REPORT ON WATER DISTRIBUTION SYSTEM FOR DARE COUNTY, NORTH CAROLINA

Prepared by

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June 1986

B&V Project No. 02581.201

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County of Dare
Water Distribution System
Study

B&V Project 02581.201
B&V File E
June 23, 1986

County of Dare
P.O. Drawer 1000
Manteo, North Carolina 27954

Attention: Mr. Robert V. Owens, Jr.
Chairman of the Board of Commissioners

Gentlemen:

Enclosed is our final report on the water distribution system for the northern Dare beaches. This study was undertaken at the request of County Manager Jack Cahoon, originally for the purpose of identifying the best way to alleviate low pressure in the Duck and Sanderling areas and later expanded to a more complete analysis of the entire distribution system.

The report begins with an introductory section that defines the study purpose and scope. This is followed by a summary of the major findings and recommendations, which can be used as a quick reference section. Several sections then discuss the details of the study and explicitly describe needed improvements. The final section provides cost opinions for recommended improvements. It also provides a capital improvements plan for the years 1986 through 1990 to assist the County in its budgeting process.

Also under separate cover, are worksheets of the computer distribution analyses and updated distribution system maps that were prepared as part of this project.

It has been a pleasure to undertake this study for Dare County. We thank Jack Cahoon, Phelpie Edmondson, Randy McPhee, and others on their staffs who have assisted us in this work. We believe that the results of the study, as expressed in this report, will serve Dare County well in improving its distribution system in a timely and cost-effective manner.

We remain at your disposal to present this report at a Commission meeting, to discuss it with Dare County's staff, and to answer any questions you may have.

Very truly yours,

BLACK & VEATCH

David A. Todd

David A. Todd

mlp
Enclosure

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to present the findings and recommendations of the Dare County Water Distribution System study. This report will help guide the Dare County Board of Commissioners and staff in meeting the water needs created by growth in the northern Dare County beaches.

1.2 SCOPE

The study area, shown in Figure 1-1, consists of that part of the outer banks that is north of Kill Devil Hills and south of Currituck County. It includes the Towns of Kitty Hawk and Southern Shores and the unincorporated areas known as Martins Point, Duck, and Sanderling.

The study period covers the years through 2005. A year of concern is 1990, which represents the limit of year-by-year planning and is considered the "immediate" period.

This study includes (1) determination of projected population growth, (2) determination of projected water demands, (3) development of alternatives for improvements to the distribution system to support projected growth, (4) development of a phased plan for implementing improvements, and (5) development of preliminary cost opinions for the improvements.

The analyses completed as part of this study include computer modeling of the distribution system for the years 1986, 1990, and 2005, for both the existing system and an improved system. Separate analyses were performed to determine the effect on the Dare County distribution system of selling water to the Currituck County outer banks. In all analyses, attempts were made to make maximum use of existing facilities.

This study excludes any detailed look at the water supply and treatment needs of Dare County, except to identify the total amount of water that will need to be supplied to the study area.

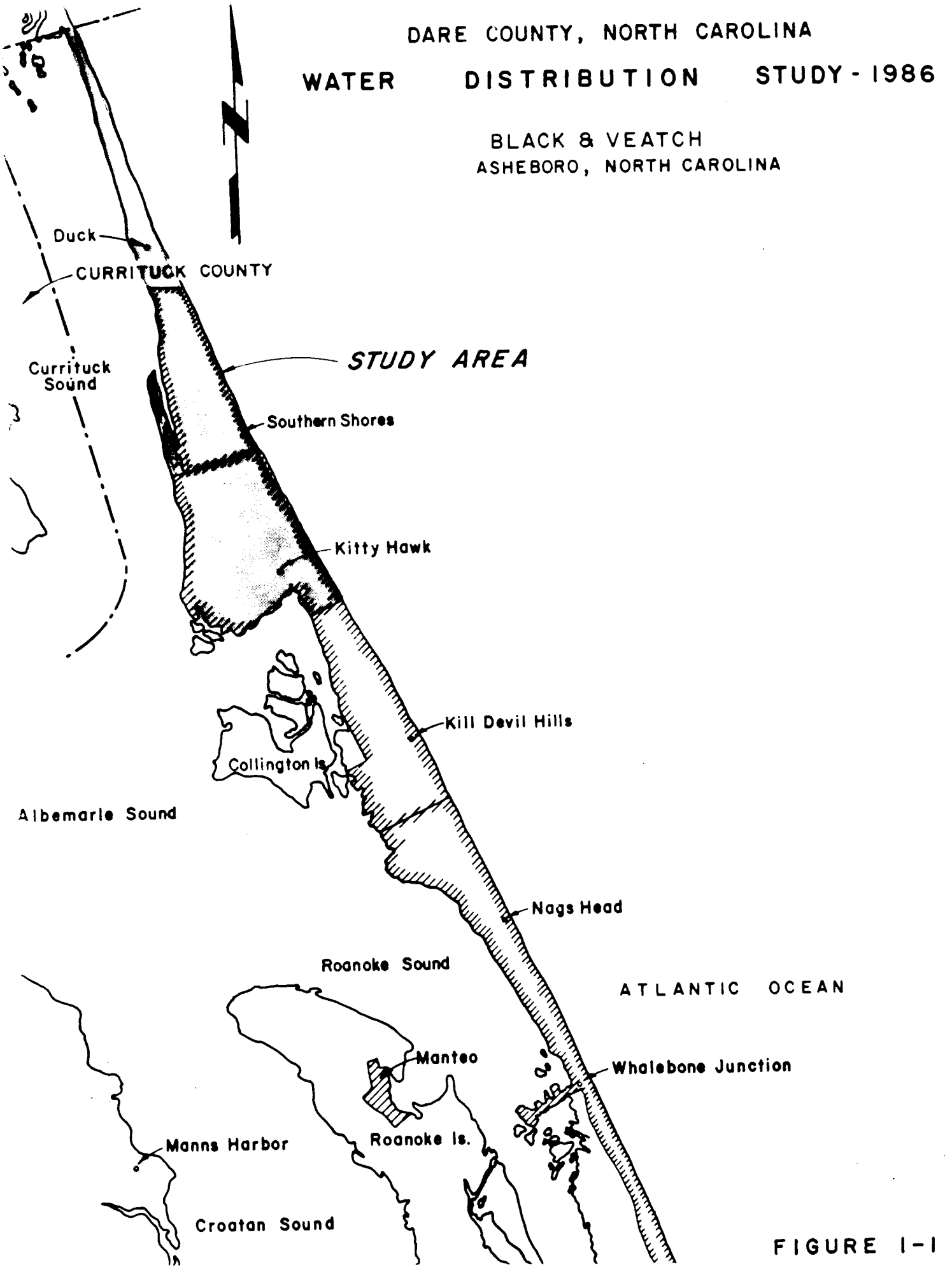

DARE COUNTY, NORTH CAROLINA
WATER DISTRIBUTION STUDY - 1986
BLACK & VEATCH
ASHEBORO, NORTH CAROLINA
Duck
CURRITUCK COUNTY
STUDY AREA
Currituck Sound
Southern Shores
Kitty Hawk
Kill Devil Hills
Collington Is.
Albemarle Sound
Nags Head
Roanoke Sound
ATLANTIC OCEAN
Manteo
Whalebone Junction
Roanoke Is.
Manns Harbor
Croatan Sound

FIGURE 1-1

1.3 RELATED REPORTS

Reports reviewed and considered under this study or related to this study are as follows.

1. Comprehensive Engineering Report on Water System Improvements for County of Dare, by Moore, Gardner & Associates/Black & Veatch, 1984. This report was being updated and expanded during the time this study was being conducted. This will hereinafter be referred to as the 1984 Comprehensive Engineering Report.
2. Although no report was available, this study considered the work undertaken in the carrying capacity study, by Booz, Allen, and Hamilton. This will hereinafter be referred to as the 1986 Carrying Capacity Study.

1.4 ABBREVIATIONS

gpm - gallons per minute
mg - million gallons
mgd - million gallons per day
NCSR - North Carolina State Road
psi - pounds per square inch

2.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Dare County Water Distribution study, conducted by Black & Veatch, prompted the following findings and recommendations.

2.1 FINDINGS

- The population, combined permanent and seasonal within the study area, is projected to grow from 18,400 in 1985 to 24,000 in 1990 and 40,900 in 2005.
- The population projections in the 1984 Comprehensive Engineering Report correspond to the medium growth projection of the 1986 Carrying Capacity Study.
- Water use within the study area increased 114 percent from 1981 to 1985.
- Projected water use in 1990 is 2.4 mgd for maximum day and 4.8 mgd for maximum hour.
- Projected water use in 2005 is 4.17 mgd for maximum day and 8.34 mgd for maximum hour.
- Existing distribution facilities will not satisfactorily supply 1990 demands and, consequently, 2005 demands.
- The existing distribution system cannot deliver fire fighting flow rates in Kitty Hawk village and in Duck village and Sanderling.
- The distribution system can supply 1.0 mgd to the Currituck County outer banks in 1990 with no additional improvements other than those required for Dare County's own needs.
- The distribution system cannot supply 1.0 mgd to the Currituck County outer banks in 2005 without improvements over and above those required for Dare County's own needs.
- The Kitty Hawk Pumping Station will be inadequate to supply the distribution system in 1990 and beyond.

2.2 RECOMMENDATIONS

- The County should plan to supply a population in the study area of 24,000 by 1990 and 40,900 in 2005.

- The County should plan and implement improvements to deliver maximum day and maximum hour rates of 2.4 mgd and 4.8 mgd in 1990 and 4.17 mgd and 8.34 mgd in 1990 and 2005, respectively.

- Immediate improvements recommended (on-line by 1987) are a 1.0 mg elevated tank in Duck and approximately 9,000 feet of 16-inch water main.

- Improvements required by 1990 are 8-inch and 12-inch water mains in Kitty Hawk and Southern Shores and the installation of two 1,200 gpm pumps in the Kitty Hawk Pumping Station.

- Improvements projected for 2005 include a 16-inch water main in Southern Shores and the addition of two 1,200 gpm pumps in the Kitty Hawk Pumping Station. Additional improvements recommended to serve Currituck County are a 12-inch main from Duck to the County line, a 12-inch main in Kitty Hawk, and a 1,300 gpm booster pumping station.

3.0 POPULATION AND WATER REQUIREMENT

3.1 POPULATION PROJECTION

The population of the study area was taken from the 1984 Comprehensive Engineering Report. The permanent and seasonal population projections are shown in Table 3-1 below.

TABLE 3-1

POPULATION PROJECTION OF STUDY AREA

Year	Permanent & Seasonal Population
1985	18,400
1990	24,000
2000	32,500
2005	40,900

In their work to determine Dare County's carrying capacity Booz, Allen, and Hamilton has not yet provided information concerning the potential for growth within the study area. They have identified growth throughout Dare County, and their final report, when available, will reflect potential growth within the study area. Table 3-2 compares growth projections from the 1984 Comprehensive Engineering Report to the 1986 Carrying Capacity Study. Although there are differences in the projections, the two projections are comparable. The population projections for the year 2000 are almost equal when the medium growth scenario of the 1986 Carrying Capacity Study is used.

TABLE 3-2

POPULATION PROJECTIONS, TOTAL PERMANENT AND SEASONAL

	1985	1990	2000	2005
1984 Comprehensive Engineering Report	97,772	124,158	157,822	200,795
1986 Carrying Capacity Study				
Low Growth	78,690	93,268	115,454	N/A
Medium Growth	78,870	99,837	156,770	N/A
Rapid Growth	77,775	112,108	252,509	N/A

3.2 WATER REQUIREMENTS

Water usage rates vary during different times of the day and periods of the year. Demand rates are defined by three terms: annual average day, maximum day, and maximum hour. Annual average day use is the yearly total quantity of water distributed, divided by the number of days in the year. This demand rate is used as a basis for maximum day and maximum hour projections for long-term water supply requirements, and for projecting operation and maintenance costs. Maximum day is determined by the maximum quantity of water used in any 24-hour period during the year. Maximum day is used to size water production and treatment facilities. Maximum hour is the maximum amount of water required during any 60-minute period of the year. This demand rate is generally the critical condition that causes minimum residual pressures in the distribution system. Sizing and location of distribution facilities are determined on the basis of maximum hourly demand rates.

In Dare County, there is a great fluctuation in water use because of the seasonal population. The seasonal water use period occurs between May and October, with major usage peaks occurring during July and August. The difference between maximum day and the minimum water use in any 24-hour period is 5 to 1, which is a very large ratio.

3.2.1. Past Water Use.

Table 3-3 lists past water use by all users in the study area based on County Water Department records. Because of the failure of the telemetry system and primary measuring instruments, the County data is obtained by totaling raw water production individually at each well and subtracting water delivered to wholesale water users. There are many inaccuracies in this method of data acquisition; however, the data will be used since it is the only data available. It should be noted that the failure of the instrumentation systems has eliminated any possibility of computing past water use during maximum hour conditions. It was necessary to assume a ratio of maximum hour to maximum day to complete the analyses of this study.

TABLE 3-3

PAST WATER USE

	1981 (mgd)	1982 (mgd)	1983 (mgd)	1984 (mgd)	1985 (mgd)
Minimum Day	0.1	0.1	0.2	0.2	0.3
Annual Average Day	0.4	0.4	0.5	0.6	0.7
Maximum Day	0.7	0.8	0.9	1.1	1.5
Maximum Hour	1.4	1.6	1.8	2.2	3.0

3.2.2 Future Water Demands.

Table 3-4 indicates projections for water use in the study area. The maximum hour projections assume a maximum hour to maximum day ratio of 2:1. The assumed per capita consumption for maximum day is 105 gallons, taken from the 1984 Comprehensive Engineering Report.

TABLE 3-4

PROJECTED WATER USE

	1990 (mgd)	2000 (mgd)	2005 (mgd)
Annual Average Day	1.2	1.63	2.1
Maximum Day	2.4	3.25	4.17
Maximum Hour	4.8	6.50	8.34

4.0 DISTRIBUTION SYSTEM FACILITIES

4.1 DISTRIBUTION MAINS

The existing distribution system consists of water mains ranging in size from 2-inch through 16-inch. The major trunk main is a 16-inch pipe along U.S. 158 Bypass from the Kitty Hawk Pumping Station to the Southern Shores boundary. There it decreases to a 12-inch pipe and continues to the Southern Shores elevated tank. This major trunk main is looped with 8-inch mains in both Kitty Hawk and Southern Shores. An 8-inch main continues north through Duck to the Sanderling area.

Despite the above mentioned loops, the distribution system is not a looped system. There are many dead-end mains, and there are many areas where rights-of-way cannot be easily obtained to complete loops. The relatively long and narrow shape of the distribution system does not present many opportunities for looping.

Distribution mains are designed to deliver all conditions of flow without excess velocity or headloss and to maintain adequate system pressures. Velocities are generally limited to a maximum of 5 feet per second, and head loss is generally limited to 10 feet per 1,000 feet of main. State regulations require residual pressure to be 30 psi under all conditions of flow, with the exception of fire flows.

4.2 SYSTEM STORAGE

Distribution system storage consists of a 0.5 million-gallon ground storage reservoir located at the Kitty Hawk Pumping Station and a 0.5 milliongallon elevated storage tank located in Southern Shores. Storage in a distribution system is used to supply the difference between maximum day and maximum hour demands. For this analysis, in the absence of actual records, it was assumed that the maximum hour demand would continue for four hours. This design condition is typical for many distribution systems. It is assumed that one-half of the total storage volume will be used to satisfy maximum hour demands and that the other half will be held in reserve for emergencies and

fire fighting purposes. State regulations impose the additional requirement that sufficient storage be available to supply the annual average day demand for 24 hours.

The required storage volumes are shown in Table 4-1.

TABLE 4-1

REQUIRED STORAGE

	1986 (mg)	1990 (mg)	2005 (mg)
To supply maximum hour	0.5	0.8	1.4
To satisfy State regulations	0.7	1.2	2.1

It can be seen that additional storage will be required by 1990.

4.3 DISTRIBUTION SYSTEM PUMPING

Kitty Hawk Pumping Station, located on U.S. 158 Bypass at the southern boundary of Kitty Hawk, is the only source of water supply to the distribution system. Therefore, this pumping station must be able to supply a minimum of the maximum day demand. The pumping station includes chlorine feed, flow metering, and the 0.5 mgd ground storage reservoir. The station contains three pumps of different sizes and space for a fourth pump. Additional description of the pumping station as it now exists is contained in Section 6.0 of this report.

5.0 DISTRIBUTION SYSTEM ANALYSIS

5.1 METHOD

Black & Veatch used a digital computer to perform the hydraulic analysis for this study and report. The hydraulic analysis is an analytical method for predicting the hydraulic gradient pattern that may be expected over the system network based on a given set of water use conditions. About 20 cases were investigated on the computer for this study. Most cases included multiple computer runs to evaluate various improvement alternatives.

The physical characteristics of the distribution system were reviewed for components having the most significant effect on the system. The existing system was skeletonized, water demands were allocated to the junctions of the network, and system input flows and/or gradients were established for each water use condition. From this information, the resulting hydraulic gradient and flow patterns throughout the service area were determined. The difference between the hydraulic gradient elevation and the ground elevation at any point on the system network is the available head in feet of water or pressure (psi) at that point under the assumed condition.

Where an analysis indicated that there would be insufficient pressures to deliver the water required, improvements to the distribution system were added to the computer system network and the analysis repeated. For future years, the growth in water demand was distributed in the computer network, and system improvements were added until the analysis indicated a properly operating system.

5.2 ANALYSIS

Four sets of basic distribution system conditions were investigated to test the capability of the distribution system to meet present and future demands. The first set of conditions models the ability of the system to supply maximum day demands without significantly depleting storage for (1) the existing system and 1986 base year demands, (2) the 1990 design year projected system and demand, and (3) the design year 2005 projected system and demand.

The second set of conditions models the system's ability to maintain adequate gradients during maximum hour demand periods for the same three years as above. The third set test the capability of the system to provide limited fire flows in each design year. Finally, the fourth set models the capability of the system to replenish elevated storage following drainage for maximum hourly use for each design year.

The possibility of water being provided to the outer banks of Currituck County on a wholesale basis was modeled for the 1990 and 2005 design years for all design conditions. The flow rate to Currituck County was held constant at a maximum day demand rate under all conditions.

Exhibits showing the results of system analyses are not included in this report; but, worksheets and system gradient maps are being made available to the Public Works Department and Water Department separately. The system gradient maps show conditions of the distribution system design years 1986, 1990, and the 2005 under maximum hour and maximum day demands. Improvements to the distribution system are determined by use of the design year analyses. Year 1990 was used to stage major improvements while the year 2005 analyses were used to verify the long-range adequacy of improvements.

5.2.1 Base Year 1986.

The base year 1986 condition was first modeled with no improvements to identify deficiencies that would require immediate correction. The system was analyzed again with improvements added to the model.

5.2.1.1 Maximum Day. The maximum day analyses were run assuming existing and new storage reservoirs remain full. All water demands are satisfied from the Kitty Hawk Pumping Station. The total system demand of 1.2 mgd represents a pumping rate of 833 gpm. The existing Kitty Hawk pumps are 1,000 gpm and 1,500 gpm, and operating these pumps to supply the maximum day rates would necessitate a minimum pump run time of 18 hours per day. This calculation corresponds very well with water department experience. The analysis indicates that the maximum day rate can be adequately supplied from the pumping station without depleting storage.

5.2.1.2 Maximum Hour. These analyses examined the residual pressures throughout the existing distribution system. The analyses confirmed operational experience that pressure in Duck and northward are not sufficient. Improvements modeled to correct this problem were additional water mains to parallel the existing 8-inch main in this area and the addition of an elevated tank north of Duck. Either improvement would relieve the low pressure problem at the northern extremity of the distribution system.

5.2.1.3 Storage Replenishment. These analyses assumed that 8 hours would be available to replenish elevated storage that was drained during maximum hour conditions. The pumping station would continue to pump at the maximum day rate until storage tanks were full. The analyses showed that the Southern Shores elevated tank would be easily replenished but that the new tank could not be replenished without the construction of additional water lines.

Additional mains to parallel the existing 8-inch main to the new elevated tank were modeled, and the analysis indicated that approximately 5,000 feet of parallel 16-inch main would be required for proper tank replenishment. The analysis also showed that the gradient at the existing elevated tank at Southern Shores will be higher than the tank overflow elevation during replenishment of the new tank. Since this existing tank is not equipped with an altitude valve, it will be necessary to install one.

5.2.1.4 Fire Flow. Dare County is not required to supply adequate fire fighting flowrates in its distribution system. However, analyses were made of residential fires to show the ability of Dare County's water system to provide fire protection. The analyses were run with residential fires in Kitty Hawk village near the end of the existing water main and at the northernmost end of the distribution system near the Currituck County line. In each case, the system was not able to maintain adequate gradients to provide fire flows.

5.2.2 Design Year 1990.

The design year 1990 conditions were first modeled with the improvements required by the base year analysis. Additional improvements were added to the model, and the analysis was repeated.

5.2.2.1 Maximum Day. These analyses assume that the existing and new storage reservoirs are full. The total system demand of 2.4 mgd is being supplied from the Kitty Hawk Pumping Station. The existing and new elevated storage tanks are assumed to be full and floating on the system, and the ground storage tank at Kitty Hawk is assumed to be full. The required pumping rate of 2.4 mgd (1,667 gpm) exceeds the firm capacity of the pumping station and will require the installation of the additional pumping capacity. The maximum gradient required at the pumping station is 230 feet, which is within the range allowable for existing pipes.

5.2.2.2 Maximum Hour. This analysis shows the conditions of the distribution system under 1990 maximum hourly demands. Water is supplied from Kitty Hawk Pumping Station at the rate of 1,667 gpm, from the Southern Shores elevated tank at the rate of 593 gpm, and from the new elevated tank at the rate of 1,073 gpm. These rates add up to a total maximum hour demand of 3,333 gpm or 4.8 mgd. Improvements required to achieve proper operation include those already mentioned for 1986 and 1990 maximum day and a new 8-inch water line in Kitty Hawk to tie the long dead end line into a loop near the Southern Shores elevated tank. Despite the increase in demand, residual pressures in the northern part of the distribution system remained satisfactory.

5.2.2.3 Storage Replenishment. The requirements for storage replenishment increase by 1990, since a larger volume of water must be replenished. The analysis indicates that the 1986 improvements will still be adequate in 1990.

5.2.2.4 Fire Flows. The same fire flow analyses were run for 1990 as for 1986. The results showed that sufficient water and pressure will be available to fight these residential fires, when the improvements required by the maximum hour analysis are added.

5.2.2.5 Currituck County Supply. The analyses for maximum day, maximum hour, and storage replenishment were repeated with 1.0 mgd being supplied to Currituck County simultaneously with the Dare County demands. The system performed satisfactorily with this extra demand being pumped through Dare County's distribution system. The only additional improvement required would be extra pumping capacity at Kitty Hawk Pumping Station.

5.2.3 Design Year 2005.

The design year 2005 conditions were first modeled with the improvements required by the 1990 design year analyses. Additional improvements were added to the model as the analyses indicated their need.

5.2.3.1 Maximum Day. The 2005 maximum day demand of 4.17 mgd, (2,900 gpm) is supplied totally by the Kitty Hawk Pumping Station. This demand will require the addition of approximately 1,200 gpm of additional pumping capacity. Additional water mains are also required to distribute the increased flow from the pumping station and stay within the pressure capability of existing mains.

5.2.3.2 Maximum Hour. The 2005 design year maximum hour demand of 8.34 mgd, (5,800 gpm) is supplied by 3,000 gpm from the Kitty Hawk Pumping Station, 980 gpm from the Southern Shores elevated tank, and 1,820 gpm from the new elevated tank. These flow rates from the elevated tanks are within their capabilities. The pumping rate required at Kitty Hawk is slightly higher than that required by the maximum day analysis. The water main improvements required for maximum day allow the system to operate with satisfactory pressures during maximum hour.

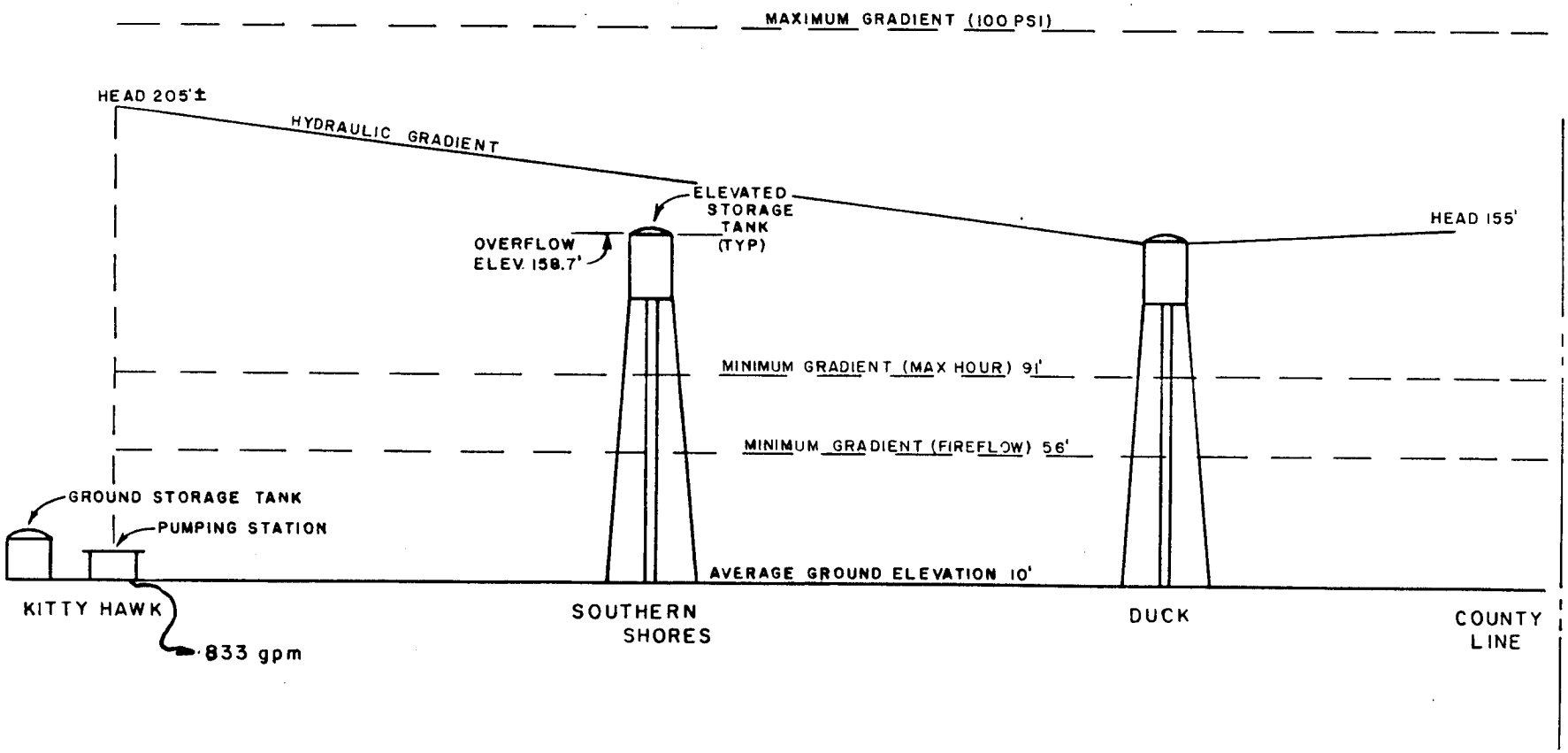
5.2.3.3 Storage Replenishment. The total drainage from storage after the maximum hour condition was determined to be 672,000 gallons. To be replenished during an 8-hour night time low demand period, the pumping rate would need to be 1,400 gpm, plus any nighttime demand. The analysis indicates that the system, with the improvements required by the 2005 design year maximum day analysis, will be able to replenish the tanks.

5.2.3.4 Currituck County Supply. The analyses for maximum day, maximum hour, and storage replenishment were repeated with 1.0 mgd being supplied to Currituck County simultaneously with the Dare County demands. The analyses revealed that additional improvements are required to supply this flow rate to Currituck County. Major water main additions would be necessary to keep system pressures within acceptable limits. These improvements are additional 16-inch mains in Kitty Hawk and a 12-inch main from the new elevated tank to

the County line. The expense for these improvements would be quite large. As an alternative, a booster pumping station could be used in conjunction with the 12-inch main to the County line and some limited 12-inch mains in Kitty Hawk. The cost of this alternative would be much less than the cost of the previously mentioned one. Also required would be more pumping capacity at the Kitty Hawk Pumping Station.

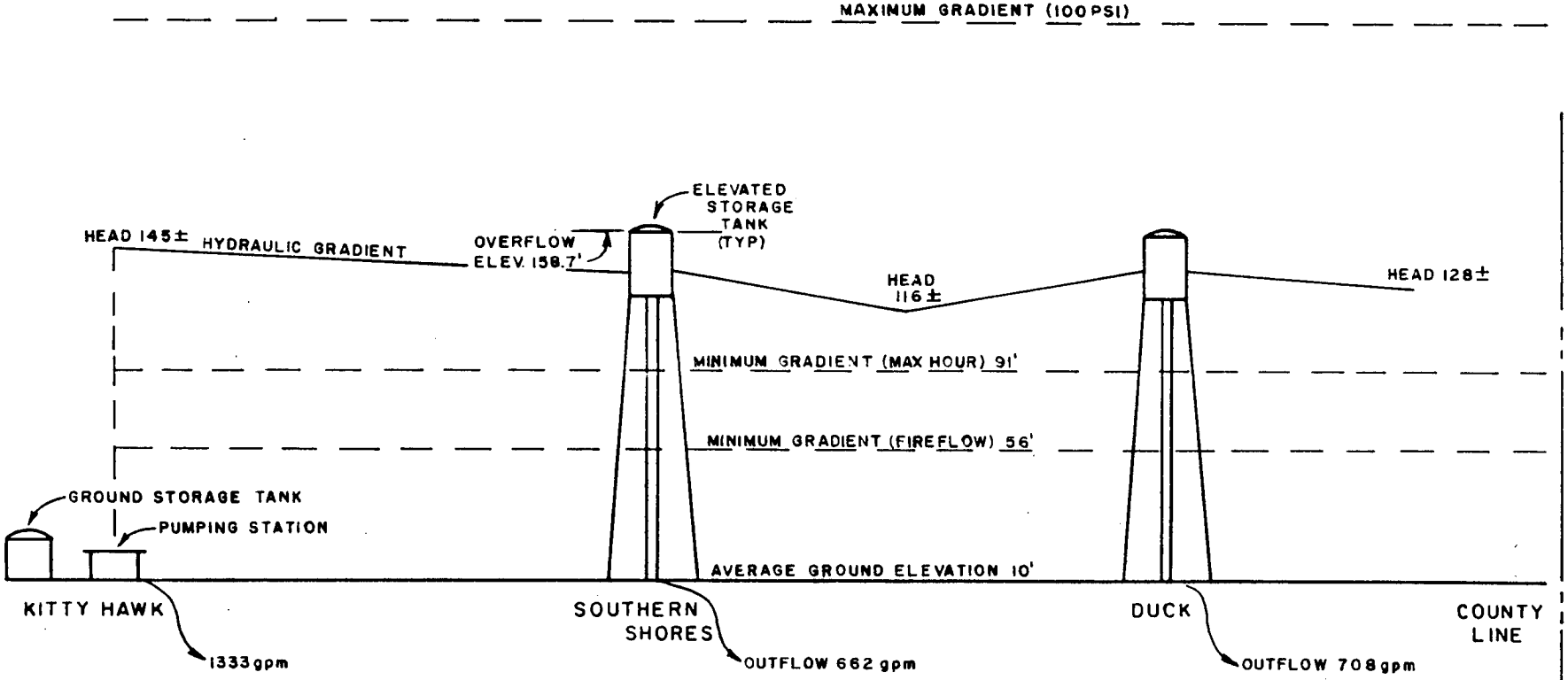
5.3 HYDRAULIC GRADIENT PROFILES

Figures 5-1 through 5-6 show profiles of the hydraulic gradient across the distribution system for various water use conditions through the study period. These are presented to aid in the reader's understanding of the distribution system, including improvements, which will be discussed in Section 6.0 of this report. These figures are not to scale.



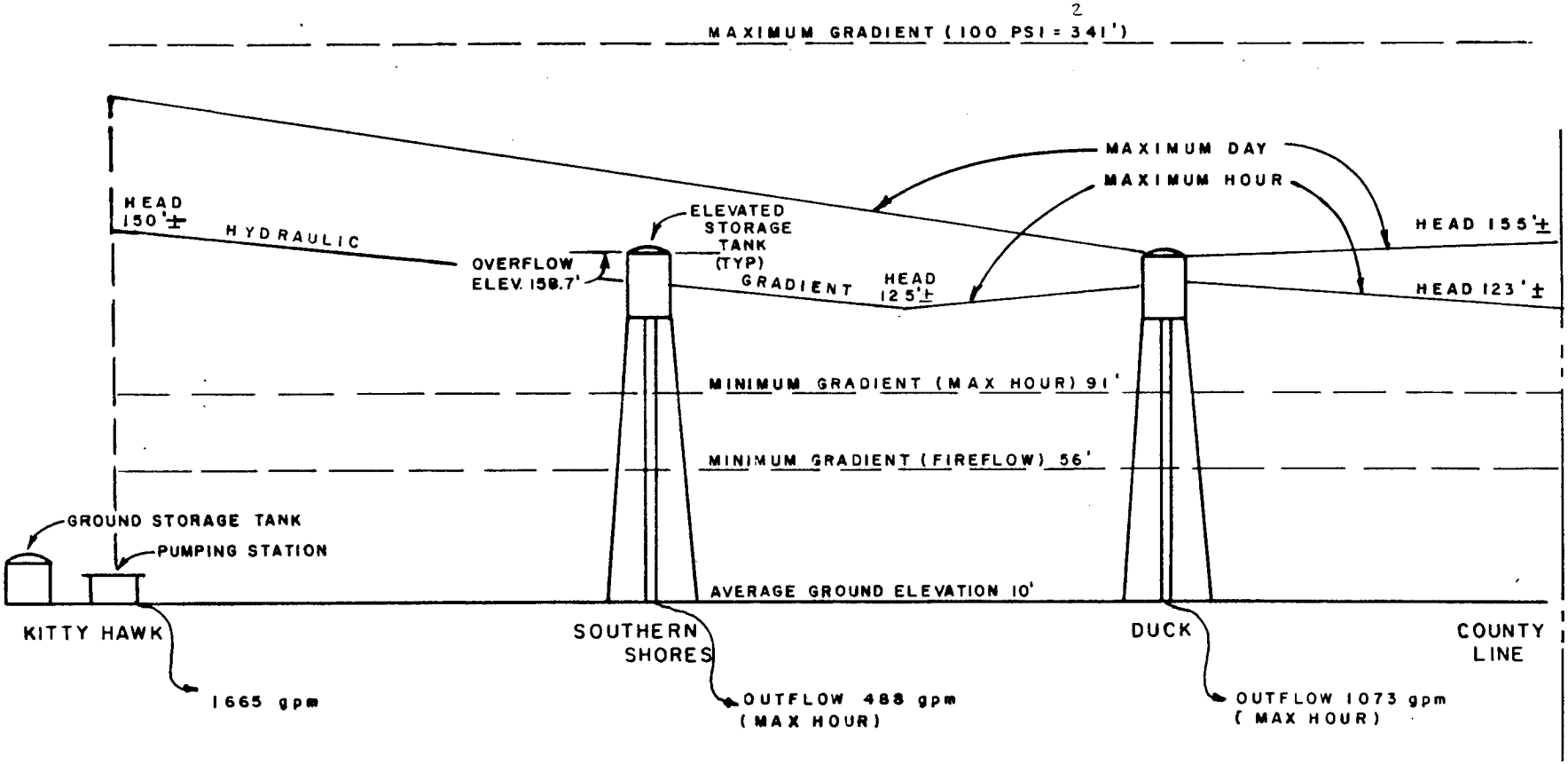
DISTRIBUTION SYSTEM 1986
MAXIMUM DAY CONDITION
DEMAND 1.2 MGD

FIGURE No. 5-1



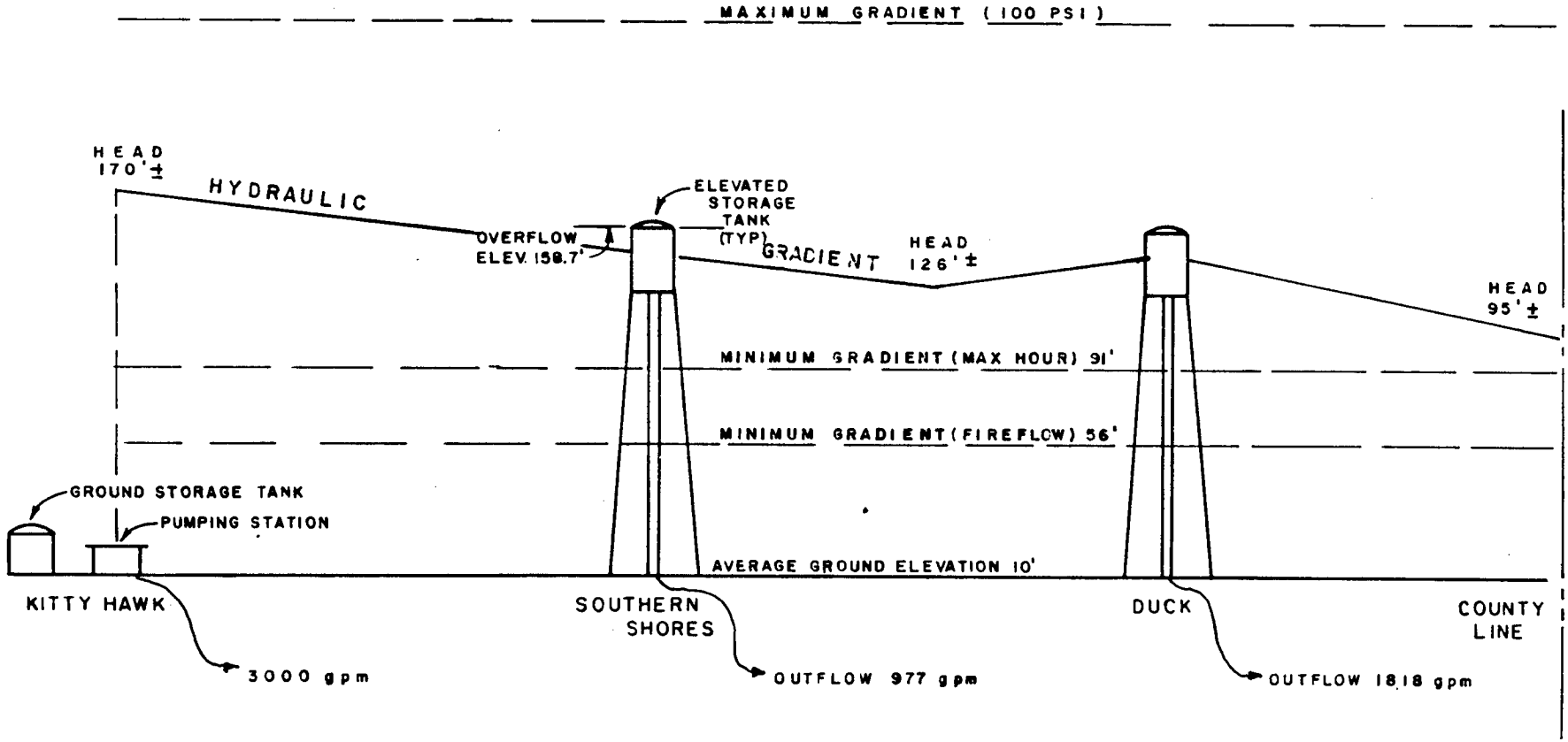
DISTRIBUTION SYSTEM 1986
MAXIMUM HOUR CONDITION
DEMAND 2.4 MGD

FIGURE No. 5-2



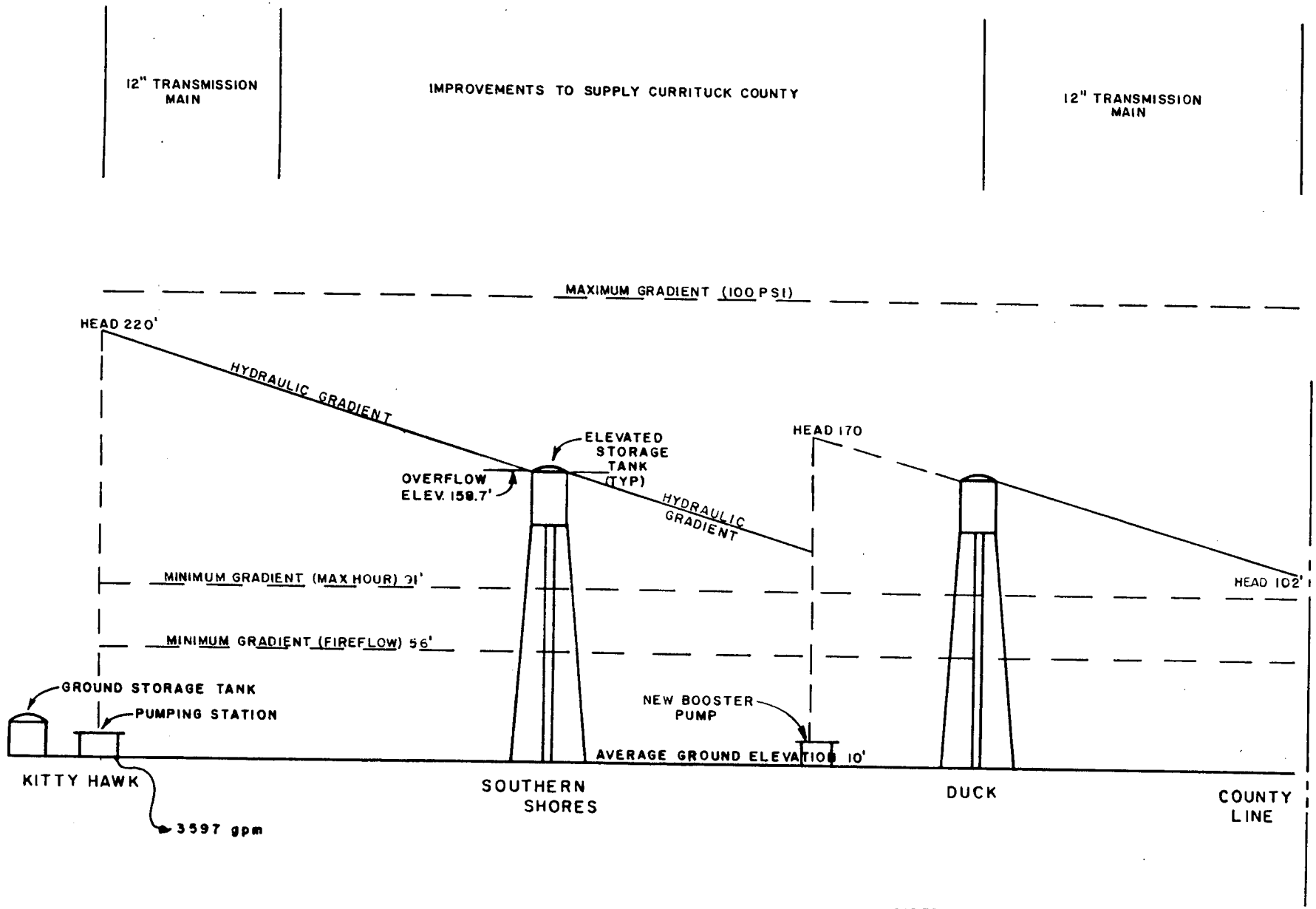
DISTRIBUTION SYSTEM 1990
MAXIMUM DAY AND MAXIMUM
HOUR CONDITIONS

FIGURE No. 5-3



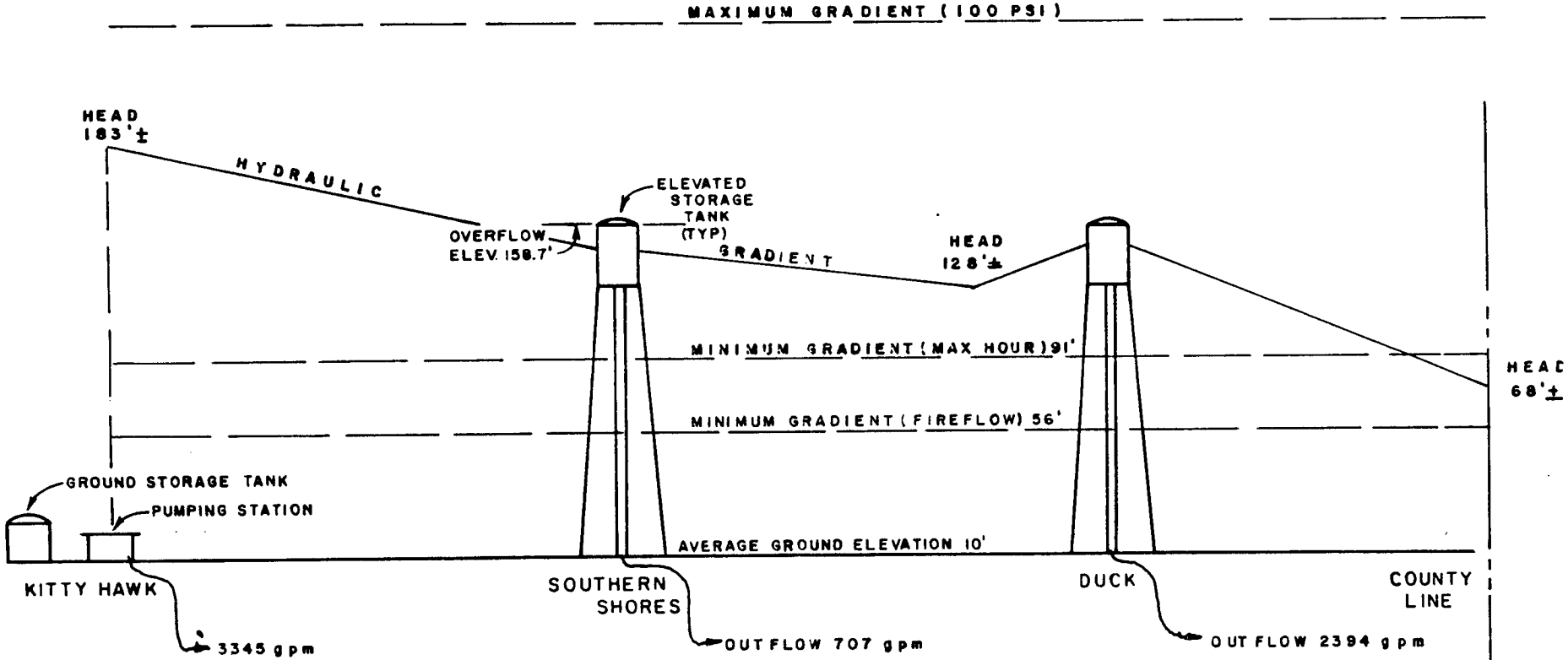
DISTRIBUTION SYSTEM 2005
MAXIMUM HOUR CONDITION

FIGURE No. 5-4



DISTRIBUTION SYSTEM 2005
MAXIMUM DAY CONDITION
DEMAND 4.1 MGD PLUS 1.0 MGD TO CURRITUCK

FIGURE No. 5-5



DISTRIBUTION SYSTEM 2005
MAXIMUM HOUR CONDITION
DEMAND 8.34 MGD PLUS 1.0
MGD TO CURRITUCK

FIGURE No. 5-6

6.0 RECOMMENDED IMPROVEMENTS

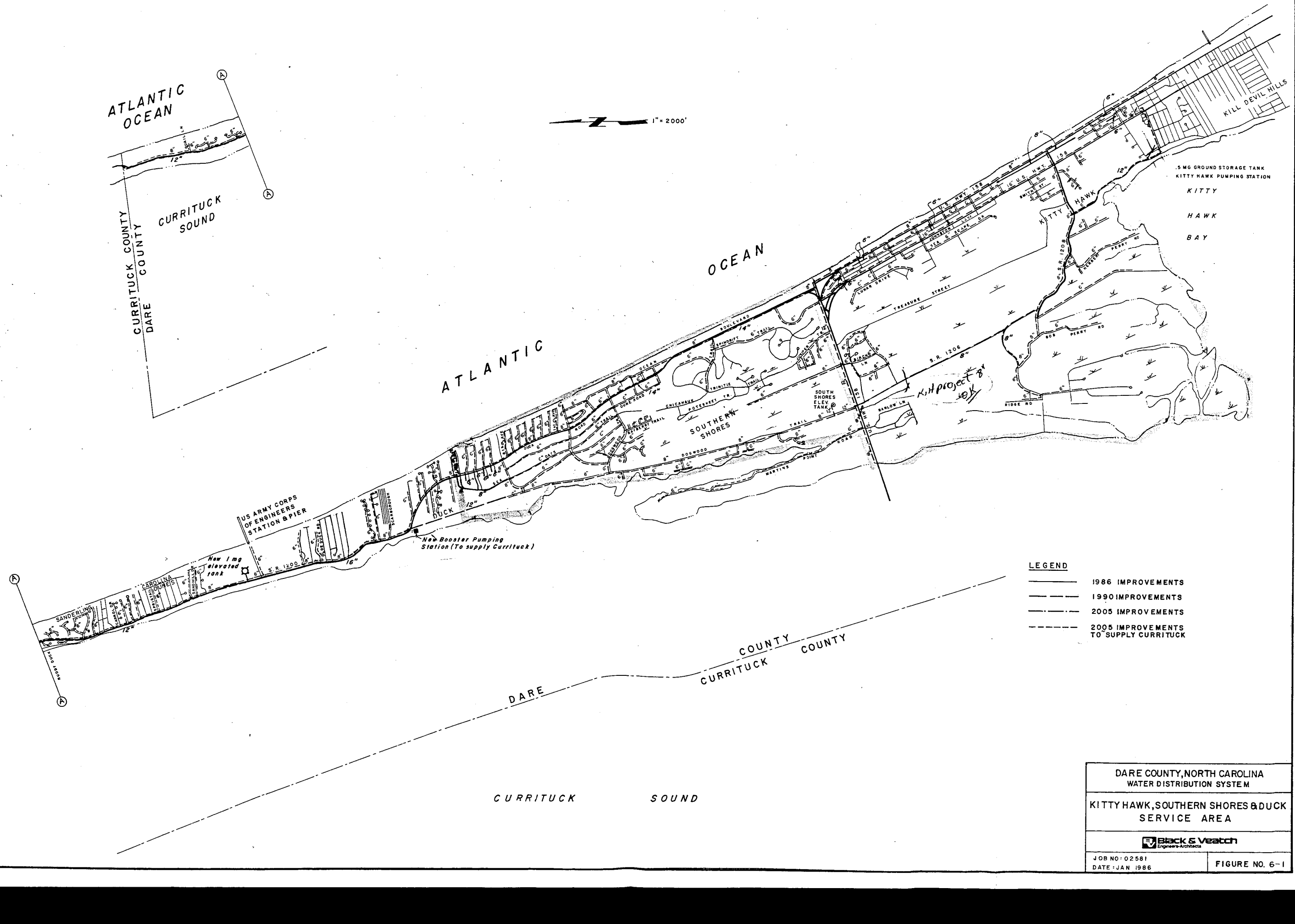
6.1 GENERAL

The study analysis determined that improvements need to be made to the distribution system to maintain adequate service to the area as growth occurs. The study concentrated on improvements required immediately to alleviate low pressures in the Duck and Sanderling areas and on improvements needed by 1990 for which immediate planning would be required. The study also looked at improvements required by the year 2005 to verify that improvements proposed for 1986 and 1990 would be adequate for long-term growth. The improvements for design year 2005 should only be implemented after a future study indicates they are adequate for the intervening and projected growth.

The water main and storage improvements are described in sections grouped by design years. The improvements to the Kitty Hawk Pumping Station are described in a separate section, as are the additional improvements required to serve Currituck County. All improvements are shown on Figure 6-1.

6.2 BASE YEAR 1986

A 1.0 million gallon elevated tank and approximately 9,000 feet of 16-inch water line are required in 1986. The elevated tank should be in the vicinity of the U.S. Army Corps of Engineers' research pier. The 16-inch water main should parallel the existing 8-inch main in the NCSR 1200 right-of-way from the elevated tank to Christopher Drive in Duck village. This main is more for transmission purposes and is not for the purpose of serving new houses. If the elevated tank is constructed in 1986, it will be possible to defer some of the water main construction until 1987. The tank volume of 1.0 million gallons is more than required simply for improving system pressures in the Duck and Sanderling areas. The tank is sized to provide adequate service through the year 2005. In the years before system demand increases to use the full tank capacity, it will be possible to use the extra tank volume to satisfy maximum day demand. For example, on a four day peak weekend in the summer, the tank could have a net drainage of 100,000



DARE COUNTY, NORTH CAROLINA
WATER DISTRIBUTION SYSTEM

KITTY HAWK, SOUTHERN SHORES & DUCK
SERVICE AREA

Black & Veatch
Engineers-Architects

JOB NO: 02581
DATE: JAN 1986

FIGURE NO. 6-1

BAV-C 2436-A

gallons each day, thereby serving an additional 250 to 500 connections, and still have more than half of its volume remaining for emergency use. The tank would have to be refilled on the off days. This practice should be implemented only through 1988, as increasing demands will require more drainage to satisfy maximum hour demands after that time.

Figure 6-1 also shows some 6-inch and 8-inch main improvements in other parts of the distribution system. They will serve new areas that have requested water. Their construction does not significantly affect distribution system performance.

One additional improvement is an altitude valve at the Southern Shores elevated tank. It is required to prevent the tank from overflowing during maximum day and tank replenishment conditions.

6.3 DESIGN YEAR 1990

Two additional water main improvements are required to satisfy the 1990 demands. One is an 8-inch main along NCSR 1206 connecting the Kitty Hawk village main with the 12-inch main in Southern Shores. This main will eliminate a long dead-end main and will provide an additional flow path for water being discharged from the Kitty Hawk Pumping Station. It will also allow additional properties to be served as development takes place along NCSR 1206.

The other improvement should be a 12-inch main, connecting Duck Village with the dead-end portion of Dogwood Trail in Southern Shores. This main will improve water distribution during maximum hour conditions. It will provide looped service to Duck, where service is now by a single 8-inch main. It is also required to help distribute water from the new elevated tank during maximum hour conditions. The main is shown schematically on Figure 6-1 in a location where there are not dedicated streets. This main can be located along existing streets in a different location than shown, provided it connects the two indicated points.

6.4 DESIGN YEAR 2005

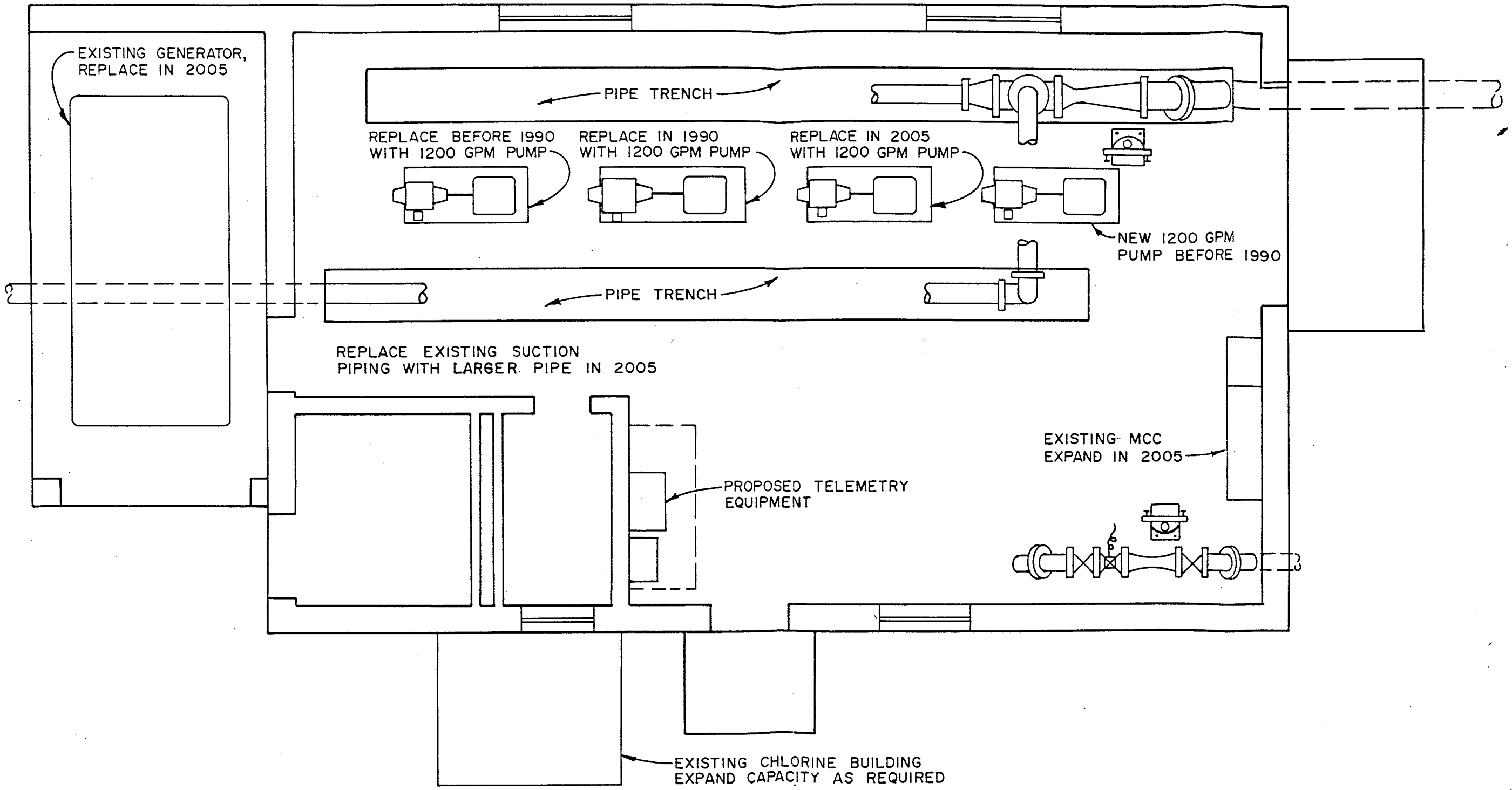
The analysis indicates that one major main improvement will be required to maintain an adequate distribution system in 2005. A 16-inch main will be needed from the Southern Shores/Kitty Hawk boundary to Atlantic Road along Duck Road, paralleling an existing 8-inch main. The length and actual location of this main should be reviewed in the future to verify the correctness of the improvement. Changes in the pattern of growth may supersede this recommendation.

The analysis did not indicate the need for any additional storage for the 2005 design year. However, the large pumping rate from the Kitty Hawk Pumping Station may require the addition of additional storage at the pumping station. This storage does not contribute to maximum hour demands, but serves as a buffer between the delivery capabilities of the transmission main and the pumping rate required at the pumping station. At the present time, the reservoir is sometimes drained of more than 70 percent of its volume during average and maximum daily conditions. This report is not making a firm recommendation for additional storage here, because the future construction of a water treatment plant on the outer banks should increase the delivery capability of the transmission main and reduce the required storage need. This must have future evaluation to determine whether additional storage is required.

6.5 KITTY HAWK PUMPING STATION

The Kitty Hawk Pumping Station will require significant improvements to continue to supply the distribution system through the year 2005. However, it appears that no improvements will be necessary for 1986 and probably 1987. Figure 6-2 shows these improvements.

Table 6-1 lists the current pumping station capacity and the pumping rate that will be required in the future. Firm capacity is defined as the amount that can be pumped with the largest pump out of service. Standard design practice considers only firm capacity as being available to provide the required pumping rate. The pumping rates required in Table 6-1 assume the following:



KITTY HAWK PUMPING STATION
IMPROVEMENTS
FIGURE 6-2

1. The given pumping rate is constant over 24 hours.
2. The elevated storage tanks drain to the halfway point during maximum hour conditions.

TABLE 6-1
KITTY HAWK PUMPING UNITS

	No. 1	No. 2	No. 3	No. 4	Firm Capacity
Existing Pumps					
Flow	100	1,500	1,000	space	1,000
Head (feet)	162	200	200	-	

	No supply to Currituck Co.	1 mgd supply to Currituck Co.
Future Pumping Rates Required		
1986	833	N/A
1990	1,667	2,400
2000	2,900	3,600

These conditions are idealized and may not be exactly achieved. In past years, Water Department operators have at times used the 1,500 gpm pump for several hours per day in the summer. It appears, however, that this larger pump is used to avoid elevated tank draining and to avoid 24-hour operation. The lack of functioning telemetry and remote control have also contributed to the use of the larger pump. It is believed that the addition of elevated tank capacity, and the change to longer hours of operation will allow the lower pumping rate to be used.

Pumping improvements will be required by 1990 to maintain adequate service. To provide the right improvement now, the pumping rate for 2005 must be considered, and a decision must be made on whether to plan for water being supplied to Currituck County. The recommended pumping improvements assume

that water will be sold to Currituck County at a maximum rate of 1.0 mgd. It is recommended that two 1,200 gpm pumps be installed by 1990, one to replace existing pump No. 1 and one in the space not being used. This will be adequate for the 1990 flow rate and will be consistant with the 2005 flow rate. It is further recommended that by the year 2005 pumps 2 and 3 be replaced with two 1,200 gpm pumps. All new pumps should have a head of 240 feet. Although pumps 2 and 3 are a good size, they do not produce sufficient head to meet the future needs of the distribution system.

The larger pumping station flow rate will necessitate other changes to piping and possibly to the structure. Suction piping size will need to be increased from 16-inch to 30-inch, and pump discharge and header piping size will also need to be increased to minimize in-station head losses. The larger piping may require structural changes to pipe chases and other parts of the building. It is also likely that modifications will be required to the chlorine feed system, ventilation system, and electrical equipment. Costs have been included for these items in Section 7 of this report.

6.6 IMPROVEMENTS TO SERVE CURRITUCK COUNTY

Analysis showed that Currituck County can be supplied with up to 1.0 mgd of water with relatively few improvements to the Dare County distribution system. Improvements to the Kitty Hawk Pumping Station would be required even if no water is supplied to Currituck County. The extra cost involved to supply Currituck County is for slightly larger pumps. The storage requirements are not affected by the decision of whether to supply Currituck County.

Additional water mains are required to deliver 1.0 mgd of water to the county line. A 12-inch main will be required from the new elevated tank to the county line. This would be on NCSR 1200 and would parallel an existing 8-inch main. An additional 12-inch main will be required to connect Kitty Hawk Pumping Station to the 8-inch main in Kitty Hawk Village. The location of this main shown in Figure 6-1 is tentative, and another location would be acceptable.

In addition to the water mains described above, a booster pumping station will be required in the Duck area. The booster station should have a firm capacity of 1,300 gpm, with a pressure boost of 150 feet. The booster pumping station is recommended at this time in lieu of additional water mains. Ordinarily, more water mains would provide a better long-term solution to the problem. However, the additional mains would most likely be much more expensive. Also, the fact that the distribution system that consists of a single trunk main with branches, from Duck Village northward, presents an ideal situation for a booster pump.

Should more than 1.0 mgd be supplied to Currituck County, additional mains would be required. However, the mains proposed above would still be valid and could tie in with the other improvements.

7.0 PRELIMINARY OPINION OF COST

7.1 BASE YEAR 1986

Table 7-1 indicates the preliminary opinion of probable construction costs for projects required by design year 1986 analysis. The additional water mains listed as project 3 are mains that were planned and designed in 1984-85 but never constructed because of the shortage of water and the County's policy not to directly fund water lines to serve new locations. They are included here, since they are for areas that have requested water and for which work has been initiated. Construction of project 3 would depend on the proper financial arrangements with property owners.

7.2 DESIGN YEAR 1990

Table 7-2 indicates the preliminary opinion of probable construction costs for projects required by design year 1990 analysis. They are identified as projects 4, 5, and 6, continuing the numbering sequence begun for earlier projects.

7.3 DESIGN YEAR 2005

Table 7-3 indicates the preliminary opinion of probable construction costs for projects required by design year 2005 analysis. They are identified as projects 7 through 10. Projects 9 and 10 are those required to supply up to 1.0 mgd to Currituck County.

7.4 CAPITAL IMPROVEMENT PLAN

The projects listed in Tables 7-1 and 7-2 are required near enough to the present date for the County to plan on which budget year funds will be required for implementation. Table 7-4 groups the projects under the fiscal year in which the major expense will occur. It should be noted that these cost opinions should be updated for all projects prior to construction.

TABLE 7-1

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST
BASE YEAR 1986

PROJECT 1 - ELEVATED TANK	
Construction Cost	$800,000
Contingency (10%)	80,000
Land Cost	100,000
Subtotal	$980,000
Engineering	25,000
Legal, Administrative (1%)	9,800
Total	$1,014,800
PROJECT 2 - WATER MAIN	
Construction Cost	
9,500 ft. 16-inch pipeline	$225,600
Altitude valve vault	35,000
	$260,600
Contingency (15%)	39,090
Subtotal	$299,690
Engineering	30,000
Legal, Administrative	2,880
Total	$322,570

TABLE 7-1 (continued)

PROJECT 3 - ADDITIONAL WATER MAINS

Construction Costs	
Kitty Hawk	
6-inch pipelines	$119,340
Southern Shores	
8-inch pipelines	47,320
6-inch pipelines	31,700
	$198,360
Contingency (15%)	29,750
Rights-of-way	40,000
Subtotal	$268,110
Engineering - no further costs	
Legal, Administrative (1%)	2,680
Total	$270,790

TABLE 7-2

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST
DESIGN YEAR 1990

PROJECT 4 - KITTY HAWK WATER MAIN

Construction Cost	
12,000 ft of 8-inch pipeline	$216,000
Contingency (15%)	32,400
Subtotal	$248,400
Engineering	37,300
Legal, Administrative (1%)	2,500
Total	$288,200

PROJECT 5 - SOUTHERN SHORES/DUCK WATER MAIN

Construction Cost	
7,000 lin ft of 12-inch pipeline	$168,000
Contingency (15%)	25,200
Rights-of-way	30,000
Subtotal	$223,200
Engineering	33,480
Legal, Administrative (1%)	2,230
Total	$258,910

PROJECT 6 - KITTY HAWK PUMPING STATION IMPROVEMENTS

Construction Cost	
2-1,200 gpm pumps	$100,000
Piping Modifications	30,000
Structural Modifications	25,000
Electrical	60,000
	$215,000
Contingency (15%)	32,250
Subtotal	$247,250
Engineering	37,100
Legal, Administrative (1%)	2,470
Total	$286,820

TABLE 7-3

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS
DESIGN YEAR 2005

PROJECT 7 - SOUTHERN SHORES WATER MAIN

Construction Costs	
15,000 lin ft of 16-inch pipeline	$360,000
Contingency (15%)	54,000
Subtotal	$414,000
Engineering	45,540
Legal, Administrative (1%)	4,140
Total	$463,680

PROJECT 8 - KITTY HAWK PUMPING STATION IMPROVEMENTS

Construction Costs	
Two-1,200 gpm pumps	$100,000
Piping modifications	15,000
Electrical	60,000
Miscellaneous	20,000
Subtotal	$195,000
Contingency (15%)	29,250
Subtotal	$224,250
Engineering	33,000
Legal, Administrative (1%)	2,250
Total	$259,500

TABLE 7-3 (continued)

PROJECT 9 - WATER LINES TO SUPPLY CURRITUCK COUNTY

Construction Costs	
9,000 lin ft of 12-inch pipeline	$216,000
19,000 lin ft of 12-inch pipeline	285,000
Subtotal	$501,000
Contingency (15%)	75,150
Subtotal	$576,150
Engineering	69,140
Legal, Administrative (1%)	5,760
Total	$651,050

PROJECT 10 - BOOSTER PUMPING STATION

Construction Costs	$200,000
Contingency (15%)	30,000
Land cost	100,000
Subtotal	$330,000
Engineering	39,600
Legal, Administrative (1%)	3,300
Total	$372,900

TABLE 7-4

CAPITAL IMPROVEMENT PLAN

Fiscal Year	Project No.	Description	Cost Opinion
1986-87	1	Elevated Tank	$1,014,800
1986-87	2	Water Main	321,070
		1986-87 Total	$1,335,870
1987-88	3	Misc. Water Lines	270,790
		1987-88 Total	$ 270,790
1988-89	4	Kitty Hawk Water Main	$ 288,200
1988-89	5	Southern Shores/Duck Water Main	258,910
		1988-89 Total	$ 547,110
1989-90	6	Kitty Hawk Pumping Station Improvements	$ 286,820
		1989-90 Total	$ 286,820