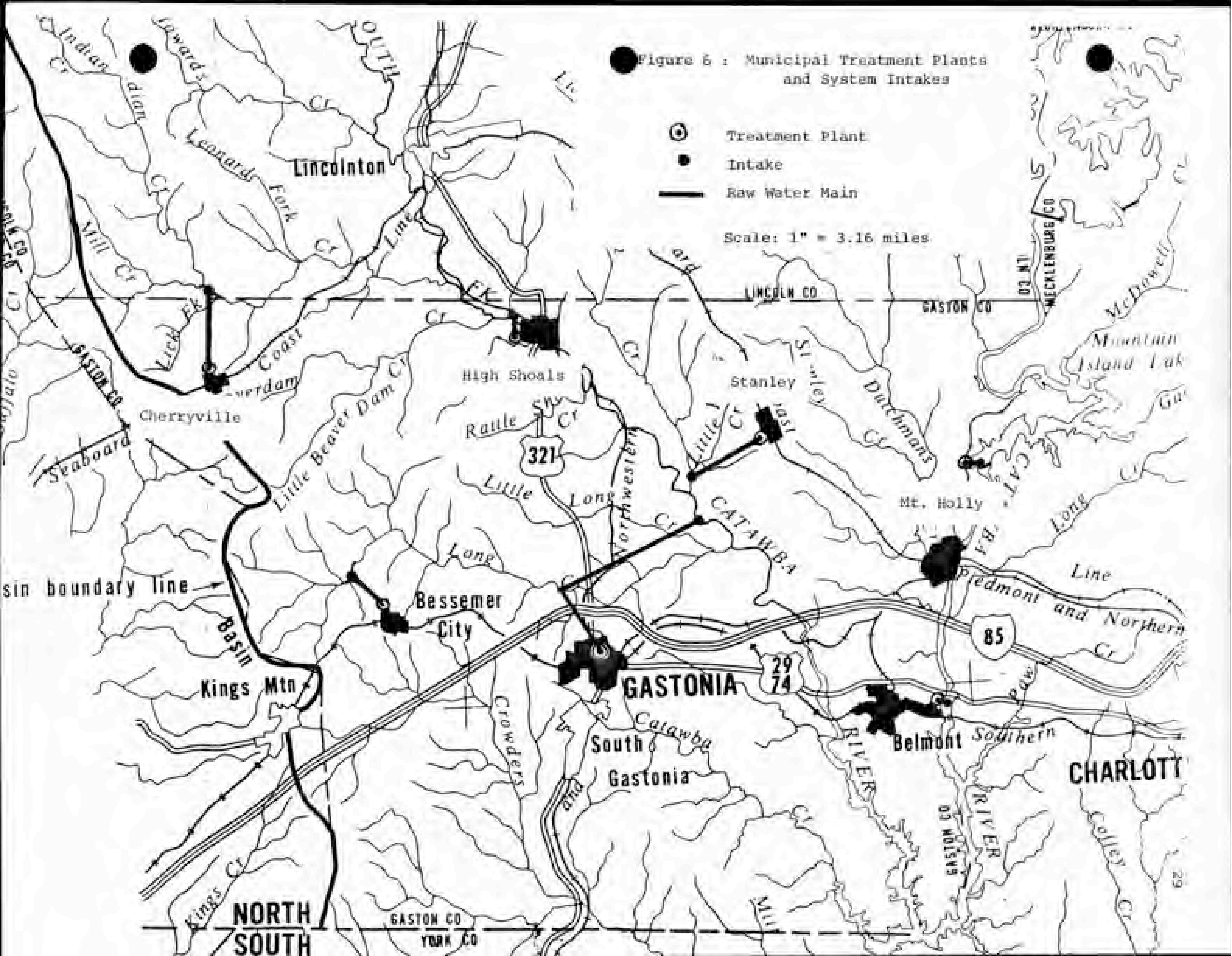


Figure 6 : Municipal Treatment Plants and System Intakes

Station	Length of Record (yrs)	Min Flow (cfs) (year)	Min Flow (cfs/sm)
Indian Cr.	33	4.6 (1954)	0.07
Long Cr.	32	0.8 (1954)	0.03
Long Cr.	19	0.5 (1976)	0.03
South Fork Catawba	30	25.0 (1954)	0.04

Because the drainage areas of the Catawba and South Fork are so large (1,860 sm and 628 sm respectively), the value of 0.04 cfs/sm, corresponding to the station located on the South Fork is used to approximate the minimum flow on the Catawba as well.

4.2.1.1 **Gastonia**

Gastonia takes its water from two sources; the South Fork of the Catawba, which furnishes most of the raw water, and Long Creek. Water from the South Fork is piped to Rankin Lake, a 275-mg impoundment located on Long Creek. Bessemer City also has an impoundment upstream of Rankin Lake, therefore the drainage area given for Long Creek does not include that part of Long Creek used by Bessemer City.

J.N. Pease Associates just completed a Raw Water Supply Study (1986) for the City of Gastonia. They cite physical restrictions as the reason the treatment plant can not expand beyond 27.3 mgd. Past records show that during the months of July and August of 1982, the South Fork Catawba was unable to meet the demand.

The City of Gastonia serves approximately 65,000 people; 53,000 persons are served through Gastonia's distribution system. The present maximum daily demand is approximately 23.8 mgd, just about plant capacity (21.3 mgd). Plant capacity is under final expansion which will bring it to 27.3 mgd. Current plant capacity is assumed to be 27.3 mgd. The 20-year maximum daily demand is estimated to be 28 mgd.

The current average daily demand and the expected 20-year maximum daily demands for the five cities that buy water from Gastonia are given below:

	Ave. Day Demand (mgd)	Max Day, 20-yr Demand (mgd)
Cramerton	0.23	0.46
Dallas	0.46	0.95
Lowell	0.42	0.88
McAdenville	0.72	1.5
Ranlo	0.41	0.85
	2.24	4.65

Gastonia sells an average of 2.24 mgd to meet the demands of the five cities. Based on population growth estimates (HDR, 1985), Gastonia may be expected to supply an additional 5 mgd by the year 2005 to adequately serve these cities.

If Gastonia continues selling water, the total estimated 20-year maximum daily demand would be approximately 33 mgd. The City of Gastonia's water supply is not only stressed at the source, but by physical treatment plant restrictions as well. The estimates are rough approximations, but show that Gastonia will need to find an additional source of water (or increase the yield of the current source) and increase its treatment capacity. With the existing treatment capacity of 27.3 mgd and a maximum daily demand of 23.8, the existing treatment facility can adequately treat water for the next seven years (based on a 20-year demand of 33 mgd).

4.2.1.2 High Shoals

High Shoals takes water directly from the South Fork of the Catawba. The gaging station on the South Fork (Figure 2) is located downstream of the intake for High Shoals, but USGS data at this station were used to approximate a minimum flow of 16 mgd. The City of High Shoals serves approximately 700 people. The design capacity of the treatment plant is 0.23 mgd, and there is a 1.2-mg raw water impoundment at the plant site. The present day maximum demand is 0.08 mgd and the 20-year maximum day is estimated to be 0.10 mgd. The Catawba is an ample source.

The water plant was constructed in 1979 and a hydroelectric plant upstream was not in operation at that time. It has since started operating, and the fluctuating water level causes problems at the intake.

4.2.1.3 Belmont

Belmont takes directly from the Catawba River. A 1976 report of the North Carolina Department of Natural Resources and Community Development (1978) suggests the following safe yield at the intake for Belmont:

Safe Yield (20-year) = 75 mgd
Safe Yield (50-year) = 50 mgd

Calculations based on the minimum annual flow give a safe yield of:

0.04 cfs/sm x 1,860 sm = 74 cfs = 50 mgd

The more conservative value of 50 mgd is used as the safe yield of the Catawba River at Belmont.

The City of Belmont serves approximately 15,000 people. The original treatment plant was constructed in 1926 and has been upgraded over the years to a 5-mgd capacity (HDR, 1985). The present day maximum demand is 6.4 mgd, and the 20-year maximum demand is estimated to be 7.5 mgd. With a safe yield of 50 mgd, the Catawba River is an ample source.

4.2.2 Safe yield of existing impoundments

The remaining four municipalities take water from existing impoundments of known storage capacity, Table 5. Figure 7 (Arteaga, 1975) was used to determine the safe yield of these impoundments assuming a 20-year recurrance interval. Ordinarily, Figure 7 could be used directly to determine the storage needed. However, since such a small percentage of the mean annual flow is required to meet demand, draft rates were extrapolated from Figure 7. The mean annual flow for Gaston County was estimated at about 1.2 cfs/sm.

4.2.2.1 Bessemer City

The water source for Bessemer City is a 50-mg impoundment on Long Creek, and a 100-mg impoundment called Arrowood Lake. According to the system manager, water can be piped from either or both sources for treatment.
There is a 6-mg raw water reservoir located on the treatment

Table 5: Safe Yield of Existing Impoundments

System	[1] Drainage Area (sm)	[2] Mean Annual Flow (cfs)	[3] Total Storage Capacity (mg)	[4] Ratio of Storage to Mean Annual Flow	[5] Draft Rate, % Mean Annual Flow (Fig. 7)	[6] Safe Yield (mgd)
Bessemer City	13.5	16.2	150	0.04	33	3.4
Cherryville	41	49.2	13	0.001	14	4.6
Stanley	22	26.4	13	0.002	17	2.9

[2] Mean Annual Flow = (1.2 cfs/sm)([1])

[4] Ratio of Storage to Mean Annual Flow = [3]/([2] x 0.65 mgd/cfs x 365 days)

[6] Safe Yield = ([5]/100)([2])(0.65 mgd/cfs)

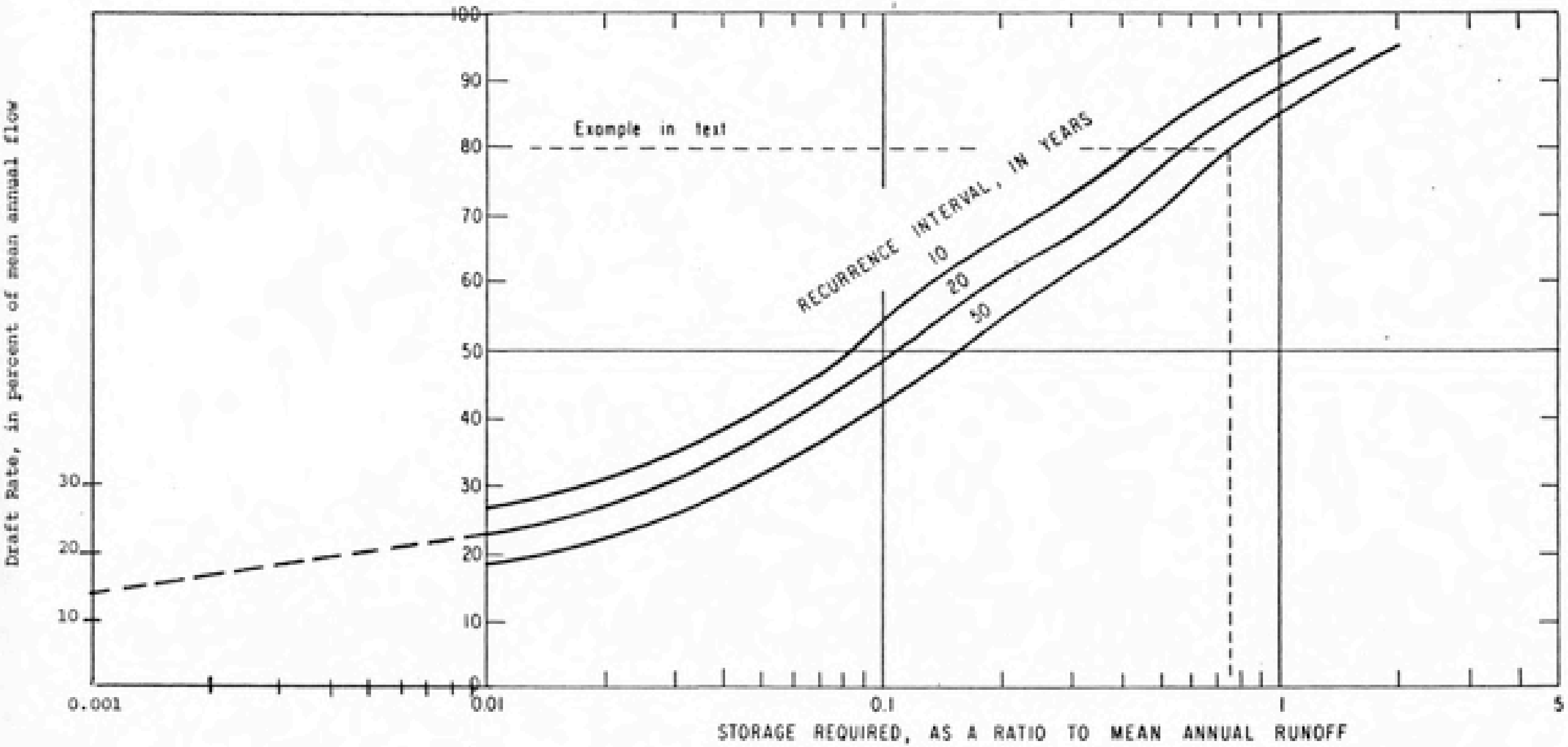


Figure 7----Draft-storage relations for 10, 20, and 50-year recurrence intervals

plant site. Taking the total storage capacity to be 150 mg, and the drainage area to be 13.5 sm, the total safe yield available from the impoundment is 3.4 mgd.

Bessemer City serves approximately 6,000 people. The design capacity of the water treatment plant is 3.0 mgd. The present day maximum demand is 2.4 mgd and the 20-year projected maximum demand is 2.9 mgd. Bessemer City has enough storage capacity (3.4 mgd) to meet future demands.

4.2.2.2 Cherryville

The City of Cherryville takes its water from an impoundment on Indian Creek. According to the City Manager, the impoundment has a storage capacity of 13 mg. Topographic maps show a drainage area of 41 sm. The safe yield of the impoundment is 4.6 mgd.

The City of Cherryville serves approximately 4,900 people. Originally constructed in 1964, the plant was expanded to 3.2 mgd in 1975. The present day maximum water demand is 2.7 mgd, and the 20-year projected maximum demand is 3.2 mgd. The impoundment on Indian Creek has a safe yield of 4.6 mgd, so Cherryville can meet future demands without increasing raw water storage.

4.2.2.3 Stanley

The City of Stanley takes water from an impoundment on Hoyles Creek. The Stanley water treatment plant operator estimated the storage capacity of the impoundment to be 5 acres by 8 feet in average depth. From topographic maps, the drainage area is estimated to be 22 sm. The safe yield is estimated to be 2.9 mgd.

The City of Stanley serves approximately 3,000 people. The last expansion was in 1958, increasing the treatment capacity to 0.8 mgd. A 1.2 acre raw water reservoir was also constructed adjacent to the impoundment to allow for increased settling during periods of high turbidity. The present day maximum demand is 1.05 mgd, and the 20-year projected maximum demand is 1.3 mgd. The safe yield of the Hoyles Creek impoundment (2.9 mgd) is enough to meet the future demand of Stanley.

4.2.2.4 Mt. Holly

Mt. Island Lake is a reservoir on the Catawba River which serves as the water supply source for the City of Mt. Holly. The drainage area of the reservoir is close to 2,000 sm.

The City of Mt. Holly serves approximately 6,300 people. A new 6 mgd plant was constructed in 1984. The present day maximum demand is 2.5 mgd, and the 20-year projected maximum demand is 3.0 mgd. Although other municipalities use Mt. Island Lake as a water source, the safe yield available to Mt. Holly is ample.

4.3 Summary of existing municipal systems

Table 6 shows a summary of the calculations, including the 20-year maximum demand projections. The existing treatment capacity and raw water supply for Bessemer City, Cherryville, High Shoals, and Mt. Holly will meet or exceed the 20-year maximum demand projections. A 50% plant

Table 6: Existing Municipal Systems

Water Systems	Source	Population Served	Plant Capacity (mgd)	Max. Water Used (mgd)	Safe Yield (mgd)	Projected 20-Yr Max. Water Used (mgd)
Belmont	Catawba River	15,000	5	6.4	50	7.5
Bessemer City	Long Creek	6,000	3	2.4	3.4	2.9
Cherryville	Indian Creek	4,900	3.2	2.7	4.6	3.2
Gastonia	South Fork Catawba Long Creek	65,246	27.3	23.8	*	33
High Shoals	South Fork Catawba	700	0.23	0.08	16	0.1
Mt. Holly	Catawba River (Mt. Island Lake)	6,300	6	2.5	ample	3
Stanley	Hoyles Creek	3,000	0.8	1.05	2.9	1.3

* Undetermined - plant capacity is limiting

expansion is required for the City of Belmont to meet their 20-year maximum demand. The Stanley water treatment plant must expand by 60% to meet their 20-year maximum demand. In both situations, the raw water source available to each is ample to meet future needs. Only the City of Gastonia must expand their existing plant and their water supply, although the next treatment plant expansion won't be necessary until 1993.

4.4 Safe yield of potential sources in Gaston County

Both Dutchmans Creek and Beaverdam Creek are high quality sources located within Gaston County. Neither Creek is being used as a water source. Topographic maps were used to site approximate locations for impoundments, and are shown in Figure 8. The Dutchmans Creek drainage area stretches through Lincoln County. According to the Director of the Gaston Planning Department, the area is fairly undeveloped. The site is located upstream of Road 1918 (which is not shown in Figure 8). Cherryville had considered Beaverdam Creek as a raw water source, but chose Indian Creek. The impoundment site is located west of highway 1609. The safe yield of either impoundment adequate to develop 60% of the mean annual flow is shown below:

Source	Drain. Area (sm)	Res. Cap. (bill. gal)	Safe Yield (mgd)
Dutchmans Creek	125	7	59
Beaverdam Creek	25	1	12

4.5 Water quality of existing and potential sources

In May 1985, the NCDNRCD, Division of Environmental Management completed a report entitled "Assessment of Water Quality in North Carolina" (NCDNRCD, 1985). Assessment of water quality is based on biological and chemical/physical indices. Streams are classified as either excellent, good, good-fair, fair or poor under both rating criteria when possible. The biological rating is an assessment of water quality based on the biological community that can exist in the stream. The aquatic life in the stream is used as the index to the water quality. The chemcial/physical index includes (but is not limited to) such parameters as biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, and temperature. Parameters that indicate potential health concerns from pollution with toxic chemicals are not generally determined, and the best measure of the significance of such chemicals is possible sources or the watershed.

Figure 8 shows the biological ratings for sources currently used by municipalities, and the two creeks that could be developed for use. Several creeks were not considered. Both Crowders Creek and Catawba Creek (as opposed to the Catawba River) are located south of Gastonia. The Bessemer City and Kings Mtn. wastewater treatment plants (WWTPs) discharge into Crowders Creek, and the Gastonia WWTP discharges into Catawba Creek. Leonards Fork and Little Long Creek are both good quality sources with no major discharges.

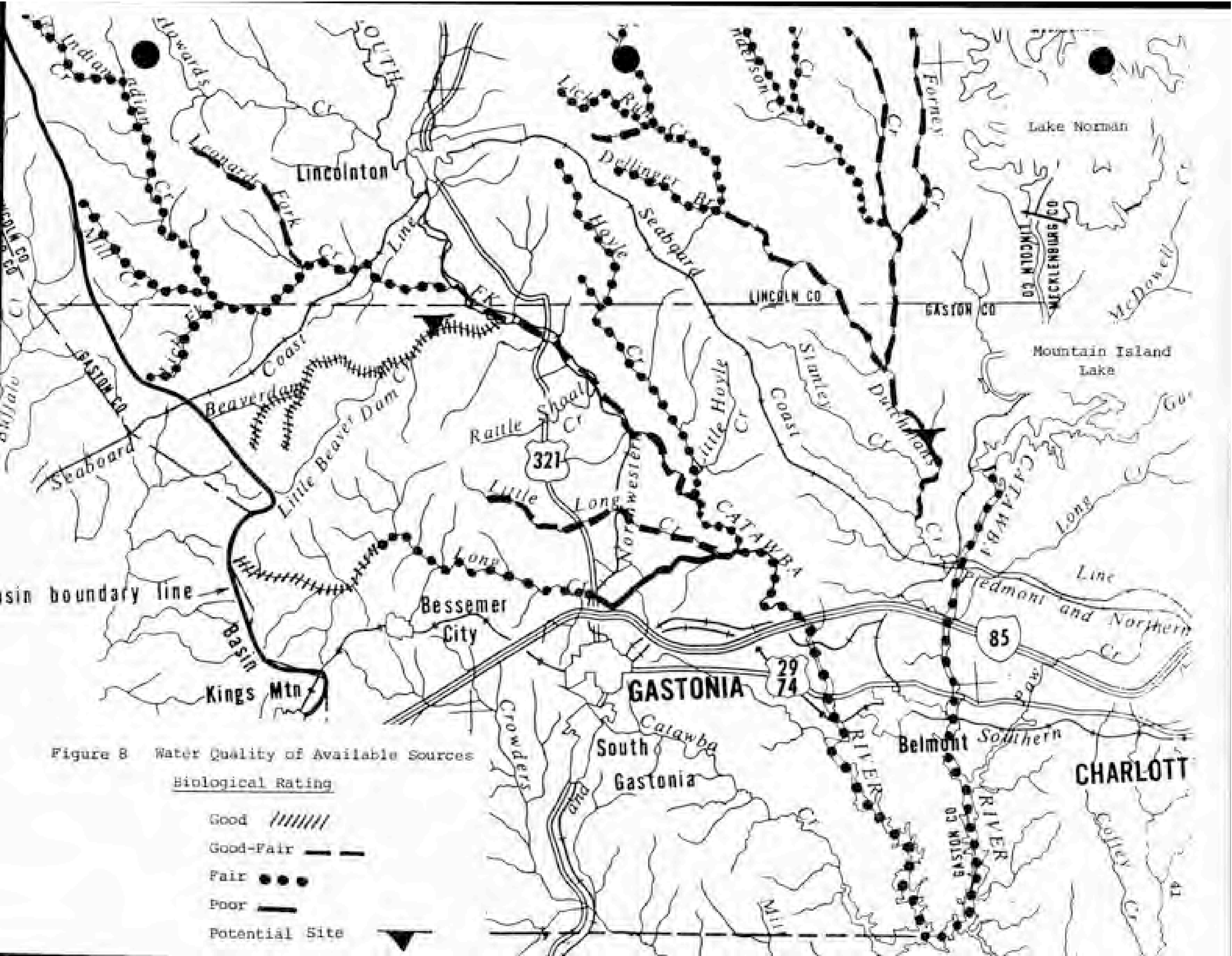


Figure 8 Water Quality of Available Sources

The area around Little Long Creek is fairly built up, making construction of an impoundment unlikely. The drainage area is not large enough to allow for direct withdrawal without an impoundment. Leonards Fork also drains a small area (less than 10 sm), and is close to Lincolnton. None of the four sources discussed above were considered any further.

Table 7 summarizes the water quality rating of only the rivers or creeks that can be used as a water source. Both the Catawba and the South Fork of the Catawba receive more municipal and industrial discharges than any of the other sources available. However, both these rivers drain much larger areas than any of the others in the county. In order to correct for this disparity, these seven sources have been ranked according to the volume of wastewater discharged per 100 square miles of drainage area. A better ranking might be by the concentration of specified contaminants, but this would entail more data than are generally available. The volume of discharge was based on previous research (Turner, 1984).

Table 8 (Turner, 1984), shows the number of major and minor dischargers in each river basin and the corresponding volume of discharge. Based on this information, an <u>average</u> major discharger discharges 6 mgd, and the <u>average</u> minor discharger discharges 0.2 mgd. Those river basins containing cooling water dischargers were not included in the calculation of the average major discharger. Multiplying these estimated volumes by the number of dischargers in each

Table 7: Discharges into Gaston County Sources

Source	Dischargers	Water Quality Index*
South Fork Catawba	6 MM 6 mM 2 MI 16 mI 17 misc	Good
Catawba River	11 MM 12 mM 9 MI 44 mI 67 misc	Good
Long Creek	0	Good-Fair
Indian Creek	1 high school	Good
Hoyles Creek	Hoyles Creek WWTP	-
Beaverdam Creek	Tryon Jr. High School Cherryville WWTP	-
Dutchmans Creek	1 high school	-

* Rating from "Assessment of Water Quality in North Carolina" (NCDNRCD, 1985)

1) MM: Major Municipal Discharger defined by EPA and State as a POTW that meets 1 or more of the following:
   - discharges 1 mgd or more or
   - serves a population of at least 10,000 or
   - impacts water quality - toxic waste
2) mM: Minor Municipal Discharger defined as a POTW which is not a major discharger
3) MI: Major Industrial Discharger is an industrial discharger receiving more than 80 points under the Industrial Permit Rating System (IPRS)
4) mI: Minor Industrial Discharger receives less then 80 points
5) misc: Miscellaneous Discharger, i.e. hotels, restaurants, etc.

Table 8

Total Number and Design Volume of Discharges by River Basin in North Carolina

River Basin	Major Discharges (mgd) Number	Design Vol.	Minor Discharges (mgd) Number[2]	Design Vol.
Broad[1]	12	24.6	63	4.75
Cape Fear[1]	53	2254.7	361	44.95
Catawba[1]	44	185.4	257	178.64
Chowan	2	1.5	38	4.37
French Broad[1]	14	130.2	176	27.10
Hiwassee	1	0.1	14	1.10
Little Tenn	1	1.5	66	3.86
Lumber[1]	12	31.7	77	6.69
Neuse	23	138.0	206	23.27
New	1	3.2	25	50.97
Pasquotank	2	3.5	47	3.47
Roanoke[1]	17	390.2	129	10.77
Savannah	0	0.0	3	0.20
Tar-Pamlico	11	92.9	109	7.57
Watauga	0	0.0	22	1.04
White Oak	2	6.2	71	46.95
Yadkin[1]	41	169.9	482	28.56
Totals	236	3433.6	2146	444.25

[1]Location of steam generating plants discharging cooling water: Broad (3), Cape Fear (4), Catawba (4), French Broad (1), Lumber (1), Roanoke (4), and Yadkin (1).

[2]Twelve minor dischargers are omitted because the river basin into which they discharged could not be ascertained. The combined discharge volume of the 12 was 0.04 mgd.

SOURCE: Turner, A.G., et al., A Survey of Potential Population Exposures to Chemical Contaminants Present in Unprotected Surface Water Supplies in North Carolina, WRRI No. 213, 1984 stream or river, Table 9 is a ranking of the sources used within the county on the basis of wastewater volume discharged. The factor, mgd of wastewater discharged per 100 sm, is a means of ranking the sources from "worst" to "best" quality, and will be referred to as the "pollution index". Without knowing the type of wastewater, an assumption is made that the larger the volume of wastewater discharged,the more polluted the source. From Table 7, industrial waste is discharged only into the South Fork and the Catawba Rivers. In any event, these two sources can be characterized as much the same, large drainage areas with significant urban and industrial discharges upstream. One significant difference between them is the amount of storage. Lake Norman and Mt. Island Lake are large reservoirs (32,510 acres and 3,300 acres respectively) on the Catawba that are potential raw water sources (Figure 8).

The remaining five sources contain no industrial discharges; they receive discharges from either small domestic wastewater treatment plants or schools. Because of the nature of the wastewaters, a comparison of these five sources is more accurate. The drainage areas above the proposed intake on Beaverdam Creek and the existing intake on Hoyles Creek are similar; 25 sm and 22 sm respectively. Both receive the discharge from small wastewater treatment plants, and can be considered of comparable quality. The drainage areas above the point of intake on Indian Creek and Dutchmans Creek are larger, yet only one high school

Table 9: Water Quality Ranking

River	DA (sm)	Wastewater Discharge (mgd)	Wastewater Discharge/sm	Factor (mgd/100 sm)
S.F. Catawba	628	56	0.089	8.9
Catawba R.	1,860	145	0.078	7.8
Beaverdam Cr.	25	0.18	0.007	0.7
Hoyles Cr.	22	0.15	0.007	0.7
Indian Cr.	41	0.01	0.0002	0.02
Dutchmans Cr.	125	0.01	0.0001	0.01
Long Cr.	14	0	0	0

discharges into each stream. Long Creek, with no discharges, would be the "best" source.

Table 9 is a ranking of the water quality based only on the amount of pollution, not comprehensive water quality. The overall quality of a stream is dependent on both biological and chemical/physical properties. The Water Quality Management Plan (1979) identified sedimentation as the most widespread problem in the state. The physical effects of excessive sedimentation increase costs in treating water for drinking. Suspended sediment, which does affect the aquatic community of a stream, is included in the biological assessment, Figure 8.

From Figure 8, the Catawba and the South Fork of the Catawba Rivers, Indian Creek and Hoyles Creek are all ranked as "fair", with suspended sediment listed as a major concern (NCDNRCD, 1985). Dutchmans Creek is rated good-fair, and both Beaverdam and Long Creeks are rated as good (ratings are at the point of intake, see Figure 6). Based on both biological and pollution ratings, the following ranking of the sources is suggested in Table 10.

Table 10: Comprehensive Water Quality Ranking

Source	Pollution Index	Bio. Rating	EMC Class.
1) S.F. Catawba	8.9	fair	WS-III
1) Catawba	7.8	fair	WS-III
2) Hoyles Cr.	0.7	fair	WS-II
2) Indian Cr.	0.02	fair	WS-II
2) Beaverdam Cr.	0.7	good	WS-II
2) Dutchmans Cr.	0.01	good/fair	WS-II
3) Long Cr.	0	good	WS-I

This is a slightly different ranking than that presented in Table 9. Both Hoyles Creek and Indian Creek now ranked as worse than Beaverdam Creek, although together with Dutchmans Creek, the four are considered comparable.

The Division of Environmental Managment recently changed the classification criteria for surface water supplies and defines a source according to the amount and type of permitted point source discharge as well as a requirement for land use management to control non-point sources of pollution. Waters of class WS-I are protected water supplies within natural and uninhabited or predominately undeveloped (not urbanized) watersheds with no permitted point source discharges and relatively unimpacted by non-point sources of pollution. Class WS-II waters are protected as water supplies in a low to moderately developed watershed. Domestic discharges and approved non-process water discharges are permitted. Both WS-I and WS-II watersheds must have local land use management programs to protect water supplies from non-point sources. Class WS-III waters are streams which permit industrial as well as municipal dischargers, and land use management is not required.

Technically, all the sources in Gaston County would be classified as WS-III; there are no land use controls. Neglecting the need for WS-I and WS-II waters to have land use management programs, the seven sources are classified according to this new classification.

Long Creek meets the WS-I standards, having no point dischargers (Table 7). Indian Creek, Dutchmans Creek, Beaverdam Creek and Hoyles Creek all receive discharge from high schools and/or WWTPs. Indian Creek and Dutchmans Creek could be classified as WS-I if the high schools were able to adopt an on-site location for discharging. Both the Catawba and the South Fork receive municipal and industrial wastes and are classified as WS-III.

There is no way to quantify the quality of the sources, but the ranking of sources (numbered 1 through 3) shown in Table 10 was used when evaluating alternatives to be compared on the basis of equal quantity.

5. INTERCONNECTION AMONG MUNICIPAL SYSTEMS

Regional alternatives involving interconnections of several systems are compared with independent system costs. Comparisons are made with the idea of providing equal levels of service (i.e., a similar quantity and quality of raw water). Before costing water supply alternatives, the cost of the major components must be estimated.

5.1 Cost Functions

Cost functions often take the form:

$$C = aX^b$$

Where:

C = cost

a = cost per unit capacity

X = capacity

b = economy of scale factor

Data from Cane Creek and Little River reservoirs (Hazen and Sawyer, 1985) were used to determine a rough cost function for reservoirs and pump stations. Pat Davis (OWASA, 1985) provided pipe costs. Costs for treatment plants in Mt. Holly and Bessemer City were used to develop a cost function for treatment plants. The cost per unit capacity ,a, was increased by 50% when applied to treatment plants using "poor" quality water, i.e., the South Fork of the Catawba and the Catawba Rivers. This increase is due to the additional costs associated with treating poor quality water, i.e. the cost of GAC, additional chemical costs and the cost of more frequent monitoring. The appropriate economy of scale factors were from Dr. Donald T. Lauria (UNC). The cost function used to compute the cost of elevated storage tanks was taken directly from HDR Infrastructure, Inc. The major components of the water supply systems are given below, along with the cost function used.

Reservoirs: $C = 4.6(X)^{0.8}$

C = cost in million dollars
X = capacity of reservoir in billion gallons

Pump Stations: $C = 0.18(X)^{0.7}$

C = cost in million dollars
X = capacity in mgd

Water Mains: $C = 0.67L(D)^{1.5}$

C = cost in dollars
L = length, feet
D = pipe diameter, inches

Water Treatment Plant (Good quality) $C = 1.5(X)^{0.7}$

C = cost in million dollars
X = capacity of plant, mgd

Water Treatment Plant (Poor quality) $C = 2.2(X)^{0.7}$

C = cost in million dollars
X = capacity of plant, mgd

Elevated Storage Tanks $C = 0.85(V)^{0.85}$

C = cost in million dollars
V = tank volume, mg

5.2 Analysis of Alternatives

Operation and maintenance costs are omitted. These cost estimates are intended to identify feasible alternatives and O & M costs are included later in a more thorough analysis of the best alternatives. If costs are within 20%, there is not sufficient reason for choosing one alternative over another, since these cost functions are used to illustrate a method of analysis.

Interconnections between various municipal systems may improve water quality and/or provide a sufficient quantity more economically. Bessemer City, Cherryville and Mt. Holly use good quality water and have sufficient plant capacity to meet the 20-year demand. Of the remaining four municipal systems, (Gastonia, Belmont, Stanley and High Shoals), three will need to expand their treatment facilities to meet future demand. The fourth system, High Shoals, has sufficient plant capacity but uses water from the "worst" source in the county.

The three cases given below involve those four systems that have either insufficient treatment capacity or withdraw from a poor quality source. The first case examines the alternatives available for meeting quantity problems. The last two cases look at the costs involved in improving water quality.

1) Sufficient plant capacity to meet the future demands of Gastonia, Belmont and Stanley.
2) Improved water quality for High Shoals
3) Improved water quality for Gastonia, Belmont, Mt. Holly and Stanley by developing the Dutchmans Creek watershed to meet existing and future demands.

5.2.1 Sufficient plant capacity to meet the future demands of Belmont, Gastonia and Stanley

Three systems within the county must expand their source and/or their facility capacity to meet their 20-year demand; Gastonia, Belmont and Stanley. The City of Gastonia must expand it's plant (although not until 1993), and consider developing a new source to meet future demands. The plant facility at Belmont and Stanley must also expand, but current sources can meet the 20-year demand.

The capital cost of four regional options are compared to the cost of each system remaining separate. Water quality is comparable in all except the last option, which examines the cost of using a better quality source. The interconnections evaluated are:

a) No interconnections - all systems remain separate.
b) Belmont expands it's treatment facility and pipes treated water to Gastonia. Stanley could either remain separate (b1), or buy treated water from Mt. Holly (b2).
c) Gastonia and Stanley remain separate and Belmont buys water from Mt. Holly.
d) A new treatment plant to serve Gastonia, Belmont and Stanley is constructed to treat water from either the South Fork (d1) or Mt. Island Lake (d2). Included under this option is another case where Belmont buys water from Mt. Holly, and Gastonia and Stanley jointly own the treatment plant, (d3).
e) A new treatment plant to serve Gastonia, Belmont and Stanley is constructed to treat water from Dutchmans Creek, a better quality source.

A short discussion of each option is presented along with the major capital cost components associated with each system included.

a) No interconnections - all systems remain separate

Both Belmont and Stanley take from sources that have an adequate safe yield to meet their 20-year demand, but these communitites do not have the capacity to treat enough water to meet these demands. The cost of individual system expansions is as follows:

Belmont:

1000 ft of 16-in raw water pipeline	$0.04 Million
2.5-mgd pump station	0.3
2.5-mgd tmt plant expansion	4.3

	$4.6 Million

Stanley:

2.4 miles of 6-in raw water pipeline	$0.1
0.5-mgd pump station	0.1
0.5-mgd tmt plant expansion	0.9

	$1.1

Unfortunately, physical restrictions prohibit further expansion beyond 27.3 mgd of the Gastonia water plant. J.N. Pease Associates (1986) identified two potential water treatment plant sites (Figure 9).

Gastonia must either develop another source, or somehow increase the safe yield of the South Fork at the point of intake. Since comparisons of the various options should be based on providing raw water of at least comparable quality, increasing the safe yield of the South Fork would provide similar water quality while retaining Gastonia's individual ownership and operation of the city's system. Site 2 is the location of the water plant used in this analysis. Figure 7 was used to determine the capacity needed to provide 33 mgd, the expected withdrawal for Gastonia, and the communities supplied by Gastonia.

maf within the drainage area = 628 sm x 1.2 cfs/sm
= 754 cfs = 490 mgd
490 mgd x 360 days = 180,000 mg

withdrawal (33mgd) = 51 cfs
annual draft required from
South Fork Catawba = 51/754 = 0.07 = 7%

Ordinarily, Figure 7 could be used directly to determine

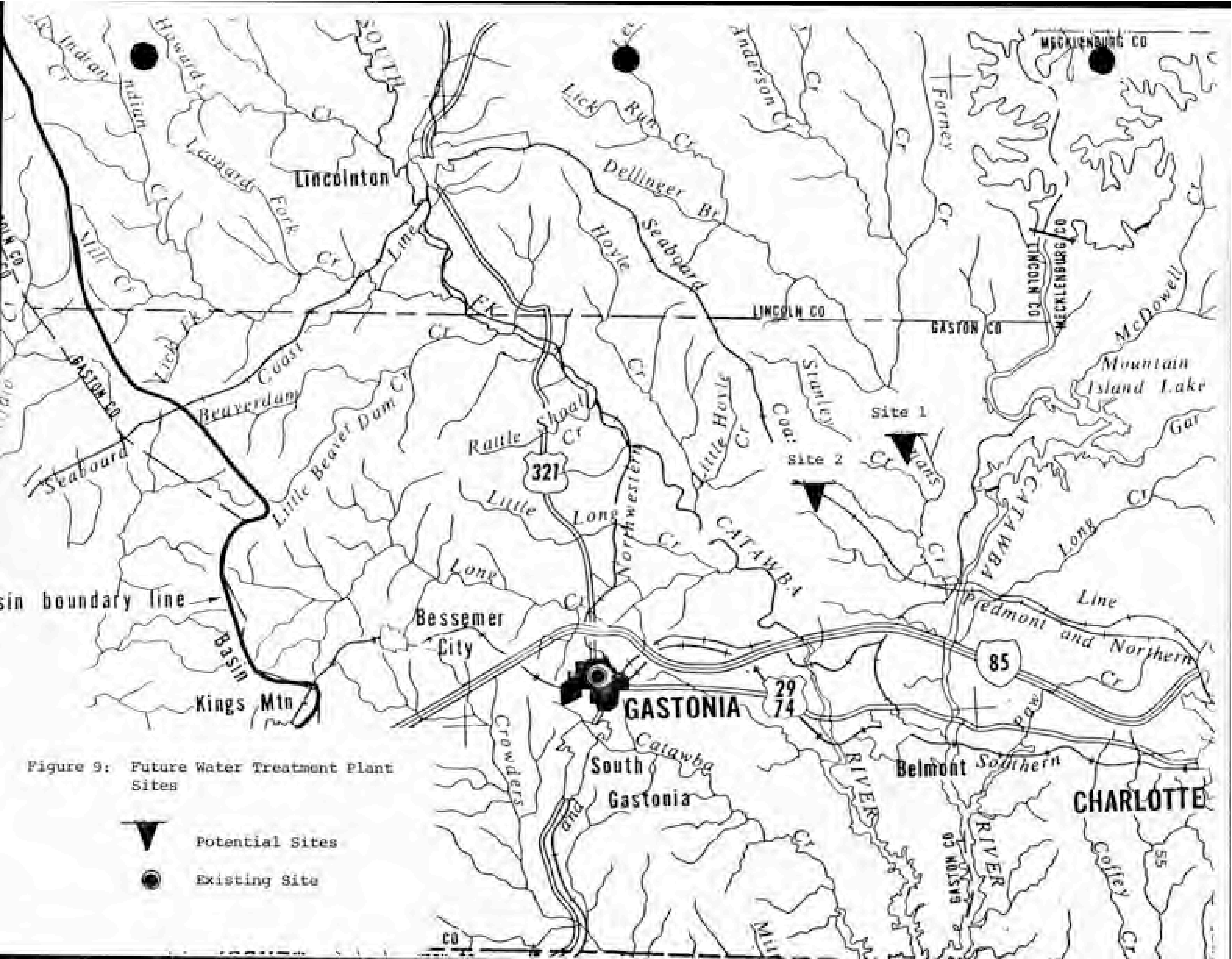


Figure 9: Future Water Treatment Plant Sites

the storage needed. However, since such a small percentage of the mean annual flow is required to meet the demand, it was assumed that 0.5% of the maf would be a sufficient storage capacity. The required storage would be:

$$0.005 \times 180{,}000 \text{ mg} = 0.9 \text{ billion gallons}$$

From the cost function determined earlier for reservoir construction, the approximate cost to construct a dam on the South Fork of the Catawba to provide adequate storage would be:

$$C = 4.6(0.9)^{0.8} = \$4.2 \text{ million}$$

The cost of treating and piping water for Gastonia and the surrounding communities is:

3.0 miles of 24-in raw water pipeline	$ 1.2
5.7-mgd pump station	0.6
5.7-mgd tmt plant	7.4
dam construction	4.2
7.9 miles of 24-in treated water pipe	3.3

	$17

The total cost for individual expansions:

Gastonia	$17
Belmont	4.6
Stanley	1.1

	$23 million

(Although Gastonia dosen't need to expand it's treatment facility until 1993, in order to make comparisons on an equal basis, all options were based on expansions occuring immediately).

b1) Belmont expands treatment facility and pipes treated water to Gastonia; individual expansion of the plant at Stanley:

The city of Belmont takes directly out of the Catawba River, the safe yield is estimated to be 50 mgd. The 20-year maximum day water demand projections for Gastonia and Belmont are:

Gastonia =	33.0 mgd (including amount sold to neighboring communities)	
Belmont =	7.5 mgd	
total	40.5 mgd	

The two existing systems combined have the capacity to treat:

Gastonia	27.3 mgd treatment plant capacity	
Belmont	5.0 mgd treatment plant capacity	
	32.3 mgd	

Therefore, for Belmont to expand their plant and pipe treated water to Gastonia, the plant would need to expand by 8.2 mgd. In this initial analysis, the five communities currently served by Gastonia are considered as being a part of Gastonia. The cost of an interconnection between Belmont and Gastonia are shown below. Costs to be shared between Belmont and Gastonia (costs for the expanded treatment facility, pump station and raw water line) are allocated according to the percentage of the total capacity required by each city to meet future demands.

	Belmont	Gastonia
1000 ft of 30-in raw water pipeline to Belmont	$0.02	$ 0.1
8.2-mgd tmt plant expansion	1.4	8.2
8.2-mgd pump station	0.1	0.7
9.5 miles of 24-in treated water pipeline to Gastonia		4.0
5.7-mgd pump station		0.6
	$1.5	$14

The expansion of the Stanley treatment plant involves the following costs:

2.4 miles of 6-in raw water pipeline	$0.1
0.5-mgd pump station	0.1
0.5-mgd treatment plant expansion	0.9
	$1.1

The total cost for this alternative is:

Belmont/Gastonia interconnection	$16.
Stanley expansion	1.1
	$17 million

b2) Belmont expands and pipes treated water to Gastonia; Stanley buys from Mt. Holly, Figure 10.

In 1984, a new 6-mgd treatment plant came on line to meet the projected 40-year demand of Mt. Holly. Currently, only 40% of the plant capacity is being used. Some agreement may be worked out whereby part of this excess capacity is used to treat water to meet the demand faced by Stanley. The 20-year demands of Mt. Holly and Stanley could both be met by the new Mt. Holly plant.

* Mt. Holly plant capacity	6.0 mgd
* 20-year demand for Mt. Holly	3.0 mgd
* Stanley 20-year demand - in excess of current plant capacity	0.5 mgd

The treated water would be piped from Mt. Holly to Stanley, and would incur the following costs:

6.3 miles of 6-in treated water pipeline	$0.3 million
0.5-mgd pump station	0.1
	$0.4

The cost for the Belmont/Gastonia interconnection is the same as that calculated in a). The total cost for this alternative is:

Belmont/Gastonia interconnection	$16
Stanley to purchase water from Mt. Holly	0.4
	$16 million

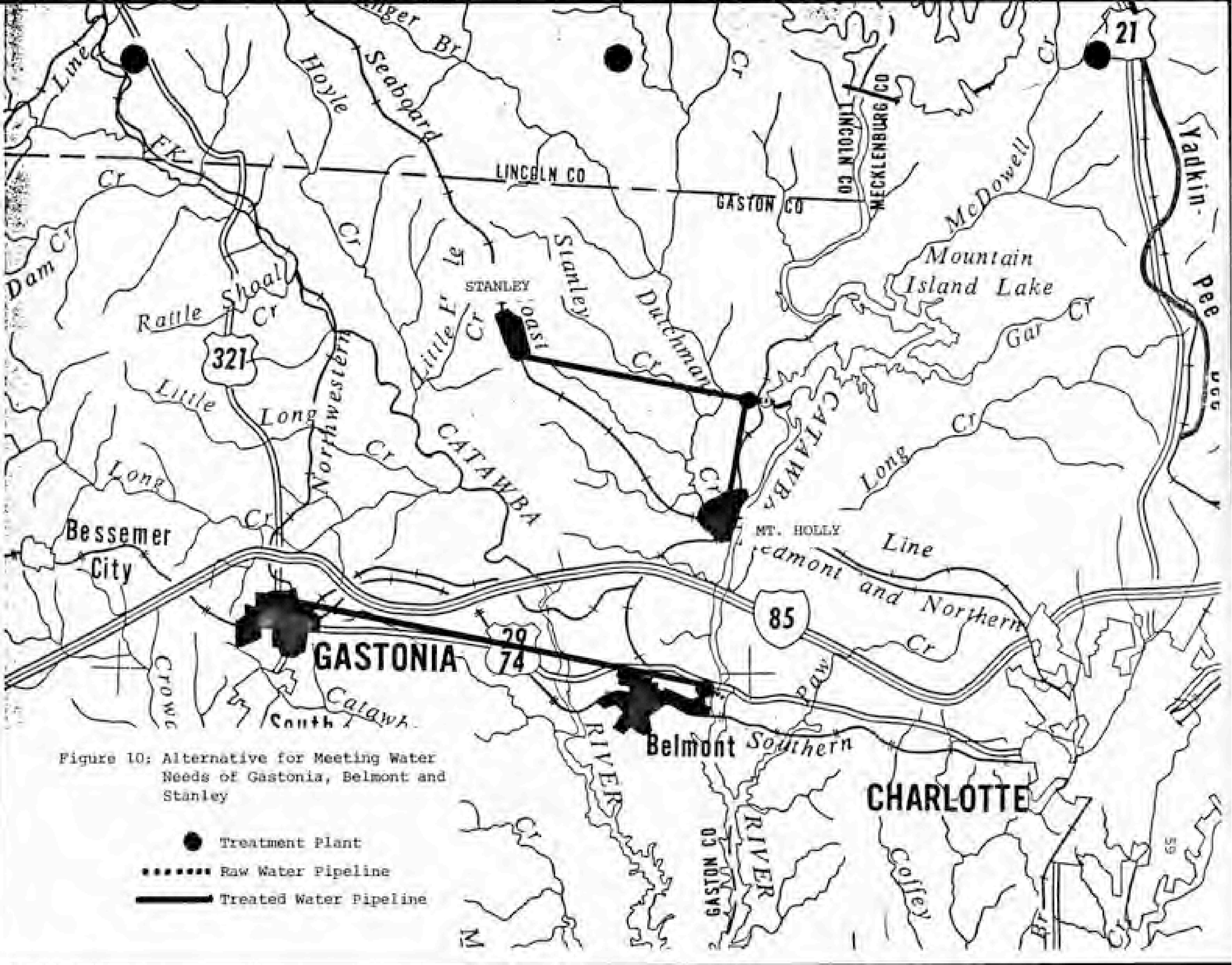


Figure 10: Alternative for Meeting Water Needs of Gastonia, Belmont and Stanley

c) Stanley and Gastonia expand independently; Belmont buys treated water from Mt. Holly

An interconnection between Belmont and Mt. Holly would cost the following:

6.3 miles of 16-in treated water pipeline	$1.4
2.5-mgd pump station	0.3

	$1.7

The individual expansion costs for Stanley and Gastonia were given above bringing the total cost for this alternative to:

Mt.Holly/Belmont interconnection	$ 1.7
Gastonia expansion	17.
Stanley expansion	1.1

	$20 million

d) Construction of a new treatment plant

When Gastonia is required to treat more than 27.3 mgd, they will have to build a new plant. Two potential water treatment sites were identified (Figure 9), and the following analysis is based on these locations. Raw water from the South Fork or Mt. Island Lake would be treated and piped to Gastonia, Belmont and Stanley, Figure 11. Because of distance, Belmont may not find it advantageous to share in the construction and operation of a new plant, so a third subcase examines the construction of a new plant to serve only Gastonia and Stanley.

1) Plant constructed at site 2 to treat water for Gastonia, Belmont and Stanley using the South Fork as the raw water source. A dam constructed on the South Fork could provide enough water to meet demands. Gastonia, Belmont and Stanley share the cost of the raw water line, pump station, treatment plant and dam. Again, costs are determined by the percentage of total capacity needed by each city.

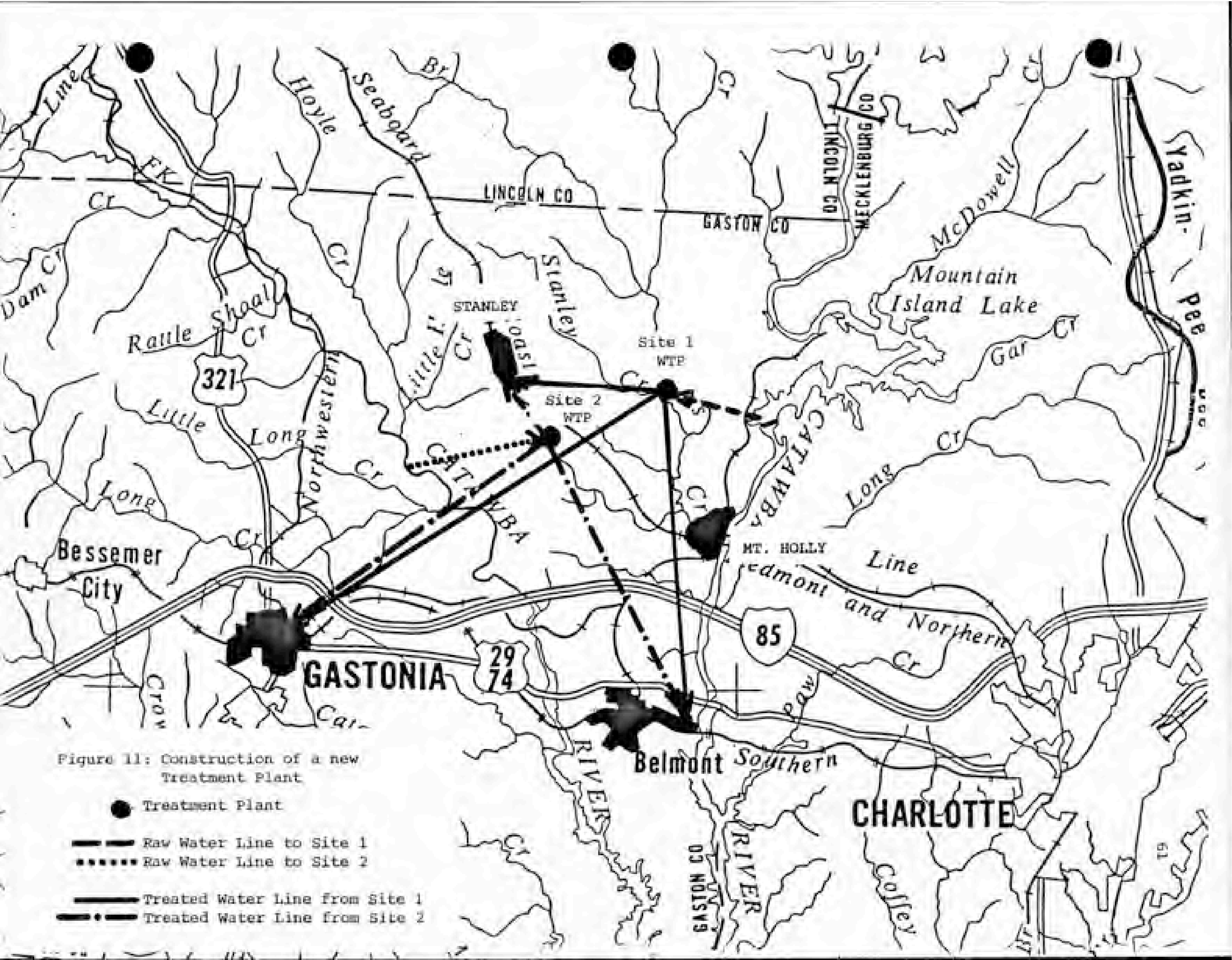


Figure 11: Construction of a new Treatment Plant

	Gastonia	Belmont	Stanley
3 miles of 24-in raw water pipeline	$0.8	$0.3	$0.1
8.7-mgd pump station from source to plant	0.5	0.2	0.1
8.7-mgd tmt plant	6.5	2.9	0.6
dam construction	2.7	1.2	0.3
0.5-mgd pump station from plant to Stanley			0.1
1.6 miles of 6-in treated water pipeline			0.1
2.5-mgd pump station from plant to Belmont		0.3	
7.9 miles of 16-in treated water pipeline		1.8	
5.7-mgd pump station from plant ot Gastonia	0.6		
7.9 miles of 24-in treated water pipeline	3.3		
	------	------	------
	$14	$6.7	$1.3

Total cost for e1) = $22 million

2) Plant constructed at site 1 to treat water for Gastonia, Belmont and Stanley using water from Mt. Island Lake.

	Gastonia	Belmont	Stanley
1.6 miles 30-in raw water pipeline	$0.6	$0.3	$0.1
8.7-mgd pump station	0.5	0.2	0.1
8.7-mgd tmt plant	6.5	2.9	0.1
0.5-mgd pump station			0.1
4.7 miles 6-in treated water pipeline			0.2
2.5-mgd pump station		0.3	
7.9 miles 16-in treated water pipeline		1.8	
5.7-mgd pump station	0.6		
11 miles 24-in treated water pipeline	4.6		
	------	-------	-------
	$13	$5.5	$1.1

Total cost for e2) = $20 Million

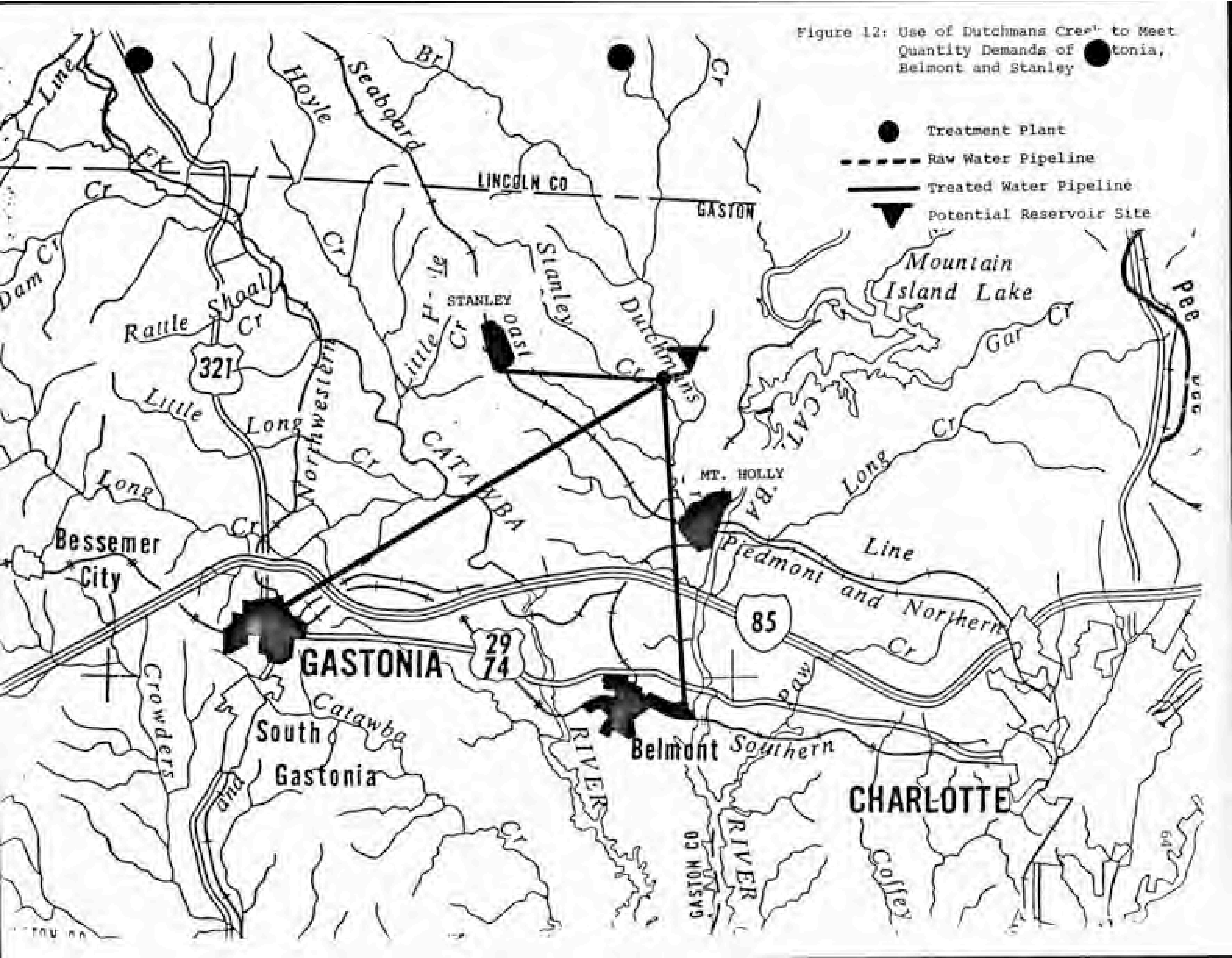
3) Plant built at site 1 to treat water for Gastonia and Stanley, Belmont buys water from Mt. Holly.
It may be possible for Gastonia and Stanley to recognize savings without the help from Belmont; Mt. Island Lake would be used by all four communities, but only two treatment facilities would be needed.

	Gastonia	Stanley
1.6 miles of 24-in raw water pipeline	$0.6	$0.1
6.2-mgd tmt plant	7.3	0.6
6.2-mgd pump station	0.6	0.1
11 miles 24-in treated water pipeline	4.6	
5.7-mgd pump station	0.6	
4.7 miles 6-in treated water pipeline		0.2
0.5-mgd pump station		0.1
	------	-------
	$14	$1.1

Belmont/Mt. Holly interconnection = $1.7
Total cost = $17 Million

e) Finally, providing improved quality, another alternative available to meet the future demands of these three communities would be the development of the Dutchmans Creek watershed. A reservoir of 0.4 billion gallons is estimated to provide an additional 8.7 mgd. Again, site 1 was used as the location of the treatment plant, Figure 12.

Figure 12: Use of Dutchmans Creek to Meet Quantity Demands of Gastonia, Belmont and Stanley



	Gastonia	Belmont	Stanley
Reservoir construction	$1.7	$0.4	$0.1
1000 ft of 30-in raw water pipeline	0.1	---	---
8.7-mgd pump station	0.5	0.2	0.1
8.7-mgd tmt plant	4.4	2.0	0.4
4.7 miles 6-in treated water pipeline			0.2
0.5-mgd pump station			0.1
7.9 miles 16-in treated water pipeline		1.8	
2.5-mgd pump station water pipeline		0.3	
5.7-mgd pump station	0.6		
11 miles 24-in treated	4.6		
	$12	$4.7	$0.9

Total cost = $18 Million

Costs for alternatives a) through e) are summarized in Table 11. Costs are shown in million dollars.

Individual ownership is approximately 40% more costly than alternative b), the least costly alternative. There are several problems with this alternative that are not included in the cost estimates. Earlier in chapter 4, the water quality of the Catawba and South Fork Catawba were evaluated and ranked as comparable. However, Belmont has the misfortune of taking water from the Catawba approximately 6 miles downstream from where Sodyeco, a division of Martin-Marietta Chemicals, discharges. Sodyeco discharges roughly 85% (by volume) of the registered toxic waste in the state. The Catawba has periods of high turbidity (sometimes over 1000 n.t.u.). Gastonia officials are not enthusiastic over using water at this point, considering finished water from Belmont to be inferior to what they are capable of producing. In addition, Belmont Converting Company, which operates the water treatment plant, has reported

Table 11: Interconnection Costs and Alternatives
(Cost in Million Dollars)

Alternative	Cost to Gastonia	Cost to Belmont	Cost to Stanley	Total Cost
a) All systems remain separate	$17	$4.6	$1.1	$23
b) Belmont sells to Gastonia				
1) Stanley remains separate	14	1.5	1.1	17
2) Stanley buys from Mt. Holly	14	1.5	0.4	16
c) Mt.Holly sells to Belmont/Stanley and Gastonia expand	17	1.7	1.1	20
d) Plant constructed to treat water for Gastonia Belmont, Stanley				
1) Using South Fork	14	6.7	1.3	22
2) Using Mt. Island Lake	13	5.5	1.1	20
3) Gastonia/Stanley use Mt. Island Lake/Belmont buys from Mt. Holly	14	1.7	1.1	17
e) Use Dutchmans Cr.	12	4.7	0.9	18

THHM concentrations over the allowable limit several times. No correlation has been found between excessive THM concentrations and Sodyeco's discharge, although there was enough concern to warrent investigation. On July 17, 1986 the Charlotte Observer carried a brief article citing an investigation into the Belmont water supply due to reports of worms in the water supply. The Belmont water treatment plant is 60 years old, and expansion of 8.7 mgd may not be possible. For these reasons, b) Belmont treating water for Gastonia, was not considered a feasible alternative.

Because Gastonia will be forced to build a new plant sometime in the next twenty years, they have the flexibility of looking at a new source. Mt. Island Lake, a reservoir on the Catawba, is generally thought of as a better source than the South Fork due to lower turbidities, only one discharger directly into the reservoir, and a more consistent water level. Using Mt. Island Lake (d2) seems preferrable to using the South Fork (d1), both from quality and cost considerations. Distance may prohibit Belmont from enjoying the benefits of a jointly owned plant.

The option of either Belmont or Stanley buying water from Mt. Holly is more a political issue than a matter of cost, and is beyond the scope of this report. In looking at the feasibility of regionalization strictly from an economic viewpoint, use of Dutchmans Creek or Mt. Island Lake seem the most attractive alternatives.

5.2.2 Improve Water Quality to Mt. Holly, Belmont, Stanley and Gastonia by Developing Dutchmans Creek to Meet Existing and Future Demands

The Dutchmans Creek watershed is a high quality source from a public health standpoint. According to the ranking of Table 10, it is better or at least equal in quality to any of the sources currently used. Dutchmans Creek could conceivably supply enough water to supply the existing and future demands for Gastonia, Belmont, Mt. Holly, and Stanley; a total of 45 mgd. This would require a reservoir with the capacity of approximately 4 billion gallons. The options presented under this heading examine the cost to the above communities to not only meet future demands, but to use the highest quality source to meet all total demands, i.e. discontinue use of the current raw water sources in favor of an impoundment on Dutchmans Creek. Water can be withdrawn and treated at a jointly owned plant (a), Figure 13, or withdrawn by each system individually, (b).

a) Raw water is treated at plant constructed at site 1, and treated water is piped to Gastonia, Belmont and Stanley

This alternative is similiar to the earlier analysis involving Dutchmans Creek, except that in this case, Dutchmans Creek provides all raw water needed to meet demand. The estimated costs are given on the next page.

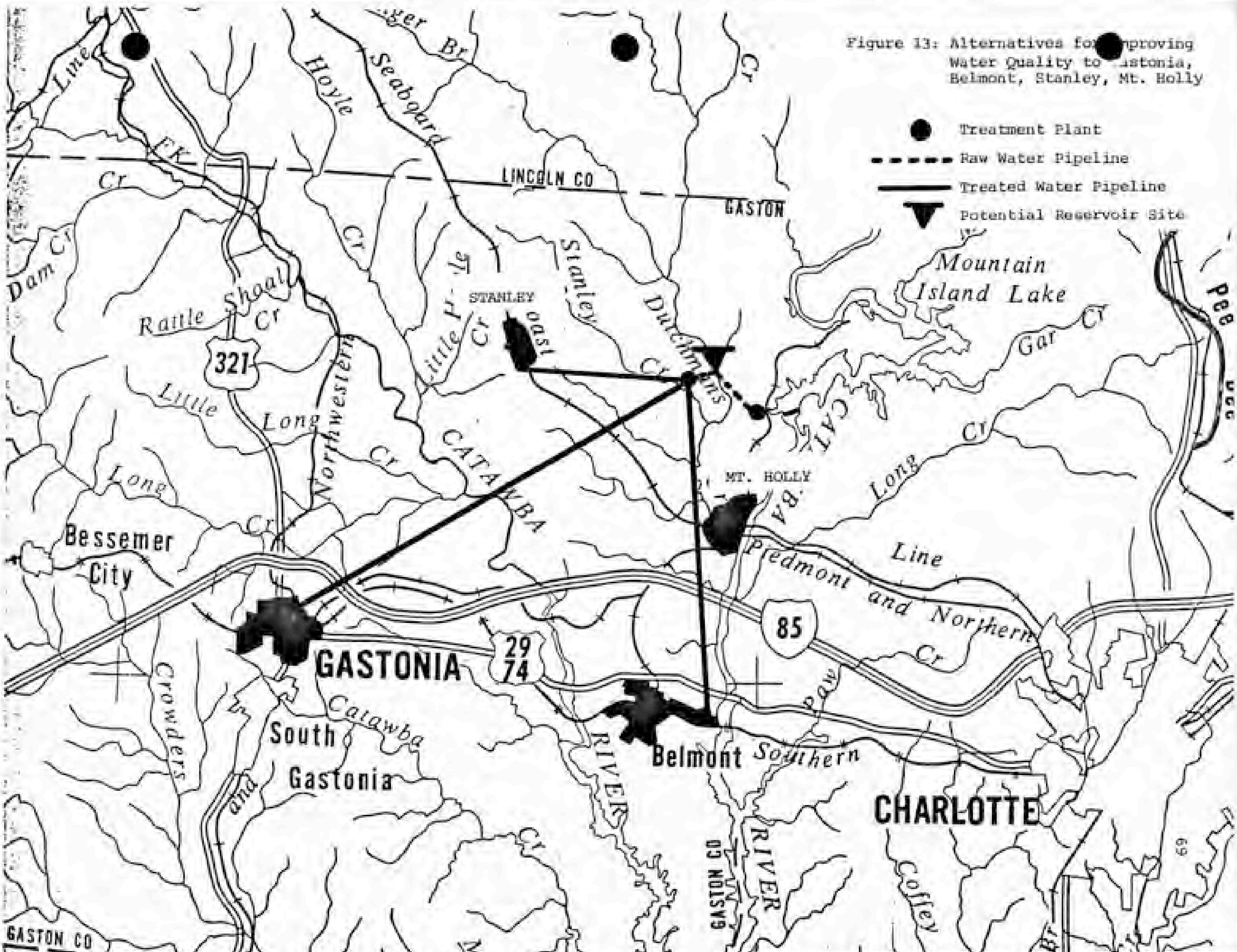


Figure 13: Alternatives for Improving Water Quality to Gastonia, Belmont, Stanley, Mt. Holly

	Gastonia	Belmont	Stanley	Mt. Holly
1000 ft of 60-in raw water pipeline	$ 0.2	$3.7	---	
42-mgd pump station	1.9	0.1	$0.1	
reservoir construction	10	2.2	0.4	$1.0
42-mgd tmt plant	16	3.7	0.6	
1.3-mgd pump station			0.2	
4.7 miles 12-in treated water pipeline			0.5	
7.5-mgd pump station		0.7		
7.9 miles 24-in treated water pipeline		3.3		
33-mgd pump station	2.1			
11 miles 54-in treated water pipeline	15			
3-mgd pump station				0.4
1.6 miles 16-in treated water pipeline				0.4
	----	-----	-----	-----
	$45	$10	$1.8	$1.8

Total cost = $59 Million

The costs given above are to build the reservoir, pipeline and treatment plant for Gastonia, Belmont, Stanley and Mt. Holly.

b) Each system could take directly from the reservoir and treat at their own plant.

Belmont:

reservoir construction	$2.2
7.9 miles of 24-in raw water pipeline	3.3
7.5-mgd pump station	0.7
2.5-mgd tmt plant expansion	2.8

	$9.0

Stanley:

reservoir construction	$0.4
5.4 miles of 12-in raw water pipeline	0.8
1.3-mgd pump station	0.2
0.5-mgd tmt plant expansion	0.9

	$2.3

Gastonia:

reservoir construction	$10
1000 ft of 54-in raw water pipeline	0.3
33-mgd pump stations (2)	4.2
33-mgd tmt plant	17
11 miles of 54-in treated water pipeline	15

	$47

Total cost = $60 million

To summarize, the total cost to each community under each alternative is:

Alternative	Gastonia	Belmont	Stanley	Mt. Holly	Total
a)-regional	$45	$10	$1.8	$1.8	59
b)-independent	47	9	2.3	1.8	60

From this analysis, the difference between a regional system and one where municipalities operated separately is negligible.

5.2.3 Improved Water Quality for High Shoals

High Shoals now takes water from the South Fork of the Catawba which is one of the poorer quality sources of drinking water in the county (see Table 10). In addition, operation of the hydroelectric plant upstream causes troublesome fluctuations in the water level. Two options are available to the community which would provide a high quality and more stable water source; withdrawing from either Holyes Creek (a), or Beaverdam Creek (b), Figure 14.

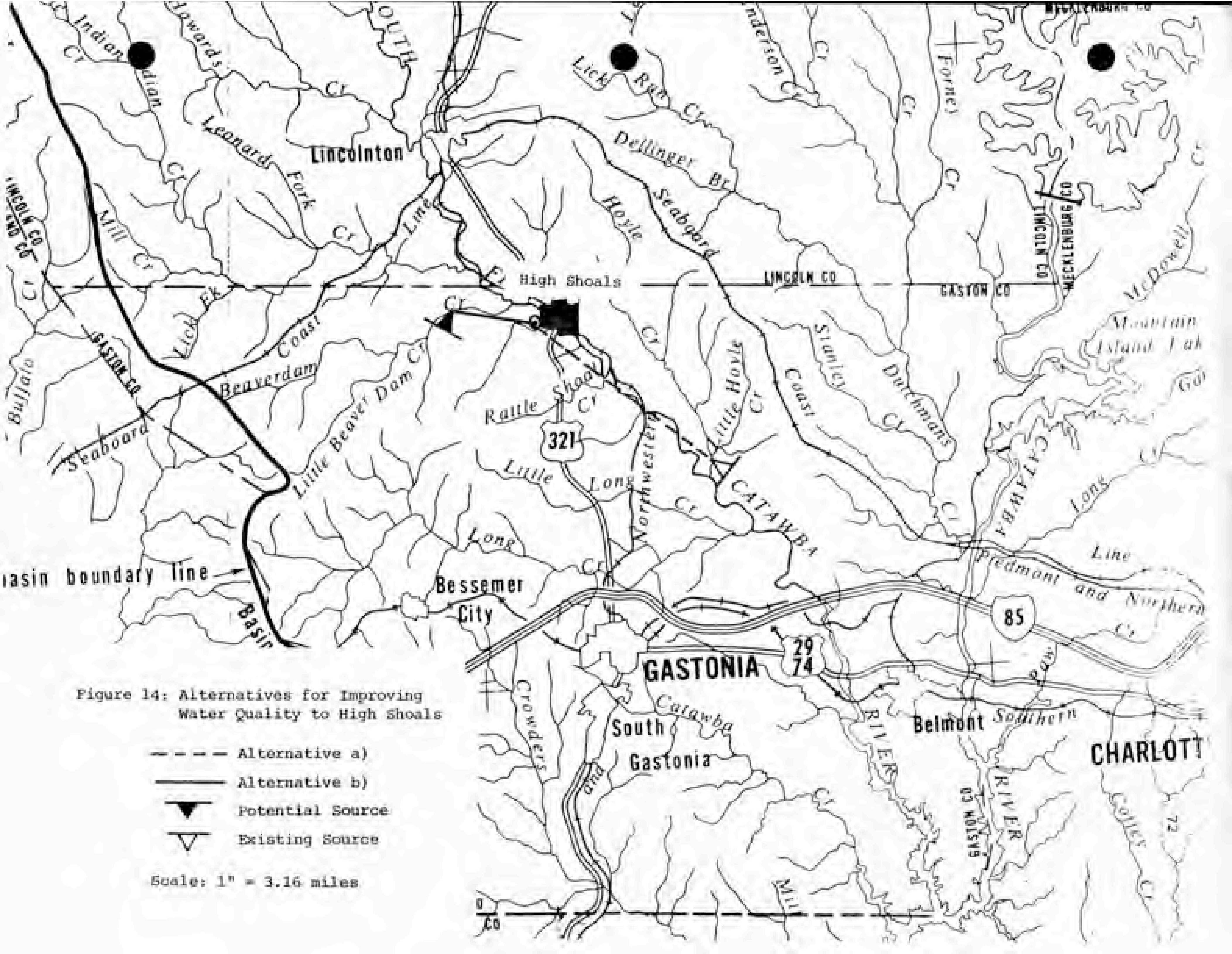


Figure 14: Alternatives for Improving Water Quality to High Shoals

a) High Shoals can take water from the Hoyles Creek impoundment.

Stanley, which draws from the impoundment has a projected demand of 1.3 mgd. The impoundment on Hoyles Creek has a safe yield of 3 mgd. With a projected demand of only 0.1 mgd and sufficient plant capacity, High Shoals may draw raw water from this impoundment and treat it at the existing plant. This would require:

6.3 miles of 3-in raw water pipeline		$0.1 million
0.23-mgd pump station		$0.1
	Total cost	$0.2

b) High Shoals can draw water from Beaverdam Creek

With no impoundment, Beaverdam Creek has a safe yield of 1 mgd, and can furnish water to High Shoals with present treatment capacity for the 20-year demand. So the only cost is piping the raw water from Beaverdam Creek to High Shoals:

2.4 miles of 3-in raw water pipeline		$0.04
0.23-mgd pump station		$0.1
	Total cost	$0.14

The raw water quality from these two sources is comparable (see Table 10). Either source would be preferable to the South Fork of the Catawba, if cost were not a consideration. In summary:

Alternative	Cost to High Shoals
a) Use of Hoyles Creek	$200,000
b) Use of Beaverdam Creek	$140,000

Either alternatives would provide better quality raw water, than what is currently used. Since the water quality of the two sources is comparable, the preferred means of improving water quality would be b), which is approximately two-thirds the cost of a). In this instance, the distance between the source (Hoyles Creek impoundment) and the existing treatment plant at High Shoals makes the regional alternative more costly than the development of a new source.

5.3 Summary of Preliminary Analysis

This preliminary analysis considers only the advantages (or disadvantages) of two or more systems utilizing common treatment facilities, pipelines and/or common raw water sources.

Unless there are health concerns with the quality of drinking water, it is doubtful that the consumers in High Shoals would be willing to pay $140,000 for a higher quality source. High Shoals consumers are already paying a high price for water, the reasons and cost are discussed later. Improving water quality to the communities of Gastonia, Belmont, Stanley and Mt. Holly individually would cost roughly three times that of using their existing source or one of comparable quality. Unless consumers are dissatisfied with their water quality, total use of a new source does not appear to be justified. Based on this initial analysis, the interconnections listed below appeared the most attractive:

* Use of Mt. Island Lake to serve Gastonia, Stanley and possibly Belmont
* Use of Dutchmans Creek to serve Gastonia, Stanley and Belmont

From Table 11, there is less than a 20% variation in the capital costs to Belmont and Stanley between using either Mt.

Island Lake or Dutchmans Creek versus expanding their systems separately. The O & M costs associated with these two alternatives are incorporated in the next analysis.

5.4 Incorporating Operation and Maintenance Costs

Building a new treatment plant to use either Dutchmans Creek or Mt. Island Lake as a supplemental water source may be more economical than for Gastonia, Belmont and Stanley to expand their own plants. Gastonia must build a new treatment plant regardless of what other communities decide and would clearly benefit from a regional plan by sharing capital and operational costs. As mentioned earlier, benefits of a regional plan to either Stanley or Belmont are not as obvious.

Capital costs were based on a 20-year design period, so O & M costs are estimated over the same length of time. Operation and maintenance in this analysis includes pumping costs and salary projections over 20 years. Utility costs were calculated assuming:

1) a pumping efficiency of 65%
2) price of electricity being \$0.045/KWH

The cost function for salaries was derived from 1985/1986 salary projections of several treatment plants. Dr. Don Lauria (UNC) provided the economy of scale factor. The resulting cost function used is:

$$C = 36000(x)^{0.6}$$

x = plant capacity, mgd
C = cost per year for personnel to run plant

5.4.1 Regional plan

5.4.1.1 Utility costs

A schematic diagram of the suggested regional plan is shown in Figure 15. Belmont and Stanley would contine to receive water from their existing sources as well as treated water from either Dutchmans Creek or Mt. Island Lake. The power costs associated with pipes (a) through (f) are calculated in Table 12. Several assumptions were made to facilitate calculations.

1) The average demand, Q(ave), is constant over the 20-year period. For pipes (a) and (b), the average flow into the plant was assumed to be 50% of the design capacity (8.7 mgd). The average flow into Stanley (pipes (c) and (d)) and Belmont (pipes (e) and (f)) is based on the average of current demand and projected demand.

	Average Demand (mgd)		Q(ave)
	1985	2005	(mgd)
Stanley	0.6	0.7	0.7
Belmont	3.2	3.7	3.5

2) All three cities will share the construction and O & M costs of the new plant. Because the plant is designed to treat the projected maximum day demand (8.7 mgd) for all three cities, the percentage of total plant capacity needed by each city is as follows:

Gastonia	65%
Belmont	29%
Stanley	6%

Since the average flow into the plant is 4.5 mgd, the average flow, Q(ave), from the plant to Gastonia, Belmont and Stanley (through pipes (g), (e), and (c)) is as follows:

Gastonia: .65 x 4.5 mgd = 2.9 mgd ; pipe (g)
Belmont: .29 x 4.5 mgd = 1.3 mgd ; pipe (e)
Stanley: .06 x 4.5 mgd = 0.3 mgd ; pipe (c)

3) The pumps will operate 24 hours/day at the new plant, but at the smaller Belmont and Stanley plants, the pumps will operate based on the ratio of average day demand to maximum day demand.

Figure 15: Schematic Diagram of Regional Plan

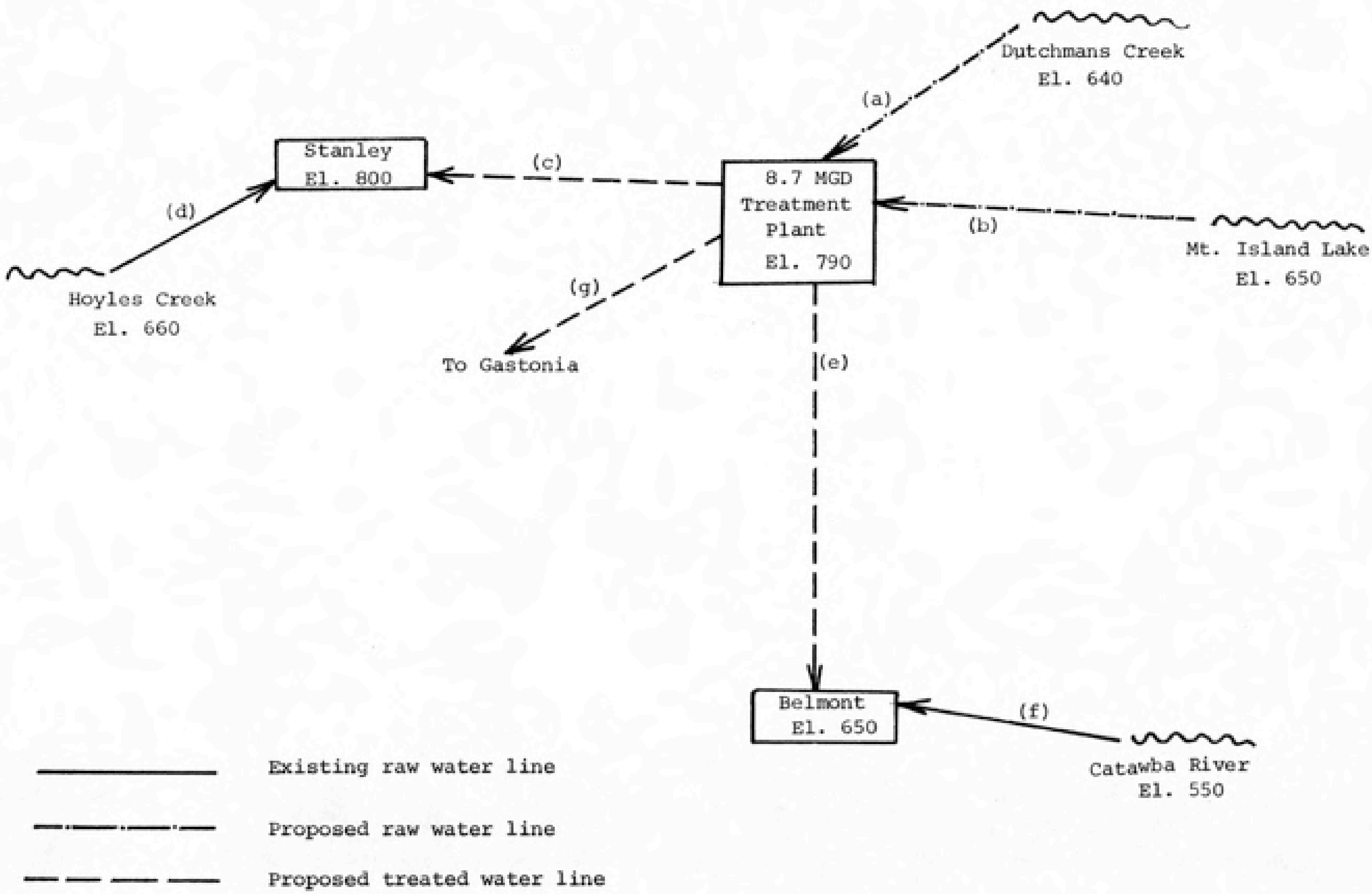


Table 12: Power Costs Associated with Regional Plan

Pipe	Pipe dia. (in)	Length (mi.)	Q(max) (mgd)	Q(ave) (mgd)	Pumping hrs/day	Friction loss (ft/1000 ft)	Static loss (ft)	(1) Total head Loss, (ft)	(2) Power (KWH/yr)	(3) Power Cost ($)
(a)	30	0.7	8.7	4.5	24	0.391	150	151	1,190,000	53,600
(b)	30	1.6	8.7	4.5	24	0.391	140	143	1,140,000	51,300
(c)	6	4.7	0.5	0.3	24	6.6	10	174	87,600	4,000
(d)	8	2.4	0.8	0.4	12	7.8	140	240	74,500	3,400
(e)	16	7.9	2.5	1.3	--*	0.9	---	---	-0	-0
(f)	20	0.2	5.0	2.2	11	3.2	100	103	181,000	8,100

(1) Total head loss = [(Friction loss)(Length)(5280 ft/mile)] + Static loss

(2) Power = $\dfrac{(Q(ave))(\text{Total head loss})(8.34\ \text{lbs/gal})(1\ \text{day}/86400\ \text{sec})(1\ \text{kw}/737.5\ \text{ft-lb/sec})}{0.65}$ (365 days/yr)(pumping hrs/day)

(3) Power cost = (Power)(.045/KWH)

* No pumping necessary

The last column in Table 12, Power Cost, is a constant, annual cost for power over the 20-year design period. The only O & M cost difference between using Dutchmans Creek and Mt. Island Lake is the cost of pumping the raw water from source to plant, $53,600 and $51,300 respectively. Therefore, O & M costs are calculated using Dutchmans Creek as the source and the final O & M costs for both regional alternatives is assumed to be equal. From Table 12, the annual power cost to Belmont and Stanley is:

<u>Belmont</u>:

0.06 x $53,600	=	$3,200
pipe (c)	=	4,000
pipe (d)	=	3,400
		$10,600

<u>Stanley</u>:

0.29 x $53,600	=	$15,500
pipe (e)	=	-0
pipe (f)	=	8,100
		$23,600

5.4.1.2 Salary Costs

Table 13 shows estimates of a constant, annual salary cost over the 20-year period. Since the new plant will supply water to supplement the existing plant, the future salary costs are a combination of both existing and future plant capacities. As with power costs, the salary costs were estimated for the current year and at the end of 20 years. The average is taken as constant over the design life of the facility. Combining utility costs with salary costs, the annual O & M costs to Belmont and Stanley are:

Table 13: Salary Costs Associated with Regional Plan

	1985		2005		
	Existing Plant Capacity, mgd	[1] Salary cost ($)	% Share of New 8.7 mgd Plant*	[2] Salary cost ($)	[3] Constant Salary cost ($)
Stanley	0.8	31,500	6	39,400	35,500
Belmont	5.0	95,000	29	133,000	114,000

[1] Salary cost = $36000(\text{existing plant capacity})^{0.6}$

[2] Salary cost = $36000(8.7)^{0.6}$ x fractional share of new plant + [1]

[3] Constant Salary cost = ([1] + [2])/2; assumed constant over the 20-yr design period

* Gastonia's share in the new plant is 65%

Stanley:

Salaries:	$35,500
Utilities:	10,600
	$46,100

Belmont:

Salaries:	$114,000
Utilities:	23,600
	$137,600

Assuming a 10% discount rate, over 20 years the present value of O & M costs is:

Belmont:	$1.2 Million
Stanley:	$0.4 Million

5.4.2 Individual Expansions
5.4.2.1 Utility Costs

A schematic diagram is shown in Figure 16. The power costs corresponding to pipes (a) through (d) are shown in Table 14. The annual power costs to Belmont and Stanley are:

Belmont:

pipe (c):	$8,200
pipe (d):	4,900
	$13,100

Stanley:

pipe (a):	$3,400
pipe (b):	2,300
	$5,700

5.4.2.2 Salary Costs

Salary costs estimates are shown below:

	Plant Capacity (mgd) 1985	2005	[1] Ave. Capacity over 20-yrs	[2] Salary Cost ($)
Stanley	0.8	1.3	1.1	$38,000
Belmont	5.0	7.5	6.3	$110,000

[2] Salary costs = $36000([1])^{0.6}$

Figure 16: Schematic Diagram of Individual Expansions

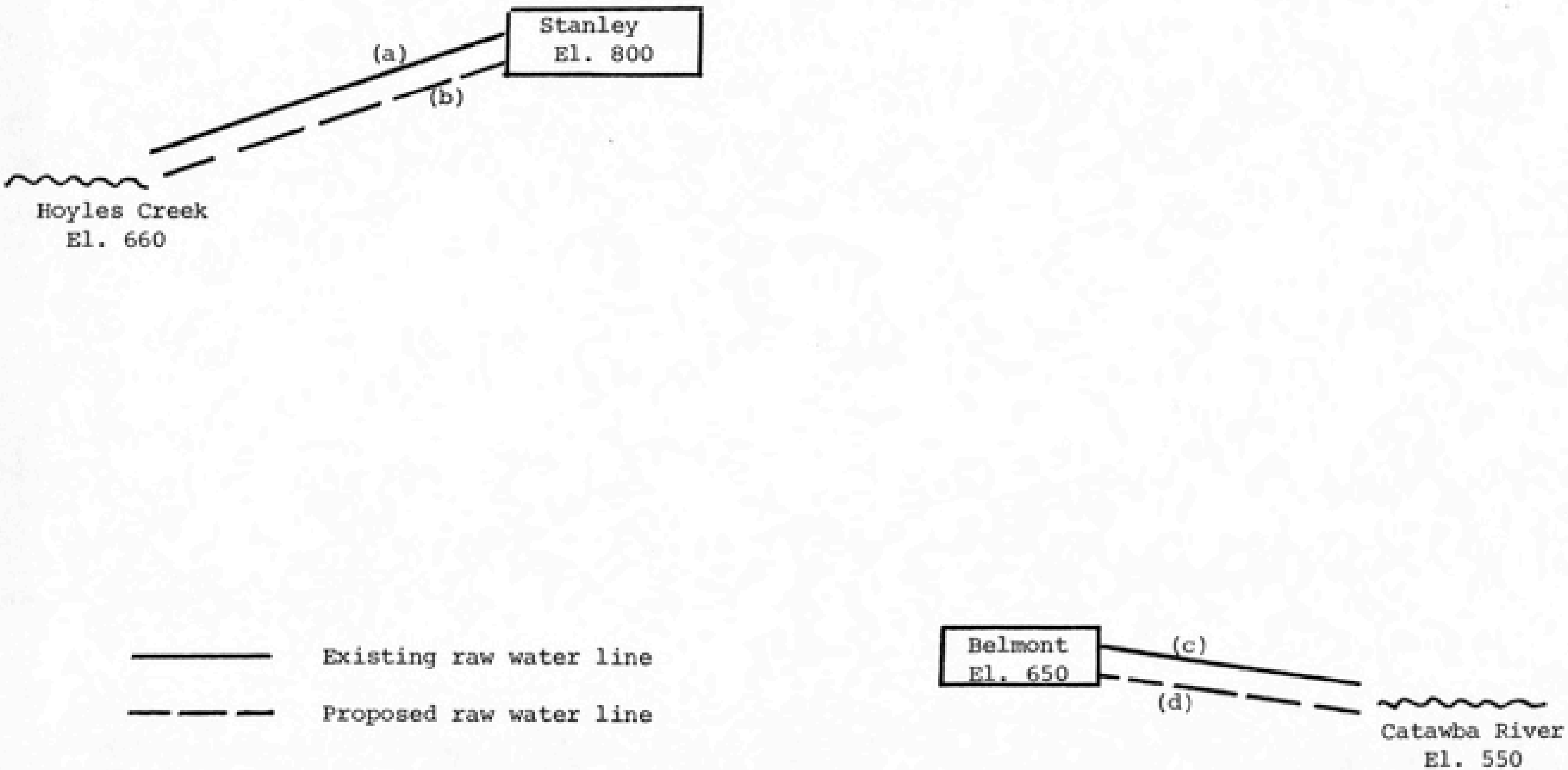


Table 14: Power Costs Associated with Individual Expansions

Pipe	Pipe dia. (in)	Length (mi.)	Q(max) (mgd)	Q(ave) (mgd)	Pumping hrs/day	Friction loss (ft/1000 ft)	Static loss (ft)	(1) Total head Loss, (ft)	(2) Power (KWH/yr)	(3) Power Cost ($)
(a)	8	2.4	0.9	0.5	12	12	140	292	74,460	3,400
(b)	6	2.4	0.4	0.2	12	12	140	292	51,200	2,300
(c)	20	0.2	4.9	2.2	11	3.2	100	103	183,000	8,200
(d)	16	0.2	2.6	1.3	11	3.2	100	103	108,250	4,900

(1) Total head loss = [(Friction loss)(Length)(5280 ft/mile)] + Static loss

(2) Power = $\frac{\text{(Q(ave))(Total head loss)(8.34 lbs/gal)(1 day/86400 sec)(1 kw/737.5 ft-lb/sec)}}{0.65}$ (365 days/yr)(pumping hrs/day)

(3) Power cost = (Power)(.045/KWH)

* No pumping necessary

Combining utility and salary costs, the annual O & M costs to Belmont and Stanley are:

Stanley:		
	Salaries:	$38,000
	Utilities:	5,700
		$43,700
Belmont:		
	Salaries:	$110,000
	Utilities:	13,100
		$123,100

Assuming a 10% discount rate, over 20 years the present value of O & M costs are:

Stanley:	$0.4 Million
Belmont:	$1.1 Million

5.5 Interconnections worth further investigation

There is virtually no difference in the estimated O & M costs of these three alternatives. Combining both capital and operating costs, the total cost differences are small.

	Costs to Stanley (million dollars)			Costs to Belmont (million dollars)		
	Capital	O & M	Total	Capital	O & M	Total
Mt. Island Lake	1.1	0.4	1.5	5.5	1.2	6.7
Dutchmans Creek	0.9	0.4	1.3	4.7	1.2	5.9
Separate	1.1	0.4	1.5	4.6	1.1	5.7

From this analysis, it would seem that the use of Dutchmans Creek is worth further investigation. The cost of a regional water system using this watershed is comparable to the cost of each system remaining independent. This cost is a strict economical cost and dosen't incorporate the benefit derived from using a higher quality source.

5.6 Storage facilities in Gaston County

According to the Rules Governing Public Water Supplies in the North Carolina Administrative Code, small municipalities should have a minimum elevated storage capacity of 750,000 gallons or a one day supply, whichever is greater. Large municipalities (Gastonia and Belmont) should maintain a one-day supply in a combination of ground and elevated storage tanks. Table 15 shows those small systems which must construct additional elevated storage facilites to meet state guidelines. High Shoals and Stanley have enough elevated storage capacity to meet their demand through 2005. Belmont and Gastonia (large municiplaities) must also increase either their elevated or ground storage facilities to meet the state guidelines.

In Denville, New Jersey, a study was done to determine if three housing developments should each have a tank or whether they should have one large tank (Biggs, 1985). They found the one tank alternative reduced capital costs by 60%, and reduced operation and maintenance costs (using a 10-year period and 8% inflation) by 20%. They report the finished project to be running well. Four of the satellite cities surrounding Gastonia (Dallas, Cramerton, McAdenville and Lowell) have their own storage facilities. Ranlo relies on the City of Gastonia for all their storage, but the Town is wanting to construct their own storage facility. Instead of building all new storage facilities, several of the cities surrounding

Table 15: Elevated Storage Required by 2005

Municipal System	Elevated Storage (mg), 1985	Estimated Demand Ave. Day, 2005	Additional Elevated Storage (mg) req'd by 2005	Cost (1985 dollars)
Cramerton	0	0.3	0.3	$300,000
Dallas	0.1	0.55	0.5	500,000
Lowell	0.1	0.5	0.4	400,000
McAdenville	0.1	0.85	0.75	700,000
Ranlo	0	0.5	0.5	500,000
Stanley	0.1	0.7	0.6	550,000

Gastonia may find it beneficial to share in the costs of one or more joint tanks.

6. SERVICE TO SATELLITE CITIES SURROUNDING GASTONIA

There is no regional water system among the municipalities in Gaston County, although regionalization was shown to provide a higher quality water at a cost comparable to remaining independent. A regional water system does exist between Gastonia and five small surrounding cities. The cities of Cramerton, Dallas, Lowell, McAdenville and Ranlo purchase water from the city of Gastonia. Figure 2 shows the location of these cities in relation to Gastonia.

6.1 Current situation

Gastonia sells water at two times the rate charged to residents within Gastonia's city limits. Prior to this year, no contract existed between Gastonia and these five cities. The city of Gastonia is now offering two alternatives to this non-binding agreement.

1) A long term (20-year) Contract
   Gastonia will initially sell water at 1.3 times the inside rate, with the understanding that this rate could be lowered during the 20-year period. As of May, 1986, the cities of Lowell and McAdenville agreed to this arrangement.

2) A complete takeover of the water business
   Gastonia will treat the city as a customer. The city of Cramerton has not decided between the long term contract or having Gastonia completely take over.

Two cities, Dallas and Ranlo, have passed bond issues to build individual treatment plants, 0.7 and 0.5 mgd respectively. Both plants would use the South Fork of the Catawba as their source. The county does not support fragmented systems, and has refused financial help to either plant. Ranlo has also been denied FmHA financing. Both cities recognize that construction of a treatment plant would lead to an increase in water rates, perhaps as much as 50%.

6.2 Advantages of continued service from Gastonia

Hypothetical water bills for 10 cities in Gaston County are shown in Table 16, based on a monthly consumption of 15,000 gallons. The city of Gastonia averages 3.2 persons per dwelling and 160 gallons/cap/day (HDR, 1979). Other cities were assumed to average 120 gal/day with 4 persons per dwelling.

Comparing the "average" water bill of these cities, increasing the customer base leads to lower customer rates. The city of Gastonia has the largest customer base and the lowest water rates. High Shoals has the highest water rates and serves the fewest number of people. Prior to 1980, the city used well water. Low water pressures and insufficient quantity led the city to seek the advice of a local consulting engineer. The engineer advised the city to construct their own plant, and later was hired to design the facility. The High Shoals plant, located on the South Fork, has experienced operational difficulties.

Table 17 shows the average price that Dallas, Cramerton, Lowell and Ranlo pay to purchase water from Gastonia. By agreeing to a long-term contract with Gastonia, these small communities can purchase water at a lower price ($18.07) then what a similar size municipality (Cherryville, see Table 16) charges the average customer.

It is interesting to note that the same engineer who

Table 16: Average Monthly Water Bills for Single Family Residents of Gaston County

System	Pop.	Inside Rate ($)	Outside Rate ($)
Gastonia	65,000	13.90	26.80
Belmont	15,000	15.00	30.00
Mt. Holly	6,300	17.25	34.50
Bessemer City	6,000	21.18	42.36
Cherryville	4,900	21.20	42.40
High Shoals	700	26.40	26.40

Source: N.C. League of Municipalities, 1986

Table 17: Current Purchase Price of Water from Gastonia Compared to Price under Long-Term Agreement

System	Pop.	Gastonia's Rate, 1986	Customers' Charge	Gastonia's Long-Term Rate, (20-yr)
Dallas	4,200	27.80	24.45	18.07
Lowell	3,300	27.80	24.30	18.07
Cramerton	1,800	27.80	24.45	18.07
Ranlo	1,800	27.80	21.00	18.07
McAdenville	1,000	27.80	*	18.07

* Data not available

Source: N.C. League of Municipalities, 1986 advised High Shoals to construct a water plant has also advised Ranlo and Dallas to construct separate water plants. Although these two communities are located within afew miles of one another and both would use the South Fork, they have each been advised to build their own plant.

Independence may be more important than low water rates, but lack of financing may prohibit any construction. Ranlo, currently serving 1,800 persons will need close to $1.5 million to construct a water treatment plant. Dallas, serving 4,200 persons, will need close to $2 million.

Construction of new water plants might be more understandable if a better source could be used. But the South Fork of the Catawba is the same source used by Gastonia, and is of poor quality. The city of Gastonia is in the intial stages of looking for a new source and two of the most promising, Mt. Island Lake and Dutchmans Creek are of much better quality. Better quality water and lower costs to consumers would result in continuing to buy water from Gastonia.

7. PUBLIC WATER SUPPLY SYSTEMS

A public water supply is one that serves at least 15 connections or an average of 25 individuals daily for 60 days or longer. With 212 public water supply systems, Gaston County has the largest number of systems in the State. Figure 17 shows the location of public water supply systems in the County (HDR, 1979). Information pertaining to these systems was obtained from the North Carolina Utilities Commission. The "average" public water system-

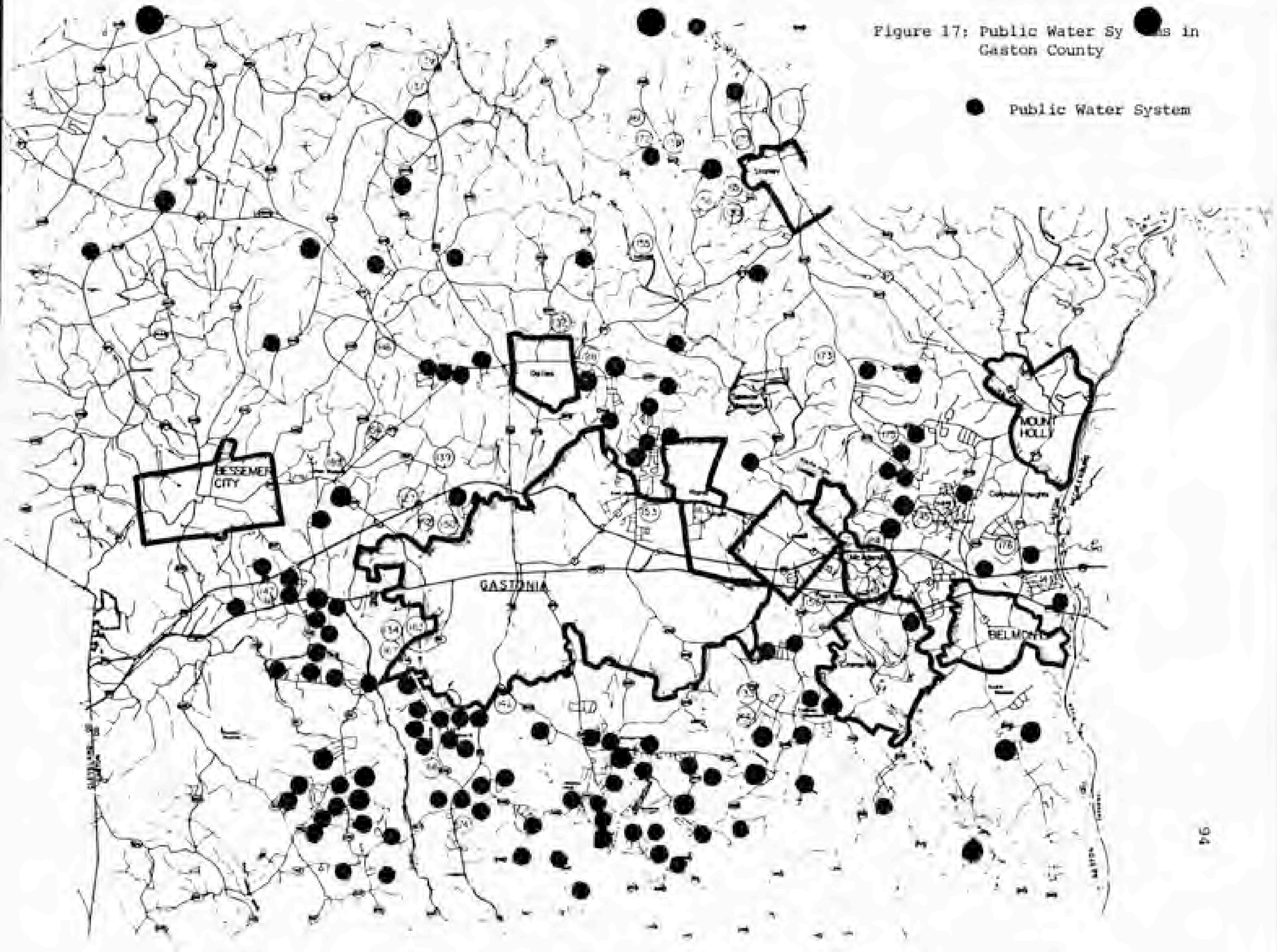
1) serves about 100 people
2) is 17 years old
3) does not chlorinate
4) is served by two wells
5) has a distribution system of 4" pipe or smaller

The major expenses are utility costs, transportation, repairs and salaries. Assuming an average monthly consumption of 15,000 gallons, water rates may vary from $8 to $26 per month depending on the system. Since most of the systems are located outside the city limits, water rates are low compared to what municipal suppliers charge to customers outside the city limits (Table 16).

7.1 Problems

Despite the low cost to customers, public water supply systems have their own set of problems. Of particular concern in Gaston County is water quality. All systems are supplied by well water. The county health department is surveying the water quality of these wells, and thus far 200 have been surveyed. Fifteen contain some sort of chemical contaminant (i.e. chromium, nitrates, oil, uranium) and twenty-five are

Figure 17: Public Water Sy[illegible]ms in Gaston County



high in fluorides (excess of 3 ppm). Groundwater contamination from petroleum-based products is a concern. Contaminants have migrated distances in excess of what was thought to be safe and acceptable (Gaston County Health Department, 1985). The high density of septic tanks and increase in hazardous waste production are areas of concern. It is quite common to read of sub-divisions or trailer parks, from all over the state, forced to boil water due to contamination. The cost of repair can be 50% of the total operating expenses, and there are probably times of poor and/or disrupted service.

Profit does not seem to be the incentive to own and operate a water system. The average system nets about $1000 per year, and several reported deficits last year. Rate increases must be approved by the utilities commission. The paperwork and effort involved in increasing water rates is probably the main reason water rates are so low.

Not much attention has been given to these small public water supply systems, although based on an average of 100 people/system, over 20,000 people are served (roughly equivalent to the combined population served by the cities of Bessemer city, Cherryville, Mt. Holly and Stanley). The owners of these systems are usually the same person responsible for the development which necessitated the water service, and consequently are required to maintain the water service.

7.2 Options for addressing the problems

The biggest threat to customers of a small water supply is the water quality. Interrupted and/or unsatisfactory service are unnecessary problems. The proliferation of these systems due to increased development can be stopped in several different ways, which are discussed below.

7.2.1 Aggregation of small systems

From Figure 17, it seems obvious that systems are clustered together in certain areas outside the city limits. A group of owners could combine resources, i.e., share trucks, equipment and personnel. However, because the profit from these systems is usually small, it is doubtful that small system owners would be enthusiastic about taking control over another similar system. It is much more likely for a large, already successful water company to take over a small one. Two such companies are Carolina Water Service and Mid South. Both operate several systems in Gaston and surrounding counties. They buy and operate systems that are no longer wanted or maintained. Because these water companies are run and operated as a business, it is most likely that service and water quality is improved.

7.2.2 Incorporation into a county system

There is no county water system is Gaston County, but there is interest. Interest in a county-wide system evolved from the realization that a planned operation under one administrative body could reduce operation costs, avoid expensive duplications and serve residents who could not otherwise obtain a safe, dependable water service (HDR, 1979). The county would most likely buy water from Gastonia. Initial lines could be extended to the area with the largest cluster of public water supply systems; growth trends show this to be the south/southeastern part of the county. Now is a good time for the county to negotiate purchasing water from Gastonia, especially since the city is looking towards building a new plant and taking from a new source.

8. WATER MANAGEMENT IN GASTON COUNTY

8.1 Current direction

There are several ways in which the proliferation of small municipal and public water systems is being discouraged.

The county will not support fragmented water systems, and in 1983, the county commission decided that all water systems should be self-supporting. Consequently, they will not fund either the Ranlo or Dallas treatment plant. The county contributed $175,000 to enable Jenkin Heights, a low-income community outside the city limits, to become part of the Gastonia city system. It is unforturnate that it took an outbreak of hepatitis within the community before something was done to provide better service.

Gastonia ia willing to decrease the water price and is looking towards a new source. The lower costs and higher quality would hopefully balance the preceived benefit that separate ownership might provide. Gastonia has also refused to maintain an interconnection for emergency purposes if Ranlo and Dallas proceed with construction. In the case of privately-owned systems, the trend seems to be towards development. The population of unincorporated areas of the county is increasing outside the political boundaries at a higher rate than the population of the muncipalities in the county (HDR, 1979). Recently, the minimum size water main pipe was changed from 4 to 6 inches. This is roughly a 50% increase in pipe cost. Most of the systems have 4 inch lines. This increase in pipe cost may prohibit the proliferation of small systems.

8.2 Options for the future

Although the county has shown some interest in regional water systems, the county commissioners are against any land use controls. Approximately 84% of the total land area in Gaston County is undeveloped (i.e. agricultural, wooded, vacant), but much of this land is already tied up. There has been no identification of good quality water sources, hence no protection. What was identified in this report as a good quality watershed (Dutchmans Creek) has been slated for development as an industrial park. No priority is given to protection of watersheds. Land use trends in Gaston County are from non-urban to urban uses. There is a need for new sources and the options to choose from are limited. By not protecting the smaller, undeveloped watersheds, the only available option may be the larger rivers (the Catawba and South Fork of the Catawba) which are contaminated by many industrial and municipal dischargers.

Besides the need for some type of land-use control, there seems to be enough interest and need within the county for a county-wide water system. The feasibility (HDR, 1979) of this system would of course depend on the number of people included and source of funding. Possible sources of funding are state money from the Clean Water Bond Act, and federal money from FmHa.

Another option may be a joint management agency between the county and the City of Gastonia. An example is Forsyth

County. The county constructed a water system mostly for serving areas around Winston Salem, in which the county purchased water from Winston Salem. In 1976, the city and county governments created a joint management agency and the two units' water (and sewerage) systems now operate as a single enterprise (Wicker, 1979).

9. SUMMARY

The water supply situation in Gaston County was analyzed as a case study of the benefits of regional water management in North Carolina. To the extent that one county can typify the state, problems experienced in Gaston County are representative of the problems found state-wide; quantity, quality and operation and maintenance problems (chpt. 2). Based on a 20-year design period, the City of Gastonia will experience quantity problems unless they develop a new source. Over half of the municipal water suppliers use water from large river systems which are used by many industrial and municipal dischargers. While drinking water quality has not been cited as a major concern, higher quality surface sources could be used. Groundwater contamination from septic tank systems is becoming more of an issue as the number of these systems is increasing. No indication of operation and maintenance problems of small water systems within the county was found, but in general larger water systems are believed to provide a better quality service.

In Gaston County, joint development and operation of a reservoir and treatment plant between several municipalities was shown to be cost approximately the same as if these municipalities expanded independently. However, the municipalities would benefit by obtaining a higher quality source. In the county (as well as in the state), distance between cities may make interconnection between systems more costly unless there is the need to contruct a new facility that could be located close to all systems involved, as in the case of Gastonia. Because Gastonia will build a new water treatment plant within the next 20-years, a regional system between Gastonia and the other systems that need to expand is an attractive alternative.

Approximately 98% of the systems in the state and in Gaston County are small. All the small suppliers rely on groundwater. County-wide regional systems have been successful where they have been started by local residents, and may actually lower costs, as in the case of Anson County. The proliferation of small systems can be slowed by providing a county system to serve rural residents, or by making it harder for small systems to begin operation, i.e. increase the minimum water main size from 4 inches to 6 inches. Encouraging large water businesses (such as Mid South and Carolina Water Service) to operate and maintain these systems may not stop the increase of small systems, but at least would provide a better quality service.

Although the benefits of regionalization may be clearly defined in terms of improved water quaity and/or lower costs, the politics involved in combining or sharing facilities may prohibit any form of regional water management. This report focused on the benefits defined in terms of cost and quality, and not the perceived benefits of remaining separate.

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