WASTEWATER FACILITIES EVALUATION CNC CHARLESTON SC

9/1/1990

CHARLESTON NAVAL SHIPYARD PUBLIC WORKS DEPARTMENT

CHARLESTON NAVAL SHIPYARD
PUBLIC WORKS DEPARTMENT

Wastewater Facilities Evaluation Charleston Naval Base Charleston, S.C.

Navy Contract # N62467-88-D-1604

Wastewater = Compliance

Scan

September 1990

Davis & Floyd, Inc.
ENGINEERS
POST OFFICE BOX 11024
CHARLESTON, SOUTH CAROLINA 29411

September 14, 1990

Public Works Department
Charleston Naval Shipyard
Charleston, S.C. 29408-6100

ATTN: Code 441.5
Mr. Richard Garcia

Re: Final Report
Wastewater Facilities Evaluation
Charleston Naval Base
Navy Contract # N62467-88-D-1604

Dear Mr. Garcia:

Davis & Floyd is pleased to submit five (5) copies of the referenced final report.

Discrepancies between existing sewer system base maps and our field information have been evaluated and adjusted, as necessary. Mark Hammond's 9/14/90 memo to Bill Lemacks confirms those findings. Appendix G includes new, reduced sewer system base maps.

Davis & Floyd is grateful for the cooperation extended by all Public Works Personnel, particularly Don Erbe and his staff at Code 453.44. We trust this document will prove useful to Naval Base planning efforts and look forward to being of further service.

Sincerely,

DAVIS & FLOYD, INC.

Jack Wright

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CHARLESTON NAVAL SHIPYARD
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FINDINGS

1. The estimated daily average flow from the Naval Base is as follows:

   1990: 1.7 mgd

   1995: 1.9 mgd

   2000: 2.0 mgd

2. The estimated peak daily flow from the Naval Base is as follows:

   1990: 5.1 mgd

   1995: 5.6 mgd

   2000: 5.9 mgd

3. The estimated daily I/I for the Naval Base is 0.75 mgd, or approximately 45% of the daily average flow.

4. Peak flows exceed the capacities of several gravity trunk lines.

5. Four pump stations are receiving peak gravity flows that exceed their pumping capacities.

6. The absence of baseline water and wastewater flow information seriously hinders effective operation of the Naval Base sewer system.

7. The discharge of industrial and commercial waste, largely oil and grease, is evident throughout the system.

8. Serious operational deficiencies are common in Naval Base pump stations, most notably in wet well-dry well stations.

CONCLUSIONS

1. The major source of I/I in the Base sanitary sewer system appears to be storm sewer cross-connections. The most serious storm sewer connections include:

   - Oil-water separators throughout the Base, most notably the separator at the Fleet and Mine Warfare Training Center fire fighting area.
   - Roof drains on several Shipyard buildings (identified in Chapter 3).
   - An abandoned storm line adjacent to Building NS-43.
   - Catch basins and drop inlets throughout the Naval Base (identified in Chapter 3).

2. Groundwater infiltration (and, in some cases, tidal influence) is a major source of I/I flows. While specific instances of groundwater infiltration cannot be identified without an intensive I/I study, heavy groundwater infiltration is evident Base-wide.

3. The prevalence of oil and grease demonstrates that Public Works should initiate tighter controls on industrial discharges to the system.

4. Portions of the gravity system determined to be over capacity include segments of the following lines:

- The 20-inch Naval Station trunk line.
- The 24-inch Shipyard trunk line.
- The 30-inch Naval Base discharge line.
- The 10-inch Naval Hospital service line.

Some of the segments are presently over capacity; however, most are projected to be over capacity in 10 years due to planned growth at the Base.

5. The existing 20-inch Naval Station trunk line does not have capacity for the projected flows from the planned Submarine Berthing Pier at the south end of the Naval Base.

6. Dry well flooding and subsequent equipment damage is possible in all wet well-dry well stations. This is a recurring problem at the Pier "K", Pier "P", and Pier "S" pump stations.

7. Due to heavy groundwater infiltration and possible tidal influence upstream of Pump Station No. 9, sand and salt water have apparently damaged both pumps and the 4-inch discharge force main. The station pumps continuously; however, at a seriously reduced rate.

8. The Pier "A" Pump Station has been out of service since Hurricane Hugo, and will probably be abandoned permanently.

9. The following pump stations were found to be handling peak gravity flows over or near their pumping capacities:

   - o Pump Station No. 1
   - o Pump Station No. 7
   - o Pump Station No. 8
   - o Pump Station No. 9

RECOMMENDATIONS

1. All instances of storm sewer cross-connections to the sewer system should be promptly repaired in order to reduce peak flows. Recommended system improvements to reduce other sources of I/I (e.g., line leaks, uncovered cleanouts) are presented in Chapter 3.

2. Because groundwater infiltration is common throughout the Naval Base, remote T.V. or other inspections should be performed on lines where heavy infiltration is suspected. These inspections should include filming during low-flow periods to better determine I/I problems. Chapter 3 includes an area-by-area discussion of I/I. Tables 3-1 and 3-2 rate the I/I potential for Naval Base gravity trunk lines.

3. A program should be implemented to eliminate the discharge of undesirable chemical substances (predominantly oil and grease) into

the sewer system. Holding tanks, separators, or other means of containing these constituents should be employed. Public Works should investigate and monitor existing oil/water separators and upgrade the separators determined to be deficient.

4. The Naval Station trunk line should be upgraded or have flow diverted from it to avoid further exceeding its capacity. Four options for ensuring future capacity in this line are examined in Chapter 4.

5. Rehabilitative measures should be initiated on all wet well-dry well pump stations. Recommended action is replacement with submersible pumps. Station 9 and Piers "K", "P", and "S" pump stations should be converted now. Conversion to submersible pumps should be phased in other stations when upgrade or major repairs are required.

6. Rehabilitation or replacement is suggested for Pump Station No. 9. Pump Station No. 1 may also require upgrading if improvements recommended herein are not carried out.

7. If Pier "A" Pump Station is abandoned, future sewer service for Pier "A" is required. A gravity line between the existing pump station wet well and Pump Station No. 9 should be considered.

8. A flow measuring flume and recorder for installation in the 30-inch Naval Base discharge line has been designed. Upon installation of that equipment, Public Works personnel should monitor Naval Base flow

patterns. That information can help further define I/I flows and their sources. Flow surges immediately after a rainfall suggest direct storm discharge to the system as opposed to more gradual increases due to infiltration or indirect inflow.

9. Public Works should install water meters at appropriate points within the Base water system to determine where, and in what quantities, water is being used. Likewise, a program of periodic sewage flow measurement should be implemented to verify sewage generation from specific areas.

CHAPTER 1

INTRODUCTION

BACKGROUND

The Charleston Naval Base and contiguous activities are located on a long, narrow strip of land on the west bank of the Cooper River in Charleston, South Carolina. The base consists of two main activities: the Naval Shipyard, which includes of all facilities in the northern half of the base, and the Naval Station, which comprises the southern half of the base. Together with the spoil area east of the river, the Naval Base covers approximately 2,915 acres.

In the early 1970's, a sanitary sewage collection system was constructed to collect the total wastewater flow from all Naval Base facilities. This system has since been upgraded from time-to-time in order to keep up with the growth and expansion of the base. With the addition of several new pump stations and several thousand feet of gravity lines, the Naval Base sewer system currently consists of approximately 90,000 linear feet of gravity sewers and 22 pump stations with associated force mains.

All Naval Base wastewater flow is collected by one of two main sewer trunk lines. One of these trunk lines serves the Shipyard portion of the base; the other serves the Naval Station. Wastewater generally flows toward the center of the base, where it is collected by the Naval Base discharge line paralleling Viaduct Road. This line transports wastewater into the North Charleston Sewer District's Navy Yard Pump Station on Bainbridge Avenue; wastewater then enters the NCSD system and ultimately receives secondary biological treatment at the NCSD Felix C. Davis plant. That plant then discharges into the Cooper River.

The Naval Base sewer system is operated and maintained by the Public Works Department of the Charleston Naval Shipyard. The Pipefitter Foreman's Shop (Work Center 44) of the Public Works Utilities Division (Shop 03) handles the direct control, maintenance, and day-to-day operation of the sewer system.

Public Works has no comprehensive information on the sources and quantities of wastewater generated at the Naval Base. The lack of that information, and the problems its absence creates for wastewater planning efforts, led Public Works to contract this study.

PURPOSE AND SCOPE

The purpose of this report is to present the findings of an engineering evaluation of the Naval Base wastewater facilities. This study offers a comprehensive analysis of the existing condition of the sewer system and its ability to handle estimated present and future wastewater flows from the Naval Base. Specific problem areas are noted, and actions to improve the performance of the sewer system are recommended.

The scope of work includes a complete evaluation of all sewer system components (gravity lines, manholes, pump stations, and force mains). Those components were field-inspected to determine their physical condition. The capacities of system components were calculated based on field observations, surveys, and pumping tests, and those capacities will be compared to estimated current and future wastewater flows.

CHAPTER 2

WASTEWATER FLOW PROJECTIONS

INTRODUCTION

In order to make the evaluation of the CNSYD sewer system more manageable and to improve the accuracy of the study results, the Naval Base sewer service area was broken down into 33-evaluation zones. The configuration and size of each zone was determined by the layout of the system; generally, each zone is an area from which wastewater is collected and transported to a single point. This point is called the key manhole for the evaluation zone. The 33 evaluation zones are outlined on Figures 2-1 and 2-2.

Each zone was individually evaluated to determine its present and future wastewater flow estimates, which will be used throughout this report. Present flow estimates were derived from population data and other records provided by the CNSYD Public Works Department, while future flows were projected by assuming a standard rate of population growth and applying information on planned facilities at the Naval Base. The following is a discussion of the various criteria and the methodology used in deriving the flow estimates contained in this chapter. Proceeding this discussion, a zone-by-zone evaluation of present and future wastewater flows is presented, along with a short summary.

CRITERIA

Wastewater Flow Sources

There are five major sources of wastewater flow examined in this study: (1) residential, (2) commercial, (3) industrial, (4) medical, and (5) naval vessels. For each evaluation zone, a population attributable to each flow source was determined by one of two ways: (1) assigning the flow source a standard population density, or (2) using a known population for that source, as indicated in a CNSYD Utilities Department Water Usage Study that determined populations of most Naval Base buildings. Using the known or assumed population of each source within a certain zone, the total wastewater flow from that zone could then be estimated.

The following is a definition of each type of flow source and the method used in determining its population:

- Residential: The Naval Base residential facilities consist of single-family dwelling units and high-density units, such as military quarters, barracks and custody centers. The population of single-family units was assumed to be 3.5 people per dwelling. High-density units were assigned actual populations as provided by the CNSYD Utilities Department Study.
- Commercial: Commercial facilities at the Naval Base include recreational and entertainment facilities, restaurants and cafeterias, stores and other buildings where full-time employees and visitors can be expected at any time. Commercial populations for both employees and visitors were derived from the Utilities Department Study.

- o Industrial: Industrial facilities consist of buildings and shops containing employees who work on-base on a full-time basis, but who live off-base. Populations of industrial facilities were extracted from the Utilities Department Study.
- o Medical: The Naval Base medical facilities consist of several clinics, infirmaries, and the Navy Hospital on Rivers Avenue. The populations of medical facilities other than the Navy Hospital were taken from the Utilities Department Study. Navy Hospital population was not a concern; hospital sewage flows were estimated using a method discussed later in this chapter.
- o Naval Vessels: Most of the ships in port at the Naval Base utilize the CNSYD sewer system while they are docked. Exact naval vessel populations could not be determined. Ships' wastewater flows were estimated using a method described later in this chapter.

Sewage Loading Rates

In order to convert the known or assumed flow source populations to reasonable estimates of sewage flow from each zone, standard sewage loading rates were assumed for each source. These rates represent typical daily sewage flows contributed by each of the five flow sources examined in this study. All assumed sewage loading rates are listed in Table 2-1.

Most of the sewage loading rates indicated are widely accepted rates commonly used in engineering studies. Loading rates for naval vessels, however, were obtained from CNSYD Utilities Department water usage estimates for ships, which they use for billing purposes. It was assumed that 100 percent of the water consumed on ships was returned to the sewer system, to ensure that conservative wastewater flow estimates were produced.

TABLE 2-1 STANDARD SEWAGE LOADING ESTIMATES

Flow Source	Contributory Loading Rate
Residential	65 gallons per day per capita
Commercial	
Full-Time Employees	20 gallons per day per capita
Restaurants and Cafeterias	5 gallons per meal served
Recreational Facilities	2.5 gallons per visitor
Recreational Facilities w/Showers	10 gallons per visitor
Navy Lodge	65 gallons per day per customer
General Commercial (Commissary, Serv Mart, Post Office, etc.)	1 gallon per patron
Industrial	20 gallons per day per capita
Medical	
Full-Time Employees	20 gallons per day per capita
Patients (excluding Navy Hospital)	5 gallons per day per patient
Naval Vessels	
Destroyer Tender (AD)	7250 gallons per day per ship
Ammunitions Ship (AE)	7250 gallons per day per ship
Submarine Tender (AS)	7250 gallons per day per ship
Repair Vessel (ASR)	1100 gallons per day per ship
Guided Missile Cruiser (CG)	5250 gallons per day per ship
Destroyer (DD)	4200 gallons per day per ship
Guided Missile Destroyer (DDG)	5250 gallons per day per ship
Fast Frigate (FF)	5250 gallons per day per ship
Guided Missile Fast Frigate (FFG)	4200 gallons per day per ship
New Fast Frigate (MCM)	4200 gallons per day per ship
Mine Sweeper (MSO)	5100 gallons per day per ship
Submarine, Attack (SSN)	2150 gallons per day per ship
Submarine, Fleet Ballistic (SSBN)	2150 gallons per day per ship
Valve Barge (YFN)	1100 gallons per day per ship
Live-In Barge (YRBM)	1600 gallons per day per ship

METHODOLOGY

Wastewater flow estimates are presented for each zone as daily average flow (DAF) and peak flow. The DAF is the average daily flow of the average month. The peak flow is the maximum daily flow of the average month. The DAF and peak flows include the actual wastewater flows and the extraneous surface and groundwater flows which enter into the system. These extraneous flows are commonly referred to as infiltration/inflow (I/I).

DAF and peak flow were calculated on a zone-by-zone basis and were dependent on zone population, types of flow sources in that zone, the seriousness of I/I, and other factors. DAF and peak flow were estimated for the present and were also projected into the year 2000. The following is a discussion of the methodology used in estimating present and future wastewater flows.

Base Flow From Major Sources

The average daily flows from the five major sources were estimated for each evaluation zone to determine an expected total base flow from these sources only (not taking into account any I/I). In most cases, the known or assumed population of a particular source was multiplied by its appropriate sewage loading rate to determine this flow. In order to accurately estimate the base flow from naval vessels and the Navy Hospital, however, an alternate method had to be used due to the fact that exact populations could not be determined for either of these sources.

Flow from naval vessels was cumulatively estimated and reported as average daily flow from each pier. Monthly docking records are kept by the

CNSYD Utilities Department for Piers "L" through "Z". Using these records over a two-year period and applying the estimates for sewage loading by ship class (from Table 2-1), a monthly average flow was calculated for each pier. This monthly average was used to determine the pier's average daily wastewater flow.

Because no docking records were kept for Piers "A" through "K", an assumption as to a typical number of ships on each of these piers was required. Based on information provided by CNSYD Public Works, the following combinations of ships was assumed:

- Pier "A": Since supply ships at this pier rarely utilize the sewer system, assumed no ships present.
- Pier "C": 2 fleet ballistic missile submarines; 2 live-in barges.
- Pier "D": 1 frigate, 1 destroyer, 2 submarines; 2 live-in barges.
- Pier "F": 1 submarine tender.
- Pier "G": 1 attack submarine; 1 live-in barge.
- Pier "H": 1 attack submarine, 1 fleet ballistic missile submarine; 2 live-in barges.
- Pier "J": 1 attack submarine; 1 live-in barge.
- Pier "K": 2 attack submarines; 2 live-in barges.
- Dry Dock #1: 1 destroyer.
- Dry Dock #2: 1 fleet ballistic missile submarine.
- Dry Dock #5: 1 attack submarine.

Navy Hospital Base flows were estimated using actual hospital water usage records. Monthly water flows were averaged over a 1-1/2 year period, and for the purposes of this study, it was assumed that 75 percent of the water used was returned to the sewer system. A Navy Hospital daily average flow was then derived from this average monthly wastewater flow.

Infiltration/Inflow

In order to determine DAF, the base flow from the five sources was added to an estimated I/I for each zone. The total (average) amount of Naval Base I/I was calculated by subtracting the total base flow for the entire Naval Base from actual flows recorded for billing by the North Charleston Sewer District (NCSD). Thus, it was assumed that any sewage flow in excess of the base flow contributed by the five sources could be attributed to I/I.

Once total I/I flow for the Naval Base was found, it was then distributed to each of the 33 zones based on the judged seriousness and number of I/I sources within the zone. These sources were generally defects, leaks and storm sewer cross-connects that were determined by the gravity sewer line evaluation described in Chapter 3.

A rating system was used to determine the proportionate amounts of I/I that were distributed to the evaluation zones. Each type of defect noted (e.g., catch basin cross-connect, gravity line leak) was assigned a rating from 1 to 5 based on its potential to allow groundwater and surface water into the system. Using the information provided by the gravity line evaluation, a total rating was determined for each zone based on the number and types of defects in that zone. The ratio of the zone rating to the total Naval Base rating (the cumulative sum of all 33 individual ratings) could then be multiplied by the total Naval Base I/I to obtain the I/I flow in any given zone.

For the purpose of this study, I/I flows are assumed to remain constant over the 10-year flow projection period.

Future Flow Projections

Wastewater flow estimates, in addition to being determined for the present time, were also projected 5 years and 10 years into the future. After discussion with Naval Base planning personnel, a population growth rate of 10 percent was assumed over the 10-year period. Information on future facilities was provided by planning departments for the Naval Shipyard, the Naval Station, and the Naval Supply Center, and the populations of any major facilities were included in addition to the assumed 10 percent rate of growth.

One new pier facility, a Submarine Berthing Pier at the extreme south end of the Naval Base, is still in its planning stages at the Southern Division of the Naval Facilities Engineering Command (NAVFAC). Based on information provided by NAVFAC as to the number and type of ships expected to be berthed at this pier, an estimate of average daily flow from the pier was derived. However, NAVFAC's preliminary flow estimate was considerably higher because their estimate used higher standard loading rates than those used in this study. For the purposes of this study, the naval vessel sewage loading rates shown in Table 2-1 were assumed to be consistent with ships utilizing the new pier, and thus, are reflected in DAF estimates in Table 2-60.

Due to the fact that it has not been determined where the Submarine Berthing Pier will tie into the existing sewer system, an assumption was made as to the most suitable location, based on line capacities and present and future flow estimates. This location was found to be in Zone 31, which will be discussed later in this chapter.

Peak Flow

Once the base flow and I/I for each zone were established, the peak flow was calculated by multiplying the DAF by an appropriate peak factor. The peak factor used in this study was 3.0, which is commonly used in engineering studies.

LIMITATIONS

The major limitation to this evaluation was the absence of sewage flow monitoring. The accuracy of the results, therefore, depends upon the precision of the assumed loading rates, Base populations, I/I estimates, and other factors previously discussed. The only available flow measurements were flow recordings from the NCSD Navy Yard Pump Station, which receives all Navy Base flow and some off-base flow. However, these records were only of limited usefulness, largely because they indicated only total monthly flows. Flows for specific days were unknown. This also made it difficult to compare rainfall data to daily flows and produce an expected correlation between rainfall amounts and I/I.

A sewage flow measuring flume and recorder has been designed for the 30-inch Naval Base discharge line. Upon its construction, the flow metering system will allow more precise and useful flow measurements to be recorded and should lead to more direct control of sewer system functions by the Public Works Department.

WASTEWATER FLOW PROJECTIONS

The following tables (2-1 through 2-65) list the zone populations for each source, the DAF for 1990, 1995 and 2000, and the peak flow for the same years. All flows are presented in gallons per day (gpd), and in instances where flow is contributed by sources other than a zone's standard population, they are noted along with the flow estimates. All total DAF's were rounded up to the nearest 500 gpd and multiplied by 3.0 to determine zone peak flows.

Zone 1 (Key Manhole No. 2)

Zone 1 is located in the northernmost portion of the Naval Base. It is comprised of all base facilities north of Noisette Creek, most of which are Naval Supply Center warehouses and storage areas. Very few employees are present in Zone 1. Service to Pier "A" is rarely used, as supply ships that use this pier have independent treatment facilities on-board. As discussed in Chapter 3, I/I is apparently a major problem in this zone due to groundwater and surface water leakage.

TABLE 2-2 ZONE 1:POPULATION PROJECTIONS			
Flow Source	1990	1995	2000
Industrial:			
Employees	155	163	171

TABLE 2-3 ZONE 1:WASTEWATER FLOW PROJECTIONS			
Daily Average Flow (gpd):			
Year	Industrial	I/I	Total (Rounded)
1990	3,100	44,300	47,500
1995	3,260	44,300	48,000
2000	3,420	44,300	48,000
Peak Flow (gpd):			
Year	Industrial	I/I	Total (Rounded)
1990	9,300	132,900	142,500
1995	9,780	132,900	144,000
2000	10,260	132,900	144,000

Zone 2 (Key Manhole No. 30)

Zone 2 is located next to Noisette Creek and the Shipyard Golf Course. It is made up of the Cooper River Recreation Center, the Officers' Club, the Golf Course Clubhouse, and several residential dwellings. Flow estimates assume that the Officer's Club pool (open 98 days per year) is in operation.

TABLE 2-4 ZONE 2: POPULATION PROJECTIONS			
Flow Source	1990	1995	2000
Residential:			
Single-Family (no. of residents)	42	44	46
Commercial:			
Employees	42	44	46
Visitors (w/showers)	100	105	110
Visitors (w/o showers)	40	42	44

TABLE 2-5 ZONE 2: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	I/I	Total (Rounded)
1990	2,730	11,173*	20,850	35,000
1995	2,860	11,268*	20,850	35,000
2000	2,990	11,363*	20,850	35,500

Peak Flow (gpd):

Year	Residential	Commercial	I/I	Total (Rounded)
1990	8,190	33,519	62,550	105,000
1995	8,580	33,804	62,550	105,000
2000	8,970	34,089	62,550	106,500

*An additional 9,233 gpd was included for Officers'club pool cleaning and makeup. This was assumed to be constant over the 10-year period.

Zone 3 (Key Manhole No. 20A)

Zone 3 is located adjacent to the Shipyard Golf Course. It is comprised mainly of residential flows from officers' housing quarters (single-family dwellings) plus one small warehouse.

TABLE 2-6 ZONE 3: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
Single-Family (no. of residents)	49	51	54
Industrial:			
Employees	3	3	3

TABLE 2-7 ZONE 3: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	3,185	60	15,650	19,000
1995	3,315	60	15,650	19,000
2000	3,510	60	15,650	19,500

Peak Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	9,555	180	46,950	57,000
1995	9,945	180	46,950	57,000
2000	10,530	180	46,950	58,500

Zone 4 (Key Manhole No. 50)

Zone 4 is also situated in the officers' housing area and is primarily made up of residential flow sources. The only exception is a lumber warehouse on Avenue "D" next to Fire Station No. 2, which is an industrial source. I/I in Zone 4 is significant due to several line leaks and storm sewer cross-connections, all of which are discussed in detail in Chapter 3.

TABLE 2-8 ZONE 4: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
Single-Family (no. of residents)	81	85	89
Industrial:			
Employees	21	22	23

TABLE 2-9 ZONE 4: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	5,265	420	18,250	24,000
1995	5,525	440	18,250	24,500
2000	5,785	460	18,250	24,500

Peak Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	15,795	1,260	54,750	72,000
1995	16,575	1,320	54,750	73,500
2000	17,355	1,380	54,750	73,500

Zone 5 (Key Manhole No. 51)

Zone 5 is located across Avenue "D" from the Shipyard Golf Course and the officers' housing area. It includes Fire Station No. 2, two administrative office buildings, and a hazardous and flammable material storage building. Zone 5 is bordered by Avenue "D", Turnbull Avenue West, Avenue "F", and the Base property line.

TABLE 2-10 ZONE 5: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	124	130	136

TABLE 2-11 ZONE 5: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Industrial	I/I	Total (Rounded)
1990	2,780*	20,850	24,000
1995	2,900*	20,850	24,000
2000	3,020*	20,850	24,000

Peak Flow (gpd):

Year	Industrial	I/I	Total (Rounded)
1990	8,340*	62,550	72,000
1995	8,700*	62,550	72,000
2000	9,060*	62,550	72,000

*An extra 300 gpd, which was assumed to be constant over the 10-year period, was added to industrial flow due to truck washing at the fire station.

Zone 6 (Key Manhole No. 87)

Zone 6 is located adjacent to Avenue "F" in the old Navy Hospital area. It includes much of the flow from the old Navy Hospital complex, in addition to the residential area adjacent to Turnbull Avenue West. Several storm sewer cross-connections generate significant I/I in this zone.

TABLE 2-12 ZONE 6: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
Single-Family (no. of residents)	56	59	61
Commercial:	166	175	183
Industrial:			
Employees	574	603	631

TABLE 2-13 ZONE 6: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	3,640	3,320	11,480	26,050	44,500
1995	3,835	3,500	12,060	26,050	45,500
2000	3,965	3,660	12,620	26,050	46,500

Peak Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	10,920	9,960	34,440	78,150	133,500
1995	11,505	10,500	36,180	78,150	136,500
2000	11,895	10,980	37,860	78,150	139,500

Zone 7 (Key Manhole No. 91)

Zone 7 is also located in the vicinity of the old Navy Hospital. It is bordered by Zone 6 and the Naval Base boundary line, which runs parallel to St. George Avenue. Wastewater flow in Zone 7 is generated by industrial and residential sources; specifically, the old Navy Hospital and several officers' housing quarters. Several line leaks and storm sewer cross-connections are major sources of I/I in this zone.

TABLE 2-14 ZONE 7: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
Single-Family (no. of residents)	56	59	61
Industrial:			
Employees	270	284	297

TABLE 2-15 ZONE 7: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	3,640	5,400	41,700	51,000
1995	3,835	5,680	41,700	51,500
2000	3,965	5,940	41,700	52,000

Peak Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	10,920	16,200	125,100	153,000
1995	11,505	17,040	125,100	154,500
2000	11,895	17,820	125,100	156,000

Zone 8 (Key Manhole No. 155)

Zone 8 is located in the Second Street West-Marine Avenue area. This zone is generally made up of residential dwellings and Marine Corps facilities. The estimates below assumed that the Enlisted Barracks Building M-82, was 100% occupied. Due to inflow sources that are discussed in Chapter 3, I/I is a problem in Zone 8.

TABLE 2-16 ZONE 8: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
Single-Family (no. of residents)	49	52	54
High Density (no. of residents)	180	189	198
Industrial:			
Employees	219	230	241

TABLE 2-17 ZONE 8: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	14,885	4,380	28,700	48,000
1995	15,665	4,600	28,700	49,000
2000	16,380	4,820	28,700	50,000

Peak Flow (gpd):

Year	Residential	Industrial	I/I	Total (Rounded)
1990	44,655	13,140	86,100	144,000
1995	46,995	13,800	86,100	147,000
2000	49,140	14,460	86,100	150,000

Zone 9 (Key Manhole No. 55)

Zone 9 consists of Naval Supply Center facilities, CNSYD engineering and administrative offices, and production shops within the Controlled Industrial Area (CIA). One major facility - a Naval Supply Center administrative office - is planned for completion by 1993 within Zone 9. This building will increase the Zone 9 industrial population by 150 people over the assumed 10 percent growth rate.

TABLE 2-18 ZONE 9: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	2,249	2,511	2,624

TABLE 2-19 ZONE 9: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd): Year	Industrial	I/I	Total (Rounded)
1990	44,980	18,250	63,500
1995	50,220	18,250	68,500
2000	52,480	18,250	71,000
Peak Flow (gpd): Year	Industrial	I/I	Total (Rounded)
1990	134,940	54,750	190,500
1995	150,660	54,750	205,500
2000	157,440	54,750	213,000

Zone 10 (Key Manhole No. 168)

Zone 10 is located in the northern end of the CIA. It is comprised of industrial flow from several production shops and naval vessel flow from Pier "C".

TABLE 2-20 ZONE 10: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	726	762	799
Naval Vessels	N/A*	N/A*	N/A*

*Since the number of ships in port varies from day-to-day, it is impossible to indicate an exact population for ships. Wastewater flow projections in Table 2-21, however, reflect a 10 percent increase in ships' wastewater flows over the 10-year period.

TABLE 2-21 ZONE 10: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	17,640**	7,467	20,850	46,000
1995	18,360**	7,840	20,850	47,000
2000	19,100**	8,213	20,850	48,000

Peak Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	52,920**	22,401	62,550	138,000
1995	55,080**	23,520	62,550	141,000
2000	57,300**	24,639	62,550	144,000

**An additional 1,920 gpd was included in industrial flow due to welding processes in Building 59. This was assumed constant over the 10-year period. Also, since the Plating Shop (Bldg. 226), which employs 60 workers, was identified by the Shipyard Production Department as contributing a high rate of sewage due to industrial processes, loading rates for all shop employees was increased to 40 gallons per day per capita.

Zone 11 (Key Manhole No. 56)

Zone 11 is also located in the CIA. Wastewater flow within this zone consists of ships' flow from Pier "D", commercial flow from the Yard Cafeteria (Building 63), medical flow from the Shipyard Dispensary, and industrial flow from several CIA shops. I/I is also significant in this zone.

TABLE 2-22 ZONE 11:POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Commercial:			
Employees	45	47	50
Cafeterias (no. of meals)	666	699	733
Industrial			
Employees	874	918	961
Medical:			
Employees	49	51	54
Patients	100	105	110
Naval Vessels	N/A*	N/A*	N/A*

*Since the number of ships in port varies from day-to-day, it is impossible to indicate an exact population for ships. Wastewater flow projections in Table 2-23, however, reflect a 10 percent increase in ships' wastewater flows over the 10-year period.

TABLE 2-23 ZONE 11:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Commercial	Industrial	Medical	Naval Vessels	I/I	Total (Rounded)
1990	4,230	20,480**	1,480	16,920	50,150	93,500
1995	4,435	21,360**	1,545	17,767	50,150	95,500
2000	4,665	22,220**	1,630	18,613	50,150	97,500

Peak Flow (gpd):

Year	Commercial	Industrial	Medical	Naval Vessels	I/I	Total (Rounded)
1990	12,690	61,440	4,440	50,760	150,450	280,500
1995	13,305	64,080	4,635	53,301	150,450	286,500
2000	13,995	66,660	4,890	55,839	150,450	292,500

**An additional 3,000 gpd was included in industrial flow due to the public restrooms in Building 457. This was assumed constant over the 10-year period.

Zone 12 (Key Manhole No. 59)

Zone 12 is located in the central part of the CIA and includes Dry Docks No. 1 and No. 2, Pier "F", CIA facilities, and other industrial facilities. This zone will include several new structures through 2000, and population will increase by 350 people above the assumed 10 percent growth rate. New facilities will include a dry dock support facility and a modernization to Pier "F".

TABLE 2-24 ZONE 12: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	757	1,145	1,183
Naval Vessels	N/A*	N/A*	N/A*

*Since the number of ships in port varies from day-to-day, it is impossible to indicate an exact population for ships. Wastewater flow projections in Table 2-25, however, reflect a 10 percent increase in ships' wastewater flows over the 10-year period.

TABLE 2-25 ZONE 12: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	18,140**	13,600	26,050	58,000
1995	22,900**	14,280	26,050	63,500
2000	23,660**	14,960	26,050	65,000

Peak Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	54,420	40,800	78,150	174,000
1995	68,700	42,840	78,150	190,500
2000	70,980	44,880	78,150	195,000

**An additional 3,000 gpd was included in industrial flows due to the public restrooms in Building 77. This was assumed constant over the 10-year period.

Zone 13 (Key Manhole No. 57)

Zone 13 is located in the supply yards adjacent to McMillan Avenue. It consists mainly of Naval Supply Center warehouses, but also includes the Shipyard Security office, Design Division offices, and a CNS Federal Credit Union. Planned facilities in Zone 13 include a water treatment facility, which will significantly impact sewer demands. An additional 150 people are expected to be employed at this facility. An increase in sewer demands of 15,000 gallons per day is anticipated due to the discharge of regenerative waste.

TABLE 2-26 ZONE 13: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Commercial:			
Employees	20	171	172
Visitors (Gen. Commercial)	50	53	55
Industrial:			
Employees	61	64	67

TABLE 2-27 ZONE 13: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	450	1,220	18,250	20,000
1995	473	18,420	18,250	37,500
2000	495	18,440	18,250	37,500

Peak Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	1,350	3,660	54,750	60,000
1995	1,419	55,260	54,750	112,500
2000	1,485	55,320	54,750	112,500

Zone 14 (Key Manhole No. 222A)

Zone 14 is situated outside of Naval Base property; it includes the Navy Hospital property which is bounded by Spruill Avenue to the east, McMillan Avenue to the north, and the hospital property line to the south. Wastewater flow sources in this zone basically consist of the Navy Hospital and the Bachelor's Enlisted Quarters on Spruill Avenue. As discussed earlier, hospital flows were estimated by taking a percentage of actual water usage flows.

TABLE 2-28 ZONE 14: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
High-Density (no. of residents)	150	158	165
Medical:			
Navy Hospital	N/A*	N/A*	N/A*

*It was impossible to indicate a definite hospital population.

TABLE 2-29 ZONE 14: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Medical	I/I	Total (Rounded)
1990	9,750	91,730	13,050	114,500
1995	10,270	96,317	13,050	120,000
2000	10,725	100,903	13,050	125,000

Peak Flow (gpd):

Year	Residential	Medical	I/I	Total (Rounded)
1990	29,250	275,190	39,150	343,500
1995	30,810	288,951	39,150	360,000
2000	32,175	302,709	39,150	375,000

Zone 15 (Key Manhole No. 61)

Zone 15 is located between Dry Dock No. 2 and Dry Dock No. 5. It consists mainly of CIA shops and engineering offices.

TABLE 2-30 ZONE 15: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	1,358	1,426	1,494

TABLE 2-31 ZONE 15: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Industrial	I/I	Total (Rounded)
1990	29,160*	15,650	45,000
1995	30,520*	15,650	46,500
2000	31,880*	15,650	48,000

Peak Flow (gpd):

Year	Industrial	I/I	Total (Rounded)
1990	87,480	46,950	135,000
1995	91,560	46,950	139,050
2000	95,640	46,950	144,000

*An additional 2,000 gpd was included in industrial flows due to the public restrooms in Building 93. This was assumed constant over the 10-year period.

Zone 16 (Key Manhole No. 63)

Zone 16 is located between Hobson Avenue and Avenue "D" South near the Reynolds Avenue gate. This zone is comprised of commercial flow from the Sterret Hall Gym and the Navy Lodge, residential flow from the Marine Barracks (Building 658), and industrial flow from several sources. Two planned projects should cause an increase in population above the standard 10 percent rate of growth. A new rehabilitation center will bring an additional 50 commercial employees to the zone by 1998, while an addition to the existing Navy Lodge will allow 50 more visitors by 1992.

TABLE 2-32 ZONE 16:POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
High-Density (no. of residents)	175	184	193
Commercial:			
Employees	58	61	114
Visitors (w/showers)	225	236	248
Navy Lodge (no of visitors)	40	92	94
Industrial:			
Employees	265	278	292

TABLE 2-33 ZONE 16:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	11,375	6,010	5,800*	18,250	41,500
1995	11,960	9,560	6,060*	18,250	46,000
2000	12,545	10,870	6,340*	18,250	48,000

Peak Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	34,125	18,030	17,400	54,750	124,500
1995	35,880	28,680	18,180	54,750	138,000
2000	37,635	32,610	19,020	54,750	144,000

*An additional 500 gpd was included in industrial flows to account for truck washing at Fire Station No. 1. This was assumed to be constant over the 10-year period.

Zone 17 (Key Manhole No. 64)

Zone 17 is located in the CIA between Piers "F" and "G". It is comprised mainly of flow from industrial sources within the CIA; however, it also includes flow from Dry Dock No. 5 and two commercial facilities - the indoor swimming pool and the Naval Base Chapel.

TABLE 2-34 ZONE 17: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Commercial:			
Employees	18	19	20
Visitors (w/showers)	200	210	220
Industrial:			
Employees	727	763	800
Naval Vessels	N/A*	N/A*	N/A*

*Since the number of ships in port varies from day-to-day, it is impossible to indicate an exact population for ships. Wastewater flow projections in Table 2-35, however, reflect a 10 percent increase in ships' wastewater flows over the 10-year period.

TABLE 2-35 ZONE 17:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Commercial	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	5,102**	17,500***	2,133	20,850	46,000
1995	5,222**	18,220***	2,240	20,850	46,500
2000	5,342**	18,960***	2,347	20,850	47,500

Peak Flow (gpd):

Year	Commercial	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	15,306	52,500	6,399	62,550	138,000
1995	15,666	54,660	6,720	62,550	139,500
2000	16,026	56,880	7,041	62,550	142,500

**An additional 2,742 gpd was included in commercial flow due to indoor pool cleaning and makeup. This was assumed constant over the 10-year period.

***Since the Pipefitter's Shop (Bldg. 236), which employs 148 workers, was identified by the Shipyard Production Department as contributing a high rate of sewage due to industrial processes, loading rates for all shop employees was increased to 40 gallons per day per capita.

Zone 18 (Key Manhole No. 66C)

Zone 18 is comprised of Piers "G", "H" and "J". Wastewater flow within this zone is limited to naval vessel sources only. No population projections are shown due to the fact that exact populations of Navy ships cannot be determined; the number of ships in port varies from day to day. Flow estimates are based on DAF from each pier, and a 10 percent increase in wastewater flows is assumed over the 10-year period.

TABLE 2-36 ZONE 18:WASTEWATER FLOW PROJECTIONS			
Daily Average Flow (gpd):			
Year	Naval Vessels	I/I	Total (Rounded)
1990	14,933	15,650	31,000
1995	15,680	15,650	31,500
2000	16,427	15,650	32,500
Peak Flow (gpd):			
Year	Naval Vessels	I/I	Total (Rounded)
1990	44,799	46,950	93,000
1995	47,040	46,950	94,500
2000	49,281	46,950	97,500

Zone 19 (Key Manhole No. 68)

Zone 19 is located north of Hobson Avenue, adjacent to Piers "G", "H", and "J". It consists entirely of industrial flow from CIA facilities. One planned project - a Nuclear Logistics Facility (replacement for demolished Building 1170) - should bring an additional 50 workers to this zone in addition to the assumed 10 percent growth rate. I/I is significant in Zone 19 due to storm sewer cross-connections.

TABLE 2-37 ZONE 19:POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	512	538	563

TABLE 2-38 ZONE 19:WASTEWATER FLOW PROJECTIONS			
Daily Average Flow (gpd):			
Year	Industrial	I/I	Total (Rounded)
1990	10,240	23,450	34,000
1995	10,760	23,450	34,500
2000	11,260	23,450	35,000
Peak Flow (gpd):			
Year	Industrial	I/I	Total (Rounded)
1990	30,720	70,350	102,000
1995	32,280	70,350	103,500
2000	33,780	70,350	105,000

Zone 20 (Key Manhole No. 71A)

Zone 20 is located adjacent to Hobson Avenue and the Naval Supply Center fuel oil storage area. It includes industrial flow from several CIA facilities and commercial flow from the Mini-Mart convenience store. Planned facilities in this zone consist of a new Public Works complex, which will employ an additional 125 workers and an IMA Training Facility, employing 500 additional workers.

TABLE 2-39 ZONE 20:POPULATION PROJECTIONS			
Flow Source	**1990**	**1995**	**2000**
Commercial:			
Employees	24	650	651
Visitors (Gen. Commercial)	100	105	110
Industrial:			
Employees	445	467	490

TABLE 2-40 ZONE 20: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	580	8,900	26,100	36,000
1995	605	13,000	26,100	40,000
2000	630	13,020	26,100	40,000

Peak Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	1,740	26,700	78,300	108,000
1995	1,815	39,000	78,300	120,000
2000	1,890	39,060	78,300	120,000

Zone 21 (Key Manhole No. 72)

Zone 21 is located in the River Road - Thirteenth Street area. It includes Piers "K" and "L", Dry Docks No. 3 and No. 4 (both of which are rarely used), and several industrial shops. A modernization to Pier "L" is planned for construction by 1995. According to Naval Station planning personnel, this project will increase wastewater flow from the pier by an amount equivalent to an additional 400 employees. This is reflected in Table 2-42 as an addition to the standard 10 percent increase in wastewater flow estimates.

TABLE 2-41 ZONE 21:POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	119	125	131
Naval Vessels	N/A*	N/A*	N/A*

*Since the number of ships in port varies from day-to-day, it is impossible to indicate an exact population for ships. Wastewater flow projections in Table 2-42, however, reflect a 10 percent increase in ships' wastewater flows over the 10-year period.

TABLE 2-42 ZONE 21:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	2,680**	13,500	18,250	34,500
1995	2,800**	22,175	18,250	43,500
2000	2,920**	22,850	18,250	44,000

Peak Flow (gpd):

Year	Commercial	Naval Vessels	I/I	Total (Rounded)
1990	8,040	30,375	54,750	103,500
1995	8,400	31,893	54,750	130,500
2000	8,760	33,414	54,750	132,000

**Since the Battery-Electric Shop (Bldg. 68), which employs 15 workers, was identified by the Shipyard Production Department as contributing a high rate of sewage due to industrial processes, loading rates for all shop employees was increased to 40 gallons per day per capita.

Zone 22 (Key Manhole No. 73C)

Zone 22 is located in the vicinity of the Naval Base main gate on Viaduct Road. Only a few industrial facilities are located within this zone; however, the zone handles the cumulative flow from the entire Naval Base. Trunk lines serving the Naval Shipyard and the Naval Station converge near Viaduct Road and Hobson Avenue, and the combined flow is transported to the North Charleston Sewer District's Navy Yard pump station via a 30-inch gravity line.

TABLE 2-43 ZONE 22: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	27	29	30

TABLE 2-44 ZONE 22: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd): Year	Industrial	I/I	Total (Rounded)
1990	540*	13,050	14,000
1995	580*	13,050	14,000
2000	600*	13,050	14,000

Peak Flow (gpd): Year	Industrial	I/I	Total (Rounded)
1990	1,620	39,150	42,000
1995	1,740	39,150	42,000
2000	1,800	39,150	42,000

*An additional 200 gpd was included in industrial flow estimates to take into account truck and stall washing at Fire Station No. 3.

Zone 23 (Key Manhole No. 317)

Zone 23 is located along Hobson Avenue from Pier "L" to Pier "N". It includes several industrial facilities and Piers "M" and "Z". A new Ships' Logistic Support Center is planned for construction in Zone 23 by 2000, bringing an additional 50 employees to the zone.

TABLE 2-45 ZONE 23: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Industrial:			
Employees	146	153	211
Naval Vessels	N/A*	N/A*	N/A*

*Since the number of ships in port varies from day-to-day, it is impossible to indicate an exact population for ships. Wastewater flow projections in Table 2-46, however, reflect a 10 percent increase in ships' wastewater flows over the 10-year period.

TABLE 2-46 ZONE 23: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	2,920	33,244	18,250	54,500
1995	3,060	34,907	18,250	56,500
2000	4,220	36,568	18,250	59,500

Peak Flow (gpd):

Year	Industrial	Naval Vessels	I/I	Total (Rounded)
1990	8,760	99,732	54,750	163,500
1995	9,180	104,721	54,750	169,500
2000	12,660	109,704	54,750	177,500

Zone 24 (Key Manhole No. 323A)

Zone 24 is comprised of Piers "N", "P" and "Q". Wastewater flow within this zone is limited to naval vessel sources only. No population projections are shown due to the fact that exact populations on Navy ships cannot be determined; the number of ships in port varies from day to day. The flow estimates below are based on DAF from each pier, and a 10 percent increase in wastewater flows is assumed over the 10-year period.

TABLE 2-47 ZONE 24:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd): Year	Naval Vessels	I/I	Total (Rounded)
1990	50,819	15,650	66,500
1995	53,360	15,650	69,000
2000	55,900	15,650	71,500

Peak Flow (gpd): Year	Naval Vessels	I/I	Total (Rounded)
1990	152,457	46,950	199,500
1995	160,080	46,950	207,000
2000	167,700	46,950	214,500

Zone 25 (Key Manhole No. 324)

Zone 25 is located in the Dyess Avenue - Halsey Street area of the Naval Station. It is comprised mainly of commercial flow sources. Major contributors in this zone include the CPO Club Pool and Bath House, the Naval Station Brig, and a McDonald's restaurant. Transients at the Brig were assumed a loading rate equal to residents since they occupy the building 24 hours per day. It was assumed that the CPO Pool (open 98 days per year) was in operation.

TABLE 2-48 ZONE 25: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential			
High-Density (no. of residents)	86	91	95
Commercial:			
Employees	127	134	140
Restaurants (no. of meals)	2,200	2,310	2,420
Visitors (w/showers)	150	158	165
Industrial			
Employees	76	80	84
Medical:			
Employees	51	54	56
Patients	200	210	220

TABLE 2-49 ZONE 25:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Industrial	Medical	I/I	Total (Rounded)
1990	5,590	30,340*	1,520	2,020	20,850	60,500
1995	5,915	31,110*	1,600	2,130	20,850	62,000
2000	6,175	31,850*	1,680	2,220	20,850	63,000

Peak Flow (gpd):

Year	Residential	Commercial	Industrial	Medical	I/I	Total (Rounded)
1990	16,770	91,020	4,560	6,060	62,550	181,500
1995	17,745	93,330	4,800	6,390	62,550	186,000
2000	18,525	95,550	5,040	6,660	62,550	189,000

*Commercial flows include an additional 15,300 gpd from the Naval Station car wash, daily laundry at the Brig, and CPO Pool refilling and cleaning. This flow was assumed constant over the 10-year period.

Zone 26 (Key Manhole No. 331)

Zone 26 is located adjacent to Piers "Q" and "R". It consists of several Naval Station industrial and commercial facilities. A new fire station employing 10 workers is planned for construction in Zone 26 by 1995.

I/I is significant in this zone due mainly to the oil separator and stormwater collection facilities in the Fire Training Facility near Building 202. These deficiencies are discussed in greater detail in Chapter 3.

TABLE 2-50 ZONE 26: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Commercial:			
Employees	36	38	40
Visitors (w/o showers)	1,050	1,103	1,155
Cafeteria (no. of meals)	257	270	283
Industrial:			
Employees	1,404	1,484	1,554

TABLE 2-51 ZONE 26: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd): Year	Commercial	Industrial	I/I	Total (Rounded)
1990	4,630	52,080*	44,300	101,000
1995	4,868	53,880**	44,300	103,000
2000	5,103	55,280**	44,300	105,000

Peak Flow (gpd): Year	Commercial	Industrial	I/I	Total (Rounded)
1990	13,890	156,240	132,900	303,000
1995	14,604	161,640	132,900	309,000
2000	15,309	165,840	132,900	315,000

*An additional 24,000 gpd was included in industrial flows to take into account training exercises at the Fleet and Mine Warfare Training Center firefighting area.

**An additional 200 gpd was included in future industrial flows to account for fire station truck washing, etc.

Zone 27 (Key Manhole No. 334)

Zone 27 is situated adjacent to the Enlisted Men's Barracks on Proteus Street. It is comprised of three large Navy training buildings, a

CNS Federal Credit Union, and the Navy Exchange. A physical fitness center is planned for construction in Zone 27 by 1995 that will include 10 employees and 200 visitors per day. Population projections, therefore, reflect a commercial rate of growth slightly higher than the standard 10 percent.

TABLE 2-52 ZONE 27: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Commercial:			
Employees	204	224	234
Visitors (Gen. Commercial)	250	263	275
Visitors (w/shower)	0	200	220
Industrial:			
Employees	2,083	2,187	2,291

TABLE 2-53 ZONE 27: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	4,330	41,660	15,650	62,000
1995	6,743	43,740	15,650	66,500
2000	7,155	45,820	15,650	69,000

Peak Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	12,990	124,980	46,950	186,000
1995	20,229	131,220	46,950	199,500
2000	21,465	137,460	46,950	207,000

Zone 28 (Key Manhole No. 366D)

Zone 28 is situated between Bainbridge Avenue and Bordelon Avenue near the south end of the Naval Station. Most of the flow in this zone is contributed by residential sources, with the exception of the dental clinic. Several facilities planned for construction in Zone 28 by 2000 - three Bachelor's Enlisted Men's Club and an addition to the Enlisted Men's Club - will increase the residential and commercial populations above the standard 10 percent growth rate. The Bachelor's Enlisted Quarters are expected to house an additional 656 people, while the Enlisted Men's Club will be expanded to allow another 50 visitors into the club.

TABLE 2-54 ZONE 28:POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
High Density (no. of residents)	1,429	1,500	2,228
Commercial:			
Employees	283	297	311
Cafeterias (no. of meals)	700	735	770
Visitors (Gen. Commercial)	400	420	490
Medical:			
Employees	85	90	94
Patients	325	341	357

TABLE 2-55 ZONE 28:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Medical	I/I	Total (Rounded)
1990	92,885	9,560	3,325	13,050	119,000
1995	97,500	10,035	3,505	13,050	124,000
2000	144,820	10,560	3,665	13,050	172,000

Peak Flow (gpd):

Year	Residential	Commercial	Medical	I/I	Total (Rounded)
1990	278,655	28,680	9,975	39,150	357,000
1995	292,500	30,105	10,515	39,150	372,000
2000	434,460	31,680	10,995	39,150	516,000

Zone 29 (Key Manhole No. 323M)

Zone 29 is comprised of Piers "R", "S", "T" and "U". Wastewater flow within this zone is limited to naval vessel sources only. No population projections are shown due to the fact that exact populations on Navy ships cannot be determined; the number of ships in port varies from day to day. The flow estimates below are based on an assumed DAF from each pier, and a standard 10 percent increase in wastewater flows is assumed over the 10-year period.

TABLE 2-56 ZONE 29: WASTEWATER FLOW PROJECTIONS			
Daily Average Flow (gpd):			
Year	Naval Vessels	I/I	Total (Rounded)
1990	17,925	15,650	34,000
1995	18,821	15,650	34,500
2000	19,717	15,650	35,500
Peak Flow (gpd):			
Year	Naval Vessels	I/I	Total (Rounded)
1990	53,775	46,950	102,000
1995	56,463	46,950	103,500
2000	59,151	46,950	106,500

Zone 30 (Key Manhole No. 335)

Zone 30 is located adjacent to Piers "R" and "S" in the central portion of the Naval Station. It consists of several industrial and commercial flow sources. It was assumed that the General Instruction Building (Building RTC-1, in use 4 days per month) was fully occupied, and the swimming pool (NS-59, open 98 days a year) was in use.

TABLE 2-57 ZONE 30: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Commercial:			
Employees	8	10	12
Visitors (w/shower)	120	126	132
Industrial:			
Employees	969	1,018	1,066

TABLE 2-58 ZONE 30:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	13,971*	19,380	20,850	54,500
1995	14,071*	20,360	20,850	55,500
2000	14,171*	21,320	20,850	56,500

Peak Flow (gpd):

Year	Commercial	Industrial	I/I	Total (Rounded)
1990	41,913	58,140	62,550	163,500
1995	42,213	61,080	62,550	166,500
2000	42,513	63,960	62,500	169,500

*An additional 12,611 gpd was included in commercial flows due to cleaning and refilling of the NS-59 pool. This was assumed constant over the 10-year period.

Zone 31 (Key Manhole No. 337)

Zone 31 is located in the Osprey Avenue - Partridge Avenue area of the Naval Station. It is comprised mainly of residential flow from the Naval Station barracks along Hobson Avenue, but also includes commercial flow from the Personnel Support Activity and the Navy Racquet and Fitness Club.

As discussed earlier in this chapter, the planned facility that will most impact flow in this zone is the Submarine Berthing Pier, planned to be constructed by 1993. This pier is assumed to intersect the existing trunk line at Manhole No. 338, and it will cause an estimated increase in daily average flow of 60,000 gpd.

Other planned facilities include a rehabilitation center, an expansion of the racquet club, and a second floor addition to Building NS-654. These new facilities will increase the zone population by 90 employees and 100 visitors above the assumed 10 percent rate of growth. I/I is significant in Zone 31 due to storm sewer cross-connections that are discussed in Chapter 3.

TABLE 2-59 ZONE 31:POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
High-Density (no. of residents)	703	738	773
Commercial:			
Employees	225	275	325
Visitors (w/showers)	220	331	342

TABLE 2-60 ZONE 31:WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Naval Vessels	I/I	Total (Rounded)
1990	45,695	6,220	0	31,300	83,500
1995	47,970	8,330	60,000	31,300	148,000
2000	50,245	9,640	63,000	31,300	154,500

Peak Flow (gpd):

Year	Residential	Commercial	Naval Vessels	I/I	Total (Rounded)
1990	137,895	18,660	0	93,900	250,500
1995	143,910	24,990	180,000	93,900	444,000
2000	150,735	28,920	189,000	93,900	463,500

Zone 32 (Key Manhole No. 336)

Zone 32 is located adjacent to Piers "T" and "U". It is comprised of wastewater flow from several Naval Station industrial, commercial and residential facilities, including the Naval Station Barracks, the Enlisted Dining Hall, and Naval Station Administrative Offices. An expansion of the existing Enlisted Dining Hall will double the current number of employees and meals served per day by 1995.

TABLE 2-61 ZONE 32: POPULATION PROJECTIONS

Flow Source	1990	1995	2000
Residential:			
High-Density (no. of residents)	286	301	315
Commercial:			
Employees	48	99	101
Cafeteria (no. of meals)	750	1,500	1,575
Industrial:			
Employees	632	664	695

TABLE 2-62 ZONE 32: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	18,590	4,710	12,640	15,650	52,000
1995	19,565	9,480	13,280	15,650	58,000
2000	20,475	9,895	13,900	15,650	60,000

Peak Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	55,770	14,130	37,920	46,950	156,000
1995	58,695	28,440	39,840	46,950	174,000
2000	61,425	29,685	41,700	46,950	180,000

Zone 33 (Key Manhole No. 339)

Zone 33 is located at the south end of the Naval Base. Flow sources in this zone include the Bachelor Officer's Quarters, the Correctional Custody Unit, the SIMA Compound, and several small industrial facilities. Several facilities planned for construction in Zone 33 by 2000 will bring 561 employees and commercial visitors in addition to the assumed 10 percent growth rate. Planned structures include a chapel, an addition to the SIMA Compound, a MINEDIV storage, and a SUBS-IN-PASS building.

TABLE 2-63 ZONE 33: POPULATION PROJECTIONS			
Flow Source	1990	1995	2000
Residential:			
High-Density (no. of residents)	297	398	413
Commercial:			
Employees	6	16	16
Industrial:			
Employees	519	990	1,016

TABLE 2-64 ZONE 33: WASTEWATER FLOW PROJECTIONS

Daily Average Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	19,305	1,120*	10,380	13,050	44,000
1995	25,870	1,320*	10,900	13,050	51,500
2000	26,845	1,320*	11,420	13,050	53,000

Peak Flow (gpd):

Year	Residential	Commercial	Industrial	I/I	Total (Rounded)
1990	57,915	3,360	31,140	39,150	132,000
1995	77,610	3,960	32,700	39,150	154,500
2000	80,535	3,960	34,260	39,150	159,000

*An additional 1,000 gpd was included in commercial flow due to the marine pier. This pier will be relocated within the zone by 1995, but will not be upgraded to cause an increase in sewer demand.

SUMMARY

The Naval Base DAF is estimated to be 1.7 million gallons per day (mgd). This is projected to increase to approximately 1.9 mgd by 1995 and 2.0 mgd by 2000. These DAF estimates correspond to peak flows of 5.1 mgd at the present, 5.6 mgd in 1995, and 5.9 mgd in 2000. They do not assume any reduction in I/I due to sewer system rehabilitation. The recommended improvements presented in the following chapters, however, should reduce I/I flows, and hence, total base daily average and peak flows.

A complete listing of wastewater flow estimates for all 33 evaluation zones is shown in Table 2-65 on the following page.

TABLE 2-65 SUMMARY: NAVAL BASE WASTEWATER FLOWS

Zone	Daily Average Flow (gpd): 1990	1995	2000	Peak Flow (gpd): 1990	1995	2000
1	47,500	48,000	48,000	142,500	144,000	144,000
2	35,000	35,000	35,500	105,000	105,000	106,500
3	19,000	19,000	19,500	57,000	57,000	58,500
4	24,000	24,500	24,500	72,000	73,500	73,500
5	24,000	24,000	24,000	72,000	72,000	72,000
6	44,500	45,500	46,500	133,500	136,500	139,500
7	51,000	51,500	52,000	153,000	154,500	156,000
8	48,000	49,000	50,000	144,000	147,000	150,000
9	63,500	68,500	71,000	190,000	205,500	213,000
10	46,000	47,000	48,000	138,000	141,000	144,000
11	93,500	95,500	97,500	280,500	286,500	292,500
12	58,000	63,500	65,000	174,000	190,500	195,000
13	20,000	37,500	37,500	60,000	112,500	112,500
14	114,500	120,000	125,000	343,500	360,000	375,000
15	45,000	46,500	48,000	135,000	139,500	144,000
16	41,500	46,000	48,000	124,500	138,000	144,000
17	46,000	46,500	47,500	138,000	139,500	142,500
18	31,000	31,500	32,500	93,000	84,500	97,500
19	34,000	34,500	35,000	102,000	103,500	105,000
20	36,000	40,000	40,000	108,000	120,000	120,000
21	34,500	43,500	44,000	103,500	130,500	132,000
22	14,000	14,000	14,000	42,000	42,000	42,000
23	54,500	56,500	59,500	163,500	169,500	177,500
24	66,500	69,000	71,500	199,500	207,000	214,500
25	60,500	62,000	63,000	181,500	186,000	189,000
26	101,000	103,000	105,000	303,000	309,000	315,000
27	62,000	66,500	69,000	186,000	199,500	207,000
28	119,000	124,000	172,000	357,000	372,000	516,000
29	34,000	34,500	35,500	102,000	103,500	106,500
30	54,500	55,500	56,500	163,500	166,500	169,500
31	83,500	148,000	154,500	250,500	444,000	463,500
32	52,000	58,000	60,000	156,000	174,000	180,000
33	44,000	51,500	53,000	132,000	154,500	159,000
	1,702,000	1,859,500	1,951,500	5,106,000	5,578,500	5,854,500

CHAPTER 3

GRAVITY SEWER EVALUATION

INTRODUCTION

The CNSYD sewer system includes approximately 90,000 feet of gravity sewer line. The majority of the gravity system was constructed in the early 1970's. It has since been extended from time-to-time to provide service to new facilities. For instance, a ship-to-shore collection system was built in the late 1970's that provided sewer service to all docked ships and other pier facilities.

The gravity system begins at either extremity of the Naval Base, and wastewater is generally transported toward the center of the Base. Flow from the Naval Station and the Shipyard are collected by their respective trunk lines, which converge at the Naval Base discharge line on Viaduct Road. This 30-inch gravity line transports all Base wastewater into the North Charleston Sewer District's Navy Yard pump station, which pumps the sewage into the NCSD system.

The majority of the smaller sewer lines are vitrified clay (VC) pipes; however, many ductile iron (DI) and some polyvinyl chloride (PVC) lines have been installed. Most 12-inch and larger pipes are ductile iron.

METHODOLOGY

This chapter evaluates the present condition of the Naval Base gravity sewer system. The gravity system evaluation involved gravity line smoke testing, manhole inspections, and field investigation of potential problems. Smoke testing consists of forcing smoke from a specialized smoke candle through the gravity lines with an air blower. Smoke will escape through any defect that allows extraneous water to enter the system (pipe leaks, storm sewer cross-connects, roof drain tie-ins, etc.). Gravity lines 8-inch and larger (and most service lines) were smoke tested in this manner, and photographs were taken of all visible smoke releases. These photos are included in Appendix "A".

Also included as part of the manhole inspections were line size and material verification and manhole location surveys. These items are discussed only briefly in this chapter. Information on manhole deficiencies and findings of individual manhole inspections are included in Appendix "B". Results of the surveys and line verifications are reflected in supporting documentation within the report and on the updated (reduced) sewer system base maps included in Appendix "G".

LIMITATIONS

The major limitation in performing the gravity system evaluation was the presence of surcharged sewer lines and manholes. This condition was common in several areas of the Shipyard; no instances of line surcharge were found in the Naval Station.

Surcharges limited the performance of this evaluation for these reasons: 1) surcharged manholes could not be entered, nor the connecting lines inspected; 2) pipe size and material could not be verified; and 3) smoke tests on surcharged sewer lines were ineffective. Surcharge is undesirable because, though it is generally a symptom of other problems, it allows settlement or sand, solids, and debris in lines, manholes, and wet wells.

Deposition of this material creates line blockages or worsens existing blockages, and causes damage to pumps.

As shown on Figure 3-1, sewer line surcharge is common in four specific areas of the Shipyard. It appears that none of these surcharged lines are due to excessive sewage flows. The areas of surcharged lines and their most likely causes are the following:

- o Naval Supply Center: Surcharge is due to deficiencies in Pump Station No. 9 and groundwater infiltration (and possible tidal influence) into the line. This line is discussed later in this chapter.
- o The Shipyard Trunk Line: Surcharge has been observed from Pump Station No. 7 to Manhole No. 53. The 24-inch influent line into the pump station is below the pump-on elevation of the wet well, which causes influent sewage to back up into the line prior to reaching the pump-on level.
- o Ship-to-Shore Line: This line is influent to the Ballfield Pump Station, and its surcharge is due to the line elevation being below the pump-on elevation of the pump station.
- o CIA Line: Due to an apparent hole in this line near Hobson Avenue, infiltration of sand and silt into the pipe has caused a major line blockage. The entire line upstream of the blockage is surcharged. This deficiency will be discussed later in this chapter.

These lines were found to be surcharged continuously, which made complete gravity sewer inspections in the areas impossible.

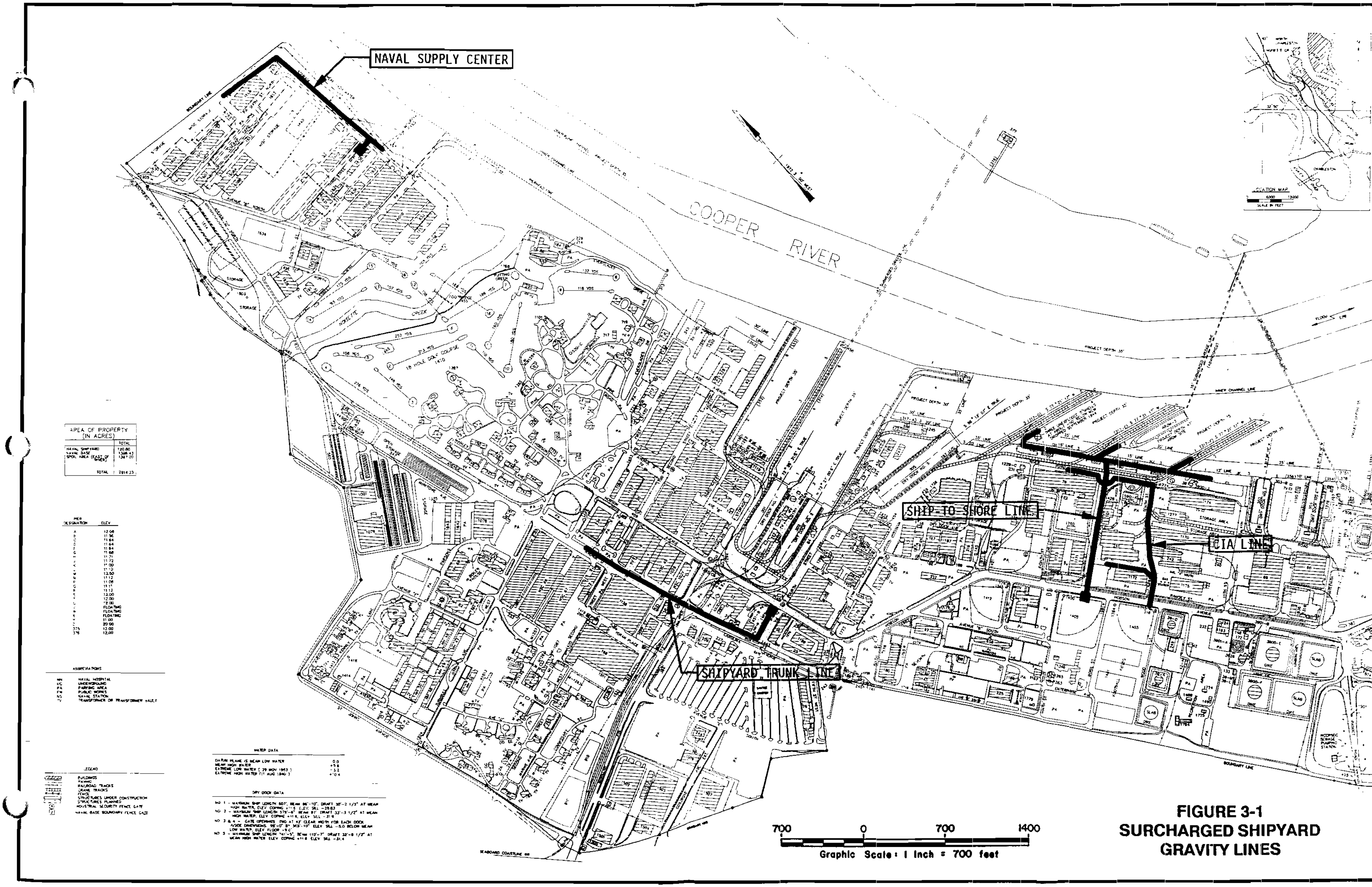


FIGURE 3-1
SURCHARGED SHIPYARD GRAVITY LINES

One additional limitation affecting the completeness of this evaluation was numerous instances of pavement, structures, and equipment placed on top of manholes, which prevented entry.

GRAVITY SEWER LINE DEFICIENCIES

All gravity line deficiencies discovered in this evaluation are described in the following sections. The thirteen areas depicted on the Naval Base sewage collection system base map (Public Works Drawings H410-121 through H410-133) serve as separate study areas. Deficiencies found in each area are discussed, and corrective action is recommended. Noted deficiencies refer to a corresponding photograph in Appendix "A", where applicable.

The following is a description of general base-wide deficiencies, which is presented first to avoid repetition within the area-by-area discussion of deficiencies.

General Base-Wide Deficiencies

General gravity sewer deficiencies consist of the following: 1) industrial waste (particularly oil and grease) that is prevalent in much of the gravity system; 2) heavy infiltration of groundwater in many of the deeper lines; and 3) the buildup of sand and debris in many smaller lines.

Oil and grease create numerous problems for sanitary sewage collection and treatment systems. For instance, its build-up on pipe and manhole walls impedes flow, and mercury float switches in pump stations malfunction frequently due to wet well grease build-up. Oil and grease build-up also create pumping problems due to increased friction loss and restricted pipe diameters of force mains.

Beyond the mechanical and functional problems that oil and grease present in a collection system, they also cause treatment process problems. NCSD prohibits discharge of oil to their system and can impose substantial penalties for such discharges.

Although oil and grease buildup is present in much of the Naval Base sewer system, its presence is more common in the Naval Station than in the Naval Shipyard. Manholes containing oil, grease and other industrial chemicals were traced back to possible sources. The most likely sources of oil and grease in the sewer system and their expected contaminants are:

- All Piers and Dry Dock Nos. 1, 2 and 5: Fuel oil, lube oil and bilge waste, lubricating grease.
- The Officer's Club (Building 1221) and the Golf Course Clubhouse (Building 220) grill: cooking grease.
- All residences near Noisette Creek and the Old Navy Hospital: cooking grease.
- The Shipyard Cafeteria (Building 63): cooking grease.
- The Minimart Service Station (Building 1346): oil, lubricating grease.
- The Auto Hobby Shop (Building 636): oil, lubricating grease.
- McDonald's (Building 642): cooking grease.
- The Fleet Mine Warfare Training Center Oil Separator (Structure No. NS-621): diesel fuel.
- The Enlisted Dining Hall (Building NS-43): cooking grease.
- The Civilian Cafeteria (Building NS-71): cooking grease.
- The Enlisted Men's Club (Building 657): cooking grease.

- Other Oil/Water Separators (Buildings 80, 123, 226, 236, 680 and NS-2).

Procedures should be implemented to minimize discharge of undesirable waste into the sanitary sewer system. Dye-testing is a simple procedure and could be quite useful in identifying the sources of oil and grease. Particular emphasis should be placed on determining the collection areas and discharge points of oil/water separators.

The Naval Base contains many separators and several area known or suspected to be significant sources of inflow and/or oil and grease. Public Works should evaluate all existing separators to identify the problem units. The separators identified as being sources of oil and grease should be studied to determine if the problem can be corrected externally, or if upgrade of the unit is required.

The separators identified as storm sewer cross-connections, but not as sources of oil, should be researched to determine if non-contaminated storm water could be isolated from those units and re-directed to the storm sewer system.

Appropriately sized grease traps should be required for grease dischargers. These grease traps should be inspected and pumped out on a scheduled basis. Some grease traps may require weekly pumpage, other less frequent.

A second major system-wide deficiency is groundwater infiltration into gravity lines. Much of the gravity sewer system lies below the ground water table. That factor, the age of the gravity system (approximately 25 years old), and the most common pipe material (vitrified clay) suggest that infiltration due to pipe defects is widespread. Quantifying the groundwater infiltration would require methods beyond the scope of this study. However, Tables 3-1 and 3-2 give a comparative analysis of the major line sections and their susceptibility to such infiltration. Associated Figures 3-2 and 3-3 illustrate the line sections analyzed. That table prioritizes line segments where more intensive I/I study is recommended.

A program of remote T.V. inspection of gravity lines should be started. Initially, those line segments identified as being the most serious potential infiltration sources should be inspected. This chapter identifies other lines, not included in Tables 3-1 and 3-2, which should be inspected for infiltration sources. Over time, all main lines should be T.V.-inspected.

The third general system deficiency is the build-up of sand and debris in gravity lines. This is most prevalent in smaller pipes and service lines (generally 8-inch and smaller) due to the fact that most of these lines are over 20 years old and have never undergone an extensive cleaning.

It is recommended that smaller gravity lines be pressure-cleaned (jetted) periodically to relieve trash buildup. This cleaning would improve the flow capabilities of the gravity system and thereby minimize blockages and subsequent sewage backups.

TABLE 3-1: SHIPYARD SEWER LINE INFILTRATION RATING					
Line I.D.	Size (A)	Pipe Material (B)	Ave. Depth (C)	Infiltration Rating (D)	Ranking
1. Shipyard Trunk "A"	2.0'	D.I. (1)	11' (7)	14	4
2. Shipyard Trunk "B"	2.0'	D.I. (1)	11' (7)	14	4
3. Shipyard Trunk "C"	2.0'	D.I. (1)	10' (4)	8	7
4. Shipyard Trunk "D"	2.0'	D.I. (1)	16' (11)	22	3
5. Shipyard Trunk "E"	1.75'	V.C. (5)	11' (7)	61	1
6. Shipyard Trunk "F"	1.25'	V.C. (5)	9.5' (4)	25	2
7. Shipyard Trunk "G"	1.0'	V.C. (5)	8' (2)	10	6
8. Old Navy Hospital	1.25'	V.C. (5)	8' (2)	12.5	5
9. Pier "C" (A)	1.25'	V.C. (5)	10' (4)	25	2
10. Pier "C" (B)	1.0'	D.I. (1)	8' (2)	2	10
11. Navy Hospital	1.25'	V.C. (5)	10' (4)	25	2
12. Pipefitters' Shop	1.33'	D.I. (1)	10' (4)	5.3	8
13. Pier "G", "H" & "J"	1.0'	D.I. (1)	9' (4)	4	9

Ranking indicates relative potential for infiltration problems. Highest rankings reflect worst suspected problems.

METHODOLOGY

(D) = (A) x (B) x (C), where

(D) = Infiltration Index [dimensionless]
(A) = Pipe Diameter [ft]
(B) = Pipe Material Factor [dimensionless]
(C) = Average Depth Factor [dimensionless]

Pipe Material Factors

Ductile Iron = 1
Vitrified Clay = 5
Reinforced Concrete = 3

Average Depth Factors

4.0' to 6.0' = 1
6.1' to 8.0' = 2
8.1' to 10.0' = 4
10.1' to 12.0' = 7
>12.0' = 11

TABLE 3-2: NAVAL STATION SEWER LINE INFILTRATION RATING					
Line I.D.	Size (A)	Pipe Material (B)	Ave. Depth (C)	Infiltration Rating (D)	Ranking
1. N.S. Trunk "A"	1.67′	D.I. (1)	8′ (2)	13	2
2. N.S. Trunk "B"	1.67′	D.I. (1)	6′ (1)	1.7	9
3. N.S. Trunk "C"	1.5′	D.I. (1)	13′ (11)	16.5	1
4. N.S. Trunk "D"	1.33′	D.I. (1)	11′ (7)	9.3	3
5. Pier "Z"	1.0′	D.I. (1)	6′ (1)	1	10
6. Pier "M"	1.0′	D.I. (1)	7.5′ (2)	2	8
7. Pier "N"	1.0′	D.I. (1)	12′ (7)	7	4
8. Pier "P"	1.33′	D.I. (1)	8′ (2)	2.7	7
9. Pier "C" & "R"	1.0′	D.I. (1)	7′ (2)	2	8
10. Pier "T"	1.0′	D.I. (1)	9′ (4)	4	6
11. Proteus St.	1.33′	D.I. (1)	11′ (7)	9.3	3
12. Magpie	2.0′	R.C. (3)	6′ (1)	6	5

Ranking indicates relative potential for infiltration problems. Highest rankings reflect worst suspected problems.

METHODOLOGY

(D) = (A) x (B) x (C), where

(D) = Infiltration Index [dimensionless]
(A) = Pipe Diameter [ft]
(B) = Pipe Material Factor [dimensionless]
(C) = Average Depth Factor [dimensionless]

Pipe Material Factors

Ductile Iron = 1
Vitrified Clay = 5
Reinforced Concrete = 3

Average Depth Factors

4.0′ to 6.0′ = 1
6.1′ to 8.0′ = 2
8.1′ to 10.0′ = 4
10.1′ to 12.0′ = 7
>12.0′ = 11

Note that the three most likely infiltration sources, based on the infiltration index, are in the Naval Shipyard system.

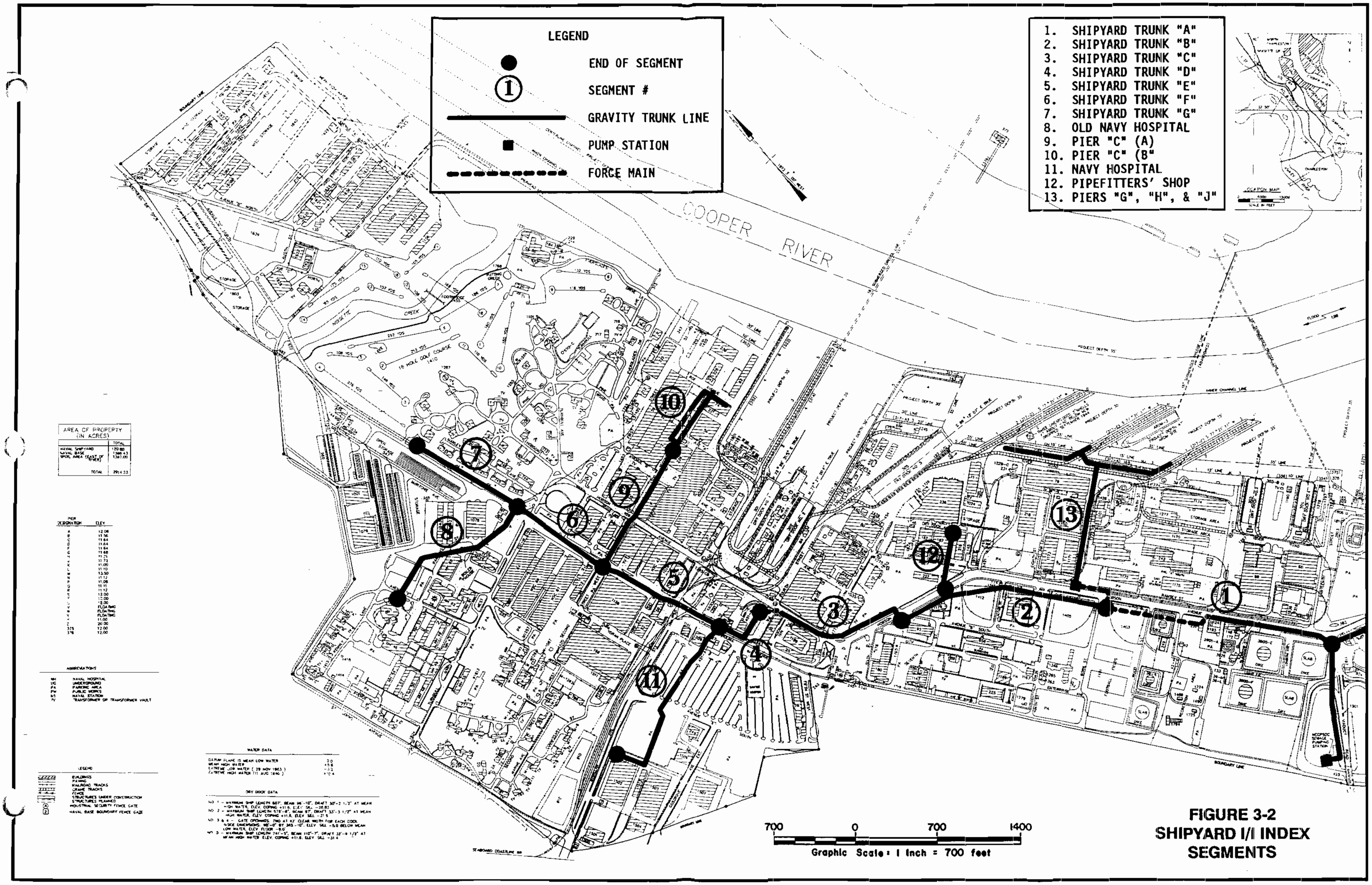


FIGURE 3-2
SHIPYARD I/I INDEX SEGMENTS

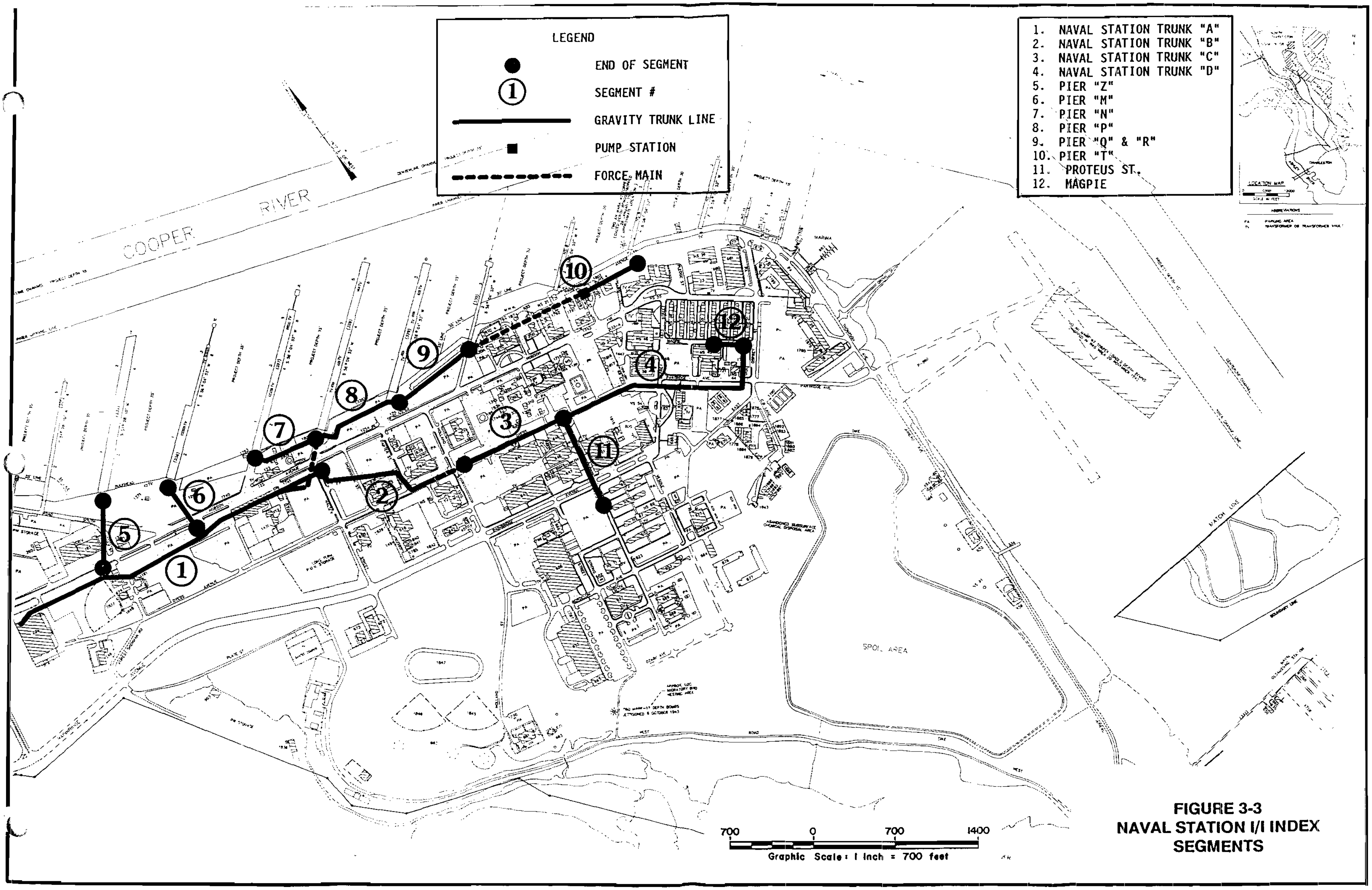


FIGURE 3-3
NAVAL STATION I/I INDEX SEGMENTS

Area 1 Deficiencies

The following deficiencies were noted during the gravity sewer line evaluation of Area 1:

- The 8-inch gravity line between Manhole (MH) No. 2 and MH No. 6 appears to be tidally influenced (no photograph taken).
- A 2'x3' drop inlet located 10 feet upstream of Manhole 6 is apparently cross-connected to the sewer line (no photograph taken).
- A minor pipe leak is located 10 feet downstream of MH No. 10 (Photo No. 1-1).
- Manhole Nos. 6C, 6D, 6G, 6H and 6J are old concrete structures with 6-inch by 8-inch rectangular holes in their top slabs. These holes are open to inflow. (Photo No. 1-2; MH 6J shown).

The major source of I/I in this area is, in all probability, the tidally influenced gravity line. This line is continually surcharged, and fluctuations in the water level inside MHs 2 through 6 have been observed to coincide with the rising and falling tides of the nearby Cooper River. In addition, the heavy buildup of sand inside the manholes and Pump Station No. 9 wet well is further indication that major infiltration is occurring.

The cross-connected drop inlet also appears to be a significant contributor to I/I. Because of surcharged lines, smoke testing could not be used to verify the connection of the drop inlet to the sewer system. However, visual observation of the line layout and the surcharged water inside the drop inlet indicate a probable cross-connection.

Area 1 Recommended Improvements

Before corrective action is initiated on the gravity line between MH 2 and MH 6, further field investigations should be performed to verify tidal influence on the line and pinpoint the source of infiltration. This may be best accomplished by remote T.V-inspection. Upon location of the infiltration source, pipe repair or replacement is recommended.

Prior to performing any corrective actions on the drop inlet, a dye test or other appropriate methods should be used to confirm the connection of the drop inlet to the sewer system.

Repair of the line leak downstream of MH 10 is not recommended. The cost of repairing this line would outweigh the slight reduction in I/I that would result. New cover plates should be installed on MHs 6C, 6D, 6G, 6H, and 6J. Regrading around the manholes may be necessary in order to divert stormwater from the manholes.

Area 2 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 2:

- o Roof drains on Residence "B" are tied into MH 31A (Photo No. 2-1).
- o Two separate drop inlets are cross-connected to sewer manholes. Locations of the drop inlets are 8 feet from MH 135D (Photo No. 2-2) and outside of Residence No. 746 on Manley Avenue, near MH 135B (Photo No. 2-3).
- o Three instances of line leakages were discovered. Locations of line leakages are under the patio of Building 1221 (Photo No. 2-

4), outside of Residence No. 743 (Photo No. 2-5), and in back of Residence No. 746 (Photo No. 2-6).

- o Three cleanouts were found to be uncovered. The cleanouts are located at Residence Nos. 745, 748 and "X" (Photo Nos. 2-7, 2-8 and 2-9, respectively).

Area 2 Recommended Improvements

Residence "B" roof drains should be isolated from the sewer system. The 4-inch VC piping that connects the gutter downspouts to MH 31A should be sealed and disconnected from the downspouts. Stormwater from the roof drains should be rerouted appropriately.

The drop inlets that are cross-connected to MHs 135D and 135B (in front of Residence No. 746) should also be isolated from the sewer system by plugging the appropriate lines. Stormwater collected by these inlets should be rerouted.

Line leaks at Residence Nos. 743 and 746 should be corrected by excavating the pipes and repairing the leaks. As the seriousness of the leak at Building 1221 could not be determined (the leak is located beneath a patio with approximately one foot of clearance), it is recommended that this leak be further evaluated prior to corrective action.

The cleanouts that were uncovered should be covered with appropriately sized covers.

Area 3 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 3:

- Roof drains on Building 1137 are tied into MH 78A (Photo No. 3-1).
- An 8-inch cleanout near MH 132 is open (Photo No. 3-2).
- Roof drains of the old Navy Hospital complex, Buildings NH-46, NH-48, NH-52 and NH-54, are connected to the sewer system (Photo Nos. 3-3, 3-4, 3-5, 3-6 and 3-7).
- Several open underground taps or other leaks were noted. Figure 3-4 shows the exact location of the six leaks that were discovered (Photo Nos. 3-8, 3-9, 3-10, 3-11, 3-12, and 3-13).

Area 3 Recommended Improvements

All roof drains on Building Nos. 1137, NH-46, NH-48, NH-52 and NH-54 should be isolated from the sewer system. The lines that connect the gutter downspouts to the sewer service lines or manholes should be sealed. Stormwater from the downspouts should be rerouted appropriately.

All of the line and tap leaks appear to be major sources of I/I, and these leaks should be repaired. As shown on Figure 3-4, leaks shown in Photo Nos. 3-8 through 3-11 are probably due to abandoned sewer taps that were improperly sealed. These taps should be located and plugged. Leaks shown in Photo Nos. 3-12 and 3-13 are due to line defects.

The open cleanout near MH 132 should be covered with a properly sized cover.

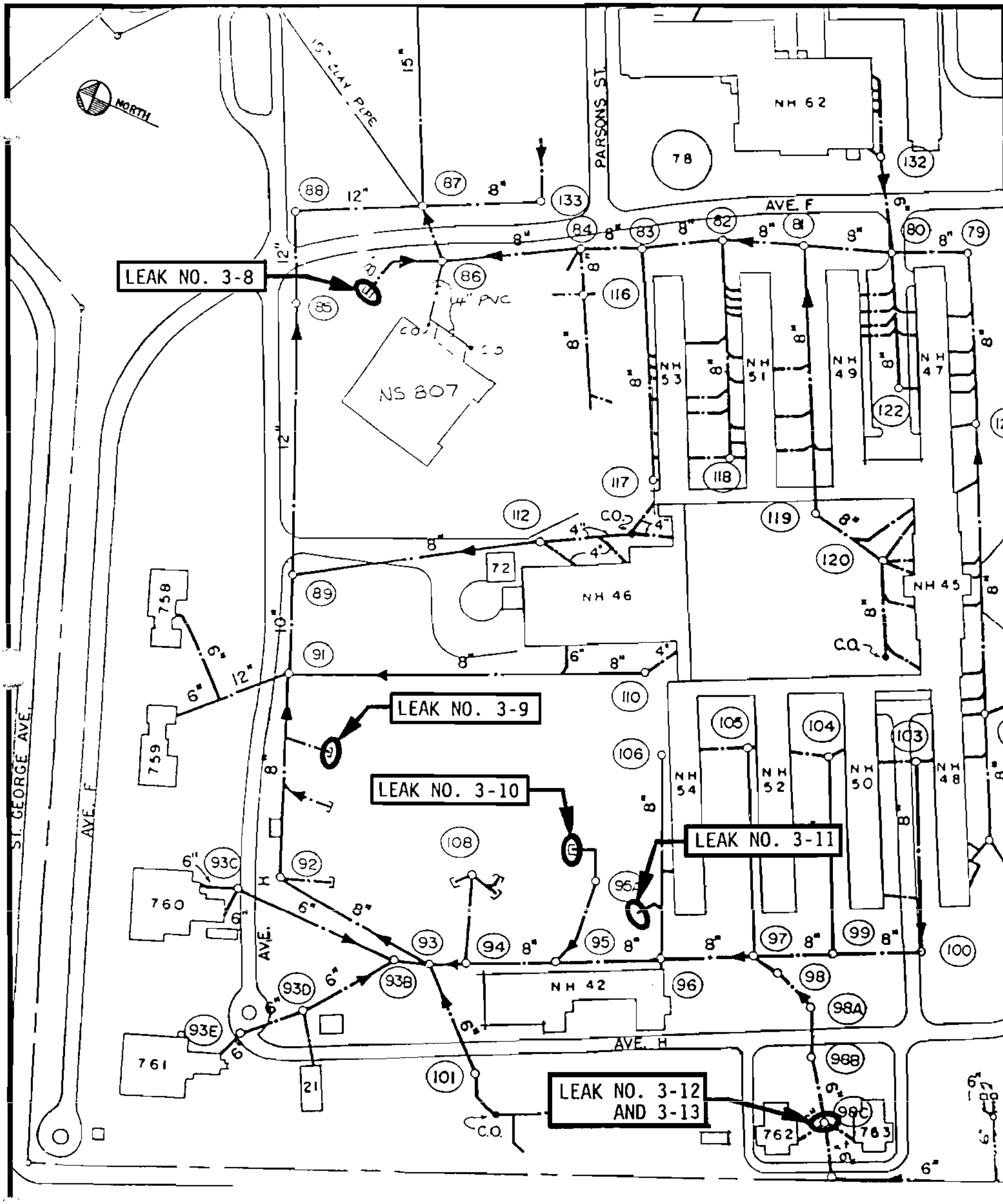


FIGURE 3-4
AREA 3 GRAVITY
LINE LEAKS

Area 4 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 4:

- o Three drop inlets are tied into MH 156A. Two of the drop inlets are located on either side of Second Street West adjacent to MH 156A (Photo No. 4-1). The other one is located in the parking lot between Building M-82 and MH 156A (Photo No. 4-2).
- o An influent line into MH 154A on Hobson Avenue (near Building 198) apparently has a large hole that is allowing the settlement of soil into the line (no photograph taken).
- o A floor drain at the base of Building M-17 basement steps is tied into the sewer system (Photo No. 4-3)

Area 4 Recommended Improvements

All three of the drop inlets at MH 156A should be isolated from the sewer system by plugging the appropriate lines. Stormwater collected by the catch basins should be rerouted appropriately.

The defect in the gravity line near MH 154A is evidenced by settlement of the ground and pavement near the manhole. It is recommended that appropriate pipe rehabilitation or replacement be performed.

Since the floor drain of Building M-82 is in a low point of a concrete surface and has the potential to collect a significant amount of stormwater, it is recommended that this drain be isolated from the sewer system.

Area 5 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 5.

- o Six drop inlets were found to be cross connected to the sewer system. Locations of the drop inlets are as follows: 1) at the east corner of Building 46 near MH 200 (Photo No. 5-1); 2) at the rear of Building 63 (Photo No. 5-2); 3) 18 feet from MH 193A (Photo 5-3); 4) 20 feet from MH 212 (Photo 5-4); 5) between Buildings 25 and 1199 (Photo 5-5); and 6) at the rear of Building 31 (Photo 5-6).
- o Two buildings were found to have roof drains cross-connected to the sewer system: Building 57 (Photo No. 5-7) and Building 43 (Photo Nos. 5-8 and 5-9).
- o One storm sewer manhole at the eastern corner of Building 57 is tied into the sewer system (Photo No. 5-10).
- o It appears that the gravity line upstream of Pier "F" pump station is submerged in the Cooper River, most likely due to Hurricane Hugo. Influent water appears to be flowing in waves, similar to the nearby river. At low tide, no water entered the wet well; the water level most likely dropped beneath the wet well's influent line (no photograph taken).
- o According to Work Center 44, a floor drain at the bottom of the indoor pool (NS-92) steps is tied into the sewer system (no photograph taken).

Area 5 Recommended Improvements

Most drop inlets that were found to be tied into the sewer system are small; however, considering the total area that each one serves, the runoff collected by a single drop inlet can be considerable. The drop inlets should be rerouted to divert stormwater from the sewer system. One of these drop inlets is a "wash basin" at Building 31 that is intended for use while washing trucks. Since this basin is not in a covered building, it is capable of collecting a large amount of stormwater runoff.

The roof drains of Buildings 43 and 57 are substantial sources of I/I. This is due to the large area of each building's roof and the volume of stormwater collected in a single storm. These roof drains should be isolated from the sewer system and rerouted into the storm sewer system.

Prior to corrective action being initiated on the storm sewer manhole near Building 57, further field investigations should be performed to verify that the storm line is still in service; no collection structures in its vicinity released smoke during testing. If it is determined that this cross-connection has the potential to allow a significant amount of stormwater into the sanitary sewer, the storm line should be isolated from the sewer system.

Prior to corrective action on the Pier "F" gravity line, further field study is recommended to confirm the submergence of the line in the Cooper River. Should the investigations prove that the line is submerged, it is recommended that, where applicable, new sewer line be re-hung from the pier to replace the old pipe.

The floor drain at the indoor swimming pool presents a possible health threat as well as a source of inflow. This drain is the first point in Area 6 to surcharge when the gravity system backs up. In the event that this cross-connection presents the potential for human contact with raw sewage, it should be disconnected and re-routed, immediately. Otherwise, Public Works personnel should look at alternatives to sanitary sewer connection.

Areas 6 and 6-A Deficiencies

The following deficiencies were noted during the gravity line evaluation of Areas 6 and 6-A:

- According to Work Center 44 personnel, a hole 50 feet upstream of MH 68 on Hobson Avenue has caused soil infiltration into the line, which in turn has caused a blockage (no photograph taken).
- Two drop inlets were found to be tied into sewer manholes. Locations of the drop inlets are 15 feet from MH 282 (Photo No. 6-1) and 36 feet from MH 296B (Photo No. 6-2).
- Heavy sand buildup in the gravity line between Pump Station No. 4 and MH 199 suggests that groundwater infiltration in this area is considerable (no photograph taken).
- A cleanout at the rear of Building 79 is uncovered (Photo No. 6-3).

Areas 6 and 6-A Recommended Improvements

Work Center 44 personnel say that the defect in the 8-inch line upstream of MH 68 is either a crushed pipe or a faulty joint. A section of pavement on top of this line has settled several inches, which suggests that pipe failure is probable. In addition, all manholes upstream are continuously surcharged, indicating a line blockage. It is recommended that this deficiency be corrected by excavating to verify the cause of road settlement and line surcharge. Necessary line repairs or replacements should be completed.

Both drop inlets should be isolated from the sewer system. Lines that connect the drop inlets to the manholes should be sealed to prevent further stormwater inflow, and stormwater should be rerouted appropriately.

Prior to corrective actions on the gravity line between Pump Station No. 4 and MH 199, further field investigations are recommended on the line to verify the source and of groundwater infiltration. This may be best accomplished using remote T.V.-inspections.

The cleanout behind Building 79 is raised approximately three inches above the surrounding concrete and should not collect stormwater; no corrective actions are necessary. One suggested improvement, however, is to reroute the air conditioner drain lines which empty into the cleanout. The A/C drain water is non-contaminated and should not require a sanitary sewer connection.

Areas 7 and 7-A Deficiencies

The following deficiency was noted during the gravity line evaluation of Area 7:

- o The mortar top of MH 73 is severely cracked and may allow significant inflow into the manhole (Photo No. 7-1).

Areas 7 and 7-A Recommended Improvements

In order to prevent further stormwater inflow into MH 73, the manhole top should be repaired.

Area 8 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 8:

- o An oil separator that collects stormwater and diesel fuel from the fire training area near Building 202 is discharging into the sanitary sewer. A layout of the storm drainage system in this area is shown in Figure 3-5, which is taken from NAVFAC Drawing No. 5018310, the site plan for the fire fighting area. (Photo No. 8-1).
- o According to Work Center 44 personnel, a cross-connection exists somewhere in the vicinity of MH 350, most likely in the 8-inch line leading to MH 350A.
- o One drop inlet was found to be tied into MH 364 (Photo No. 8-2).

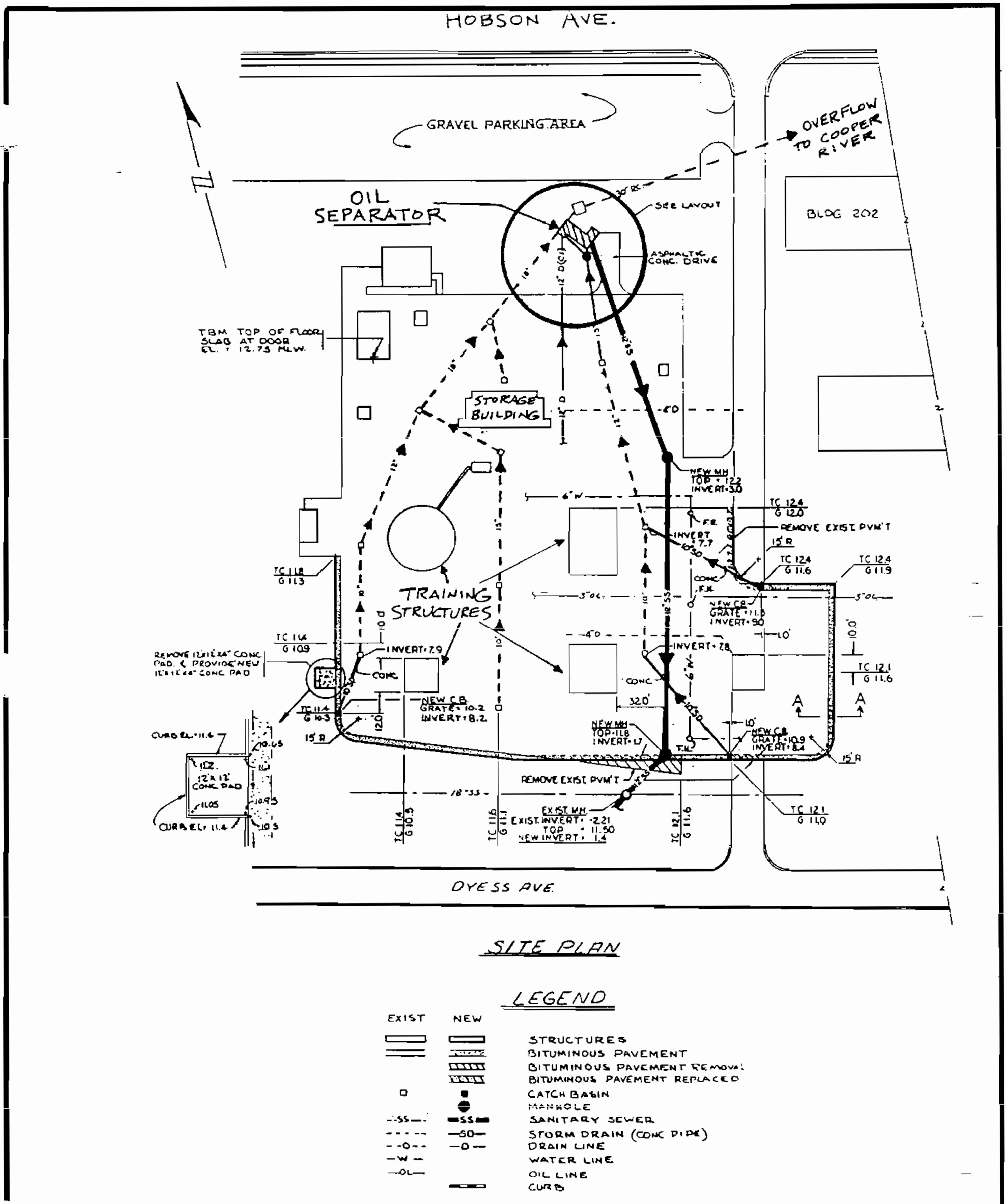


FIGURE 3-5
LAYOUT OF FIRE TRAINING AREA STORM DRAINAGE

- Minor leaks were found at the sewer tap for Building 79 (Photo No. 8-3), under a concrete pad supporting transformers (Photo Nos. 8-4 and 8-5) and at a crack in the sidewalk near MH 384A (Photo No. 8-6).
- A previously-plugged overflow in the Pump Station No. 2 wet well is leaking, and salt water from the nearby Cooper River is entering the wet well at extreme high tides (no photograph taken).

The Fleet and Mine Warfare Training Center (FMWTC) oil separator is one of the most significant sources of inflow in the entire Naval Base.

Figure 3-5 shows the layout of the drainage system in the area surrounding the fire training facility. This area is comprised of nearly two acres, most of which is impervious surface.

Water collected by the storm system consists of stormwater and water used for firefighting drills. Firefighting water includes varying amounts of diesel fuel intended to ignite the fire training structures. All of the water and unburned fuel is transported into the oil separator, which is designed to hold the fuel until it can be pumped out. Figures 3-6 and 3-7 show plan and section views of the separator.

It is apparent that significant quantities of oil are being discharged into the sewer system. This was noted during the inspection of MHs 334C and 334D, just downstream of the separator. Both manholes had considerable oil residue present.

According to personnel from Shop 99, which is responsible for pumping oil out of the separator weekly, the discharge of oil is due to a hurricane-damaged oil skimmer that is not skimming properly. This skimmer

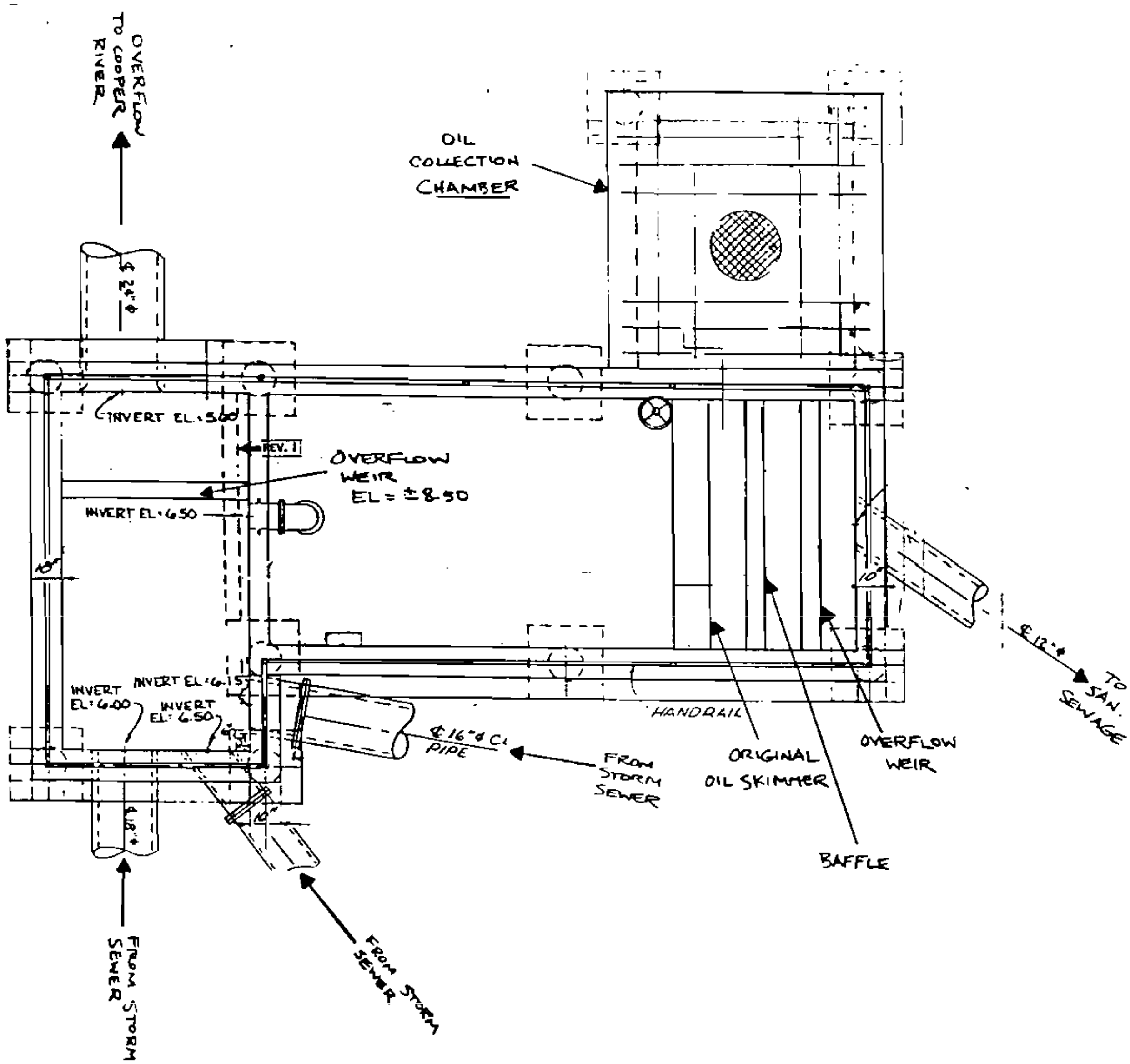


FIGURE 3-6
FMWTC OIL SEPARATOR
PLAN VIEW

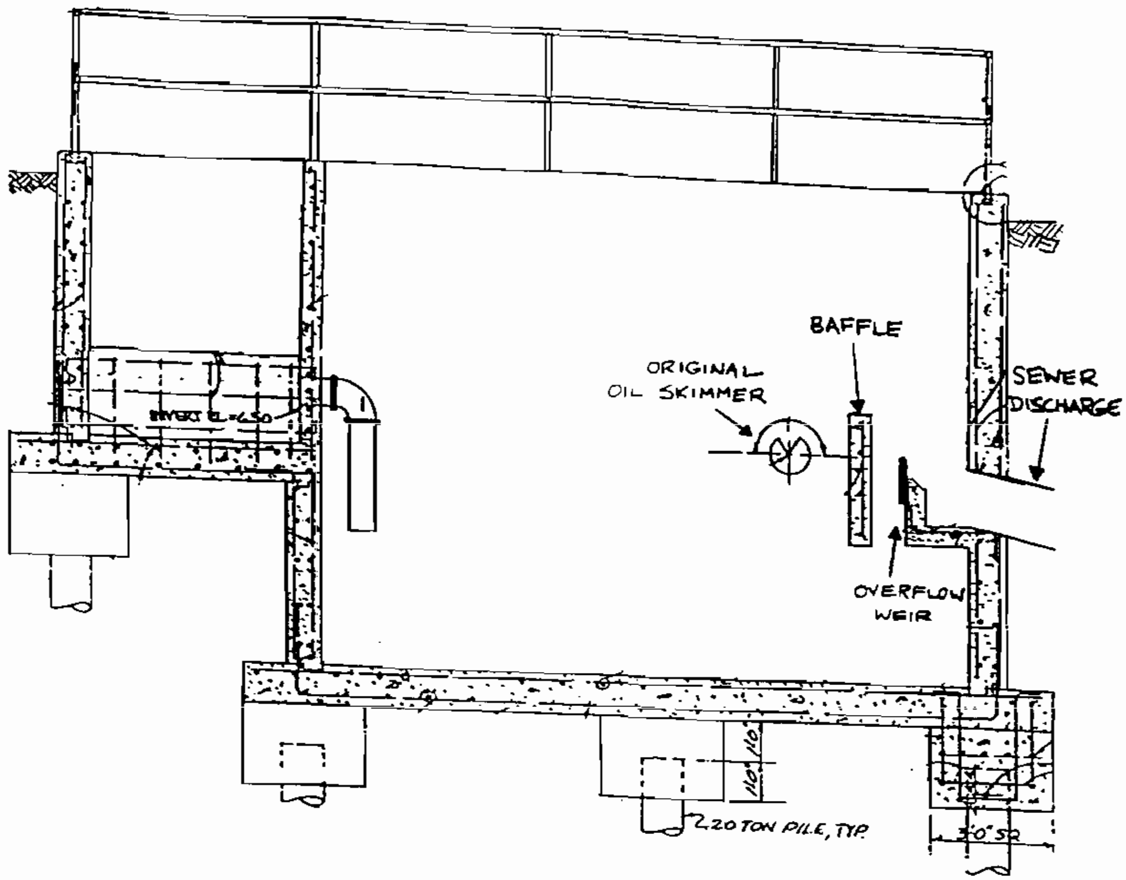


FIGURE 3-7
FMWTC OIL SEPARATOR
SECTION VIEW

is a replacement for the original slot skimmer shown in Figures 3-6 and 3-7. It works on the principle of gravity-feeding oil off the water surface into the oil collection chamber.

Another possible reason for the discharge of oil is that the separator becomes "overloaded" with oil at times. Based on information obtained from as-built drawings, the maximum volume of oil that the separator can hold is approximately 2,200 gallons. Considering that the separator is pumped out only once weekly, it is feasible that over 2,200 gallons of oil could enter the separator, mainly because the fire training facility is in use nearly every day and uses large volumes of diesel fuel. Thus, when the volume of oil in the separator exceeds the design capacity, excess oil will flow under the baffle and drain out of the separator basin. Also, heavy storms could cause such a volume of water to enter the separator basin that the 12-inch discharge line surcharges, ultimately overtopping the discharge baffle.

Area 8 Recommended Improvements

An initial solution recommended for the FMWTC facility is to isolate all catch basins and drainage areas not contaminated with run-off and reroute those discharges to the drainage ditch along the southern perimeter of the area. Several catch basins along that perimeter can apparently be isolated in this manner. Where possible, catch basins may be abandoned and sheet flow directed to the ditch.

The existing separator should be modified or replaced to provide adequate oil separation. Several manufacturers offer insertable "packs" which could upgrade performance of the existing separator considerably, and at significantly lower cost than replacement of the separator. Addition of flow equalization/surge control prior to the separator is also recommended.

The suspected cross-connection near MH 350 was not verified. Additional field investigations are recommended to verify the cross-connection. Upon verification, the storm line should be isolated from the sewer system.

Immediate repairs on the four line leaks are not required due to their minor nature. The overflow in the Pump Station No. 2 wet well, however, should be replugged to seal off further salt water inflow.

Area 9 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 9:

- Two curb inlets were found to be cross-connected to the sewer system. Those curb inlets are located on Magpie Avenue near MH 397F (Photo Nos. 9-1 and 9-2).
- A drop inlet adjacent to Building FBM-61 is tied into MH 377-A (Photo No. 9-3)
- Two minor leaks were discovered. An open tap exposed aboveground is located 40 feet from MH 365 (Photo No. 9-4); an uncovered cleanout is adjacent to Building NS-53 near MH 380 (Photo No. 9-5).

The two curb inlets are a major source of inflow. They are suspected to be part of an abandoned storm sewer line through which sanitary sewage was rerouted. The curb inlets collect stormwater from most of Magpie Avenue and several adjoining driveways and parking areas. Trash (i.e., aluminum cans, bags, bottles) is entering the sewer line at this point and creating additional problems downstream. Pump Station No. 1, for example, has had pump damage due to cans and other trash in the pumps.

Area 9 Recommended Improvements

The curb inlets on Magpie Avenue should be isolated from the sanitary system, or new sewer line installed. One catch basin is located adjacent to each of the curb inlets, and they could possibly be used to collect street runoff. However, these catch basins are full of sand and other debris and appear to be out of service. Some rehabilitative work on the catch basins would be required. Based on smoke tests and visual observation, the catch basins do not appear to be tied into the sanitary sewer system.

The catch basin at MH 377A should be isolated from the sewer system, and rerouted to discharge into the storm sewer. Both leaks discovered in this area should be repaired, and the exposed tap and cleanout should be sealed.

Area 10 Deficiencies

The following deficiencies were noted during the gravity line evaluation of Area 10:

- o Leaks were noted in the following locations: 1) under the top slab of MH 370B (Photo 10-1); 2) under a pad supporting transformers outside of Building 65 (Photo No. 10-2); 3) under the foundation of Building 656, near MH 366B (Photo No. 10-3); 4) in a crack in the sidewalk of Building 656, near MH 366B (Photo No. 10-4); and 5) in the cracked mortar at the top of MHs 371 and 371A (Photo No. 10-5; MH 371 shown).

Area 10 Recommended Improvements

The first four deficiencies listed are minor leaks and do not warrant immediate repair. The cracks in MH 371, however, should be repaired.

Areas 11, 12, and Navy Hospital

No deficiencies were noted in the gravity line evaluation of Areas 11, 12 and the Navy Hospital. These areas have limited sewer service, which may account for the absence of apparent problems.

SUMMARY

Infiltration/inflow is a serious problem in the Naval Base sewer system. The major contributors to I/I were found or suspected to be:

- Oil/water separators throughout the base, most notably the oil-water separator at the FMWTC fire training facility (Area 8).
- The base-wide infiltration of groundwater into the sanitary sewer system as well as tidally-influenced gravity lines.
- Many storm sewer-sanitary sewer cross-connections, the most notable of which are the roof drains of several Shipyard Buildings (Areas 3 & 5), curb inlets on Magpie Avenue (Area 9), and scattered catch basin and drop inlet tie-ins.
- Leaking plugged overflow lines, tap leaks, and assorted line leaks.

Other deficiencies were observed during the gravity line evaluation which do not contribute to I/I, but which have the potential to adversely affect the functions of the system. These deficiencies were found to occur base-wide, and include: 1) oil and grease in sewer lines and manholes (possible sources are listed in this chapter); and 2) the buildup of sand and debris in most smaller gravity lines.

CHAPTER 4

GRAVITY LINE CAPACITY ANALYSIS

INTRODUCTION

The physical condition of all 90,000 feet of gravity sewer line was discussed in Chapter 3. In order to make a more accurate assessment of the condition and capabilities of the gravity system, calculated gravity line capacities were compared to the estimated flow through these lines to determine the remaining capacity of the system. To facilitate gravity line capacity analysis, the 33 evaluation zones outlined in Chapter 2 (Figures 2-1 and 2-2) are utilized in this chapter.

METHODOLOGY

The purpose of this analysis is to determine the capacities of gravity sewer lines and to make recommendations on those lines that appear to be over or near their capacities. As per contract, only those gravity lines 10 inches and larger were evaluated. These lines are shown on Figures 4-1 and 4-2.

Actual wastewater flows through gravity lines were estimated using the wastewater flow projections of Chapter 2. Existing and future wastewater flows were hypothetically introduced into the system at logical entry points and carried through the system, accumulating as flow approached the NCSD pump station, which receives all wastewater generated at the Naval Base.

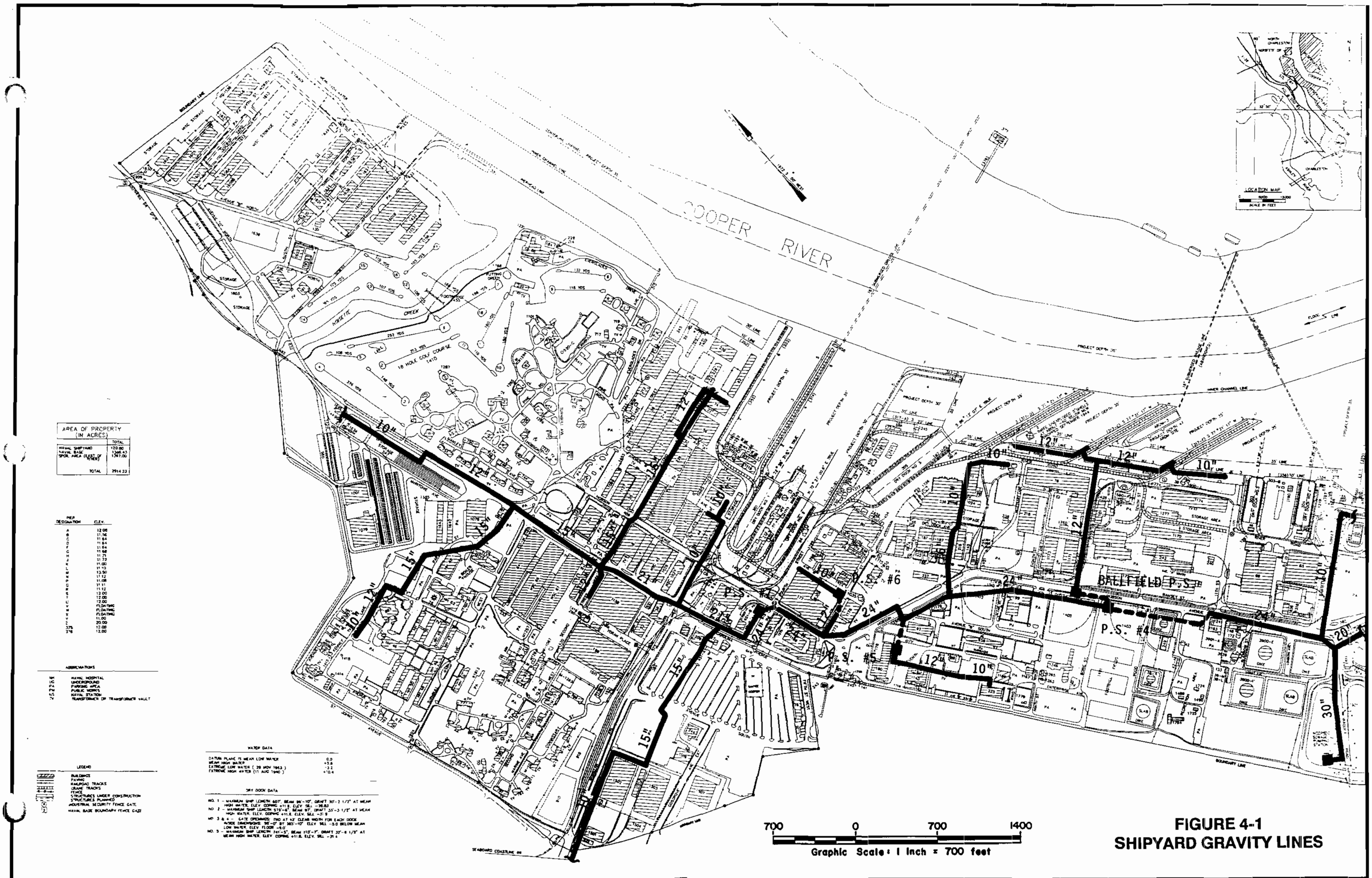


FIGURE 4-1
SHIPYARD GRAVITY LINES

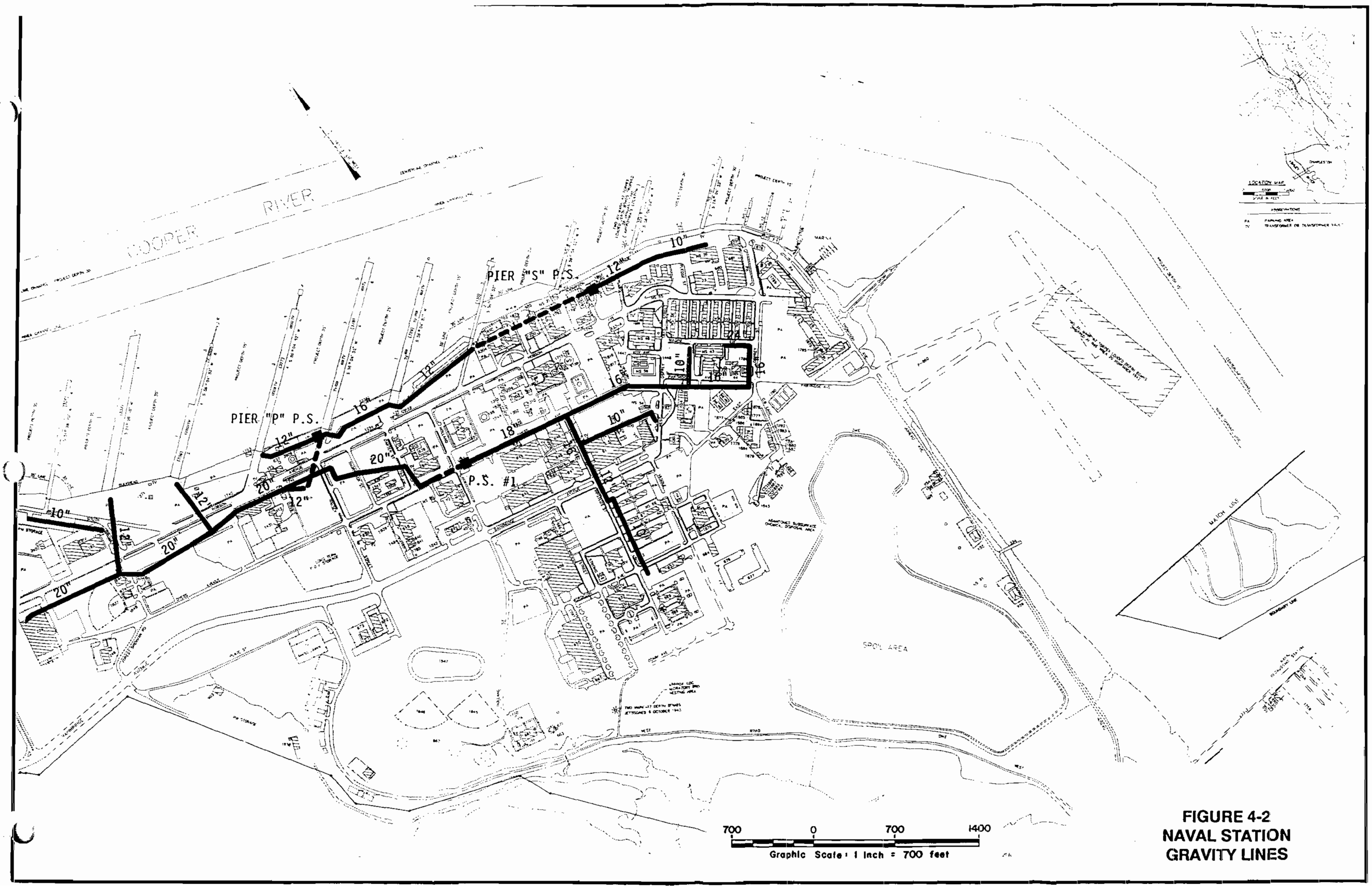


FIGURE 4-2
NAVAL STATION
GRAVITY LINES

Line capacities were determined using Manning's equation:

$$Q = (0.463/n)(D^{8/3})(S^{1/2})$$

Where Q = capacity, pipe flowing full (ft^3/s)

n = roughness coefficient (dimensionless)

D = pipe diameter (ft.)

S = pipe slope (ft./ft.)

Pipe flows were multiplied by the appropriate conversion factor to determine capacities in gallons per day. The roughness coefficient was, for the purposes of this study, assumed to be 0.013. This is a coefficient commonly used when evaluating existing pipelines. At the direction of the Shipyard Public Works Department, the pipe slope was determined by using manhole invert elevations from the Sewer Manhole Index (H410-139) and distances between manholes from the sewer system base map (H410-121 through H410-133). For some manholes, no invert information was available. In these cases, pipe slope was assumed to be the minimum design slope for a pipe flowing at 2 ft./second. This provided conservative estimates; instances where this assumption was made will be noted herein.

The gravity system was broken down into segments, which were defined by logical breaks (e.g., changes in pipe diameters, pipe slope, or line junctions).

The design capacity of each sewer line is, for the purposes of this study, 75% of the capacity of the sewer flowing completely full (.75 Q/Q). All lines transporting flows in excess of the design (75%) capacity are assumed to be over capacity.

LIMITATIONS

Several limitations were encountered in performing this evaluation. Because line capacities were calculated based on information from the previously mentioned manhole index and the unrevised sewer system base map, results depend on accurate invert elevation and line length information. In some cases, this information was missing or incorrect. Hence, it was sometimes necessary to assume that information. This was done in a conservative manner. Secondly, several instances of surcharged gravity lines made it impossible to verify line sizes for use in capacity calculations. These line sizes were assigned based on the old system base map and not verified by field observations. Finally, actual peak flows through gravity lines were derived from the flow projections of Chapter 2.

GRAVITY LINE CAPACITY ANALYSIS

The following discussion presents a zone-by-zone analysis of all gravity sewers 10-inch and larger (only zones with lines of this size are discussed). All flows and line capacities are presented in million gallons per day (mgd). Calculations used in determining actual peak flows through gravity lines are included in Appendix "D".

Following this capacity analysis, recommended improvements are presented for lines that are over capacity.

Zone 3

As shown in Table 4-1 below, Zone 3 has two major gravity line segments, and both are 10-inch ductile iron (DI) pipe. These segments are the upstream end of the Shipyard trunk line. Both segments are flowing within capacity, and this should continue beyond the year 2000.

TABLE 4-1 ZONE 3:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 3-1	10	18	19	0.498	0.143	29	0.144	29	0.144	29
GL 3-2	10	19	20A	0.509	0.143	28	0.144	28	0.144	28

Zone 4

Zone 4 consists of one major gravity segment, a 12-inch vitrified clay (VC) trunk line along Avenue "D". Estimated peak flows in this segment are within the line capacity.

TABLE 4-2 ZONE 4:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 4-1	12	20A	50	0.773	0.305	39	0.306	40	0.309	40

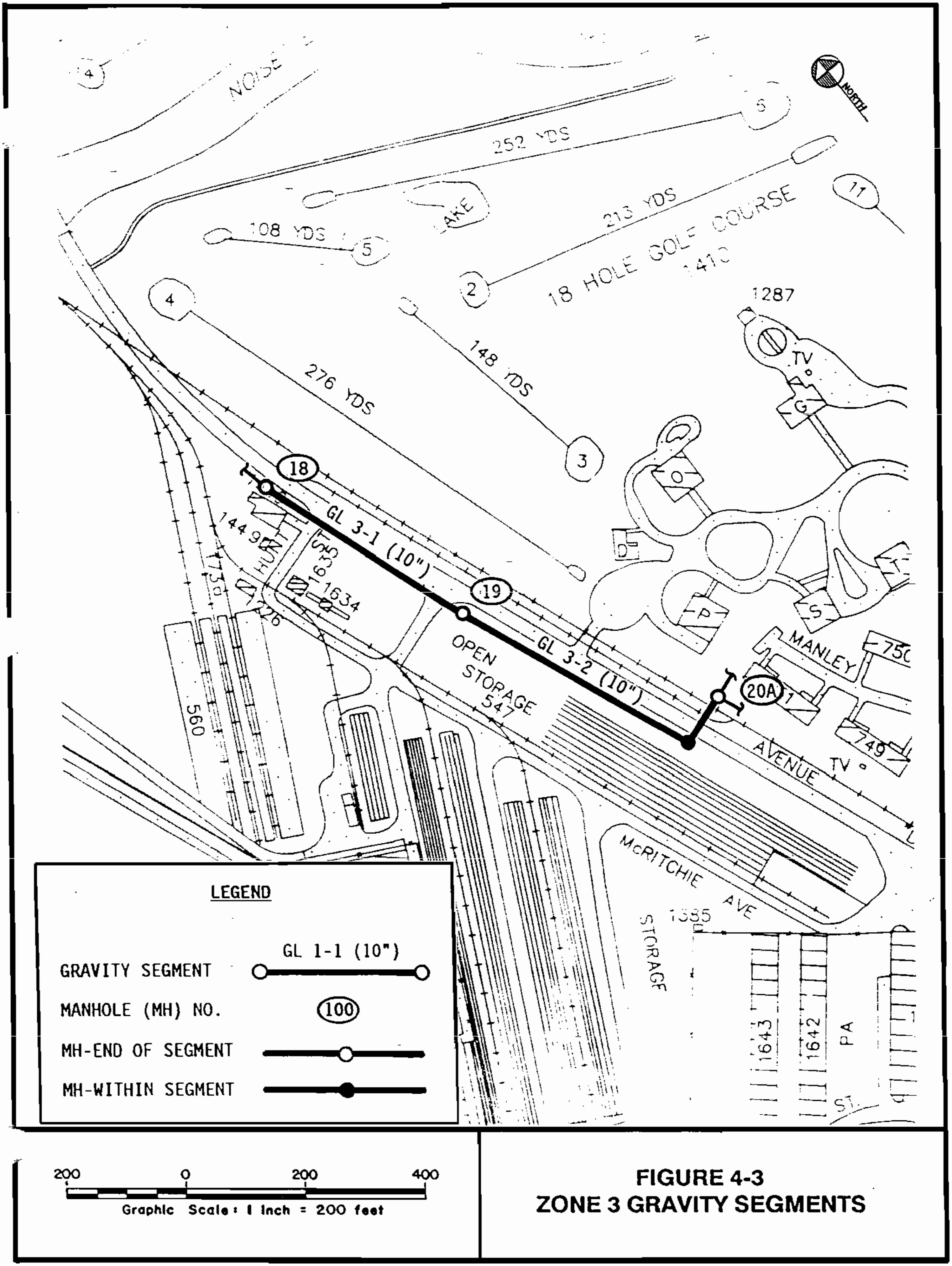


FIGURE 4-3
ZONE 3 GRAVITY SEGMENTS

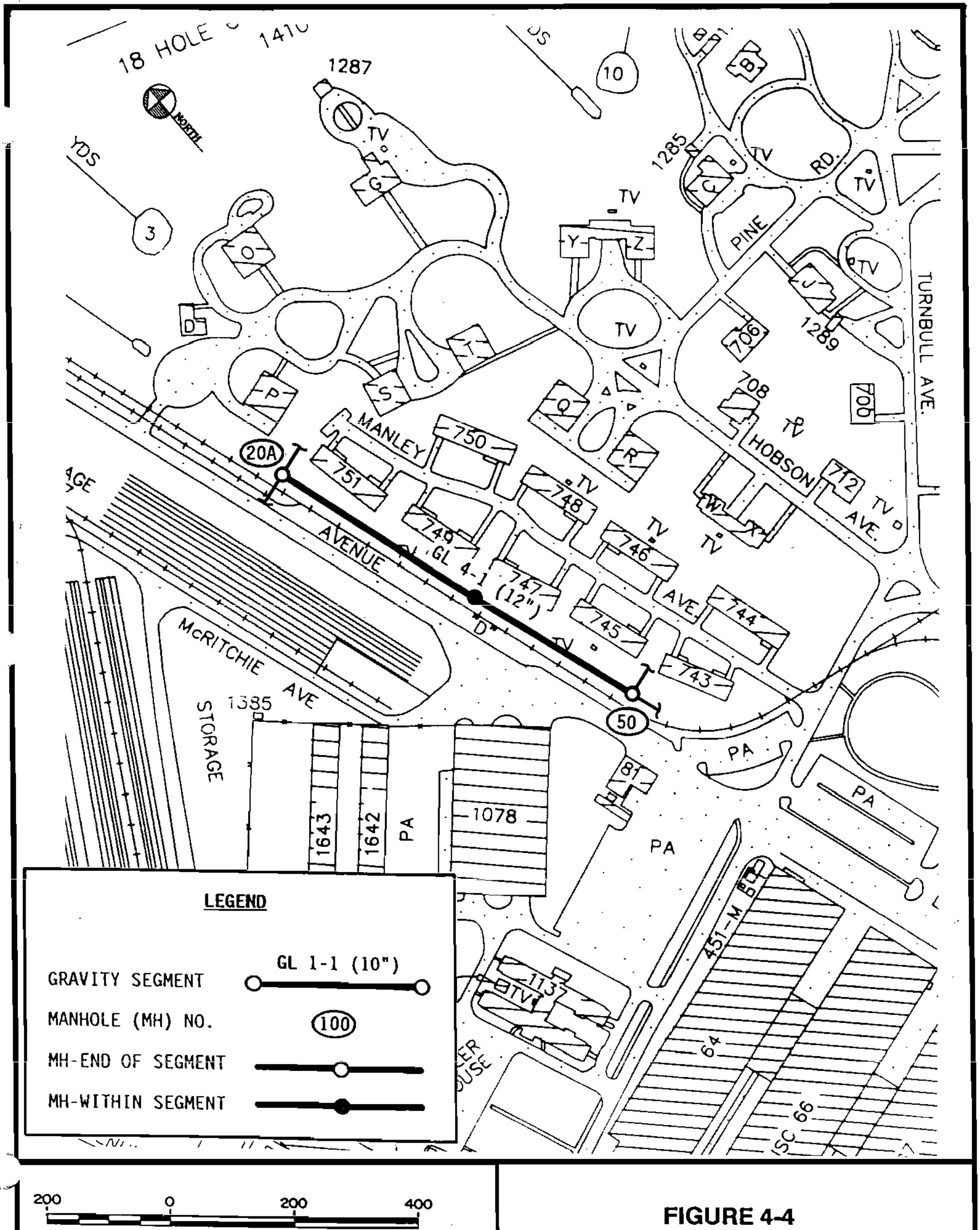


FIGURE 4-4
ZONE 4 GRAVITY SEGMENTS

Zone 5

The major Zone 5 gravity segments consist of one 12-inch VC and four 15-inch VC segments. All Zone 5 lines are presently under capacity, and this should continue through the year 2000. Many deficiencies in Zones 6 and 7 gravity lines are traceable to I/I in Zone 5 lines, and the estimated peak flow figures in Table 4-3 should decrease somewhat upon rehabilitation of line deficiencies.

TABLE 4-3 ZONE 5: GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 5-1	15	87	87A	1.252	0.287	23	0.291	23	0.296	24
GL 5-2	15	87A	74	1.904	0.287	15	0.291	15	0.296	16
GL 5-3	15	74	52	1.252	0.301	24	0.306	24	0.311	25
GL 5-4	15	52	51	1.084	0.301	28	0.306	28	0.311	29
GL 5-5	15	50	51	1.158	0.377	33	0.380	33	0.383	33

Zone 6

Zone 6 gravity segments include 10 and 12-inch lines on either side of the old Navy Hospital complex. All six segments should remain within capacity through 2000, as shown in Table 4-4.

TABLE 4-4 ZONE 6: GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 6-1	10	125E	125D	0.531*	0.014	3	0.014	3	0.014	3
GL 6-2	12	125D	125B	0.772*	0.014	2	0.015	2	0.015	2
GL 6-3	12	125B	125	0.772*	0.020	3	0.021	3	0.021	3
GL 6-4	10	91	89	0.562	0.153	27	0.155	28	0.156	28
GL 6-5	12	89	88	1.868	0.175	9	0.177	9	0.179	10
GL 6-6	12	88	87	0.691	0.175	25	0.177	26	0.179	26

*Minimum slopes of 0.0025 for GL 6-1 and 0.0020 for GL 6-2 and GL 6-3 were assumed due to lack of information in the manhole index.

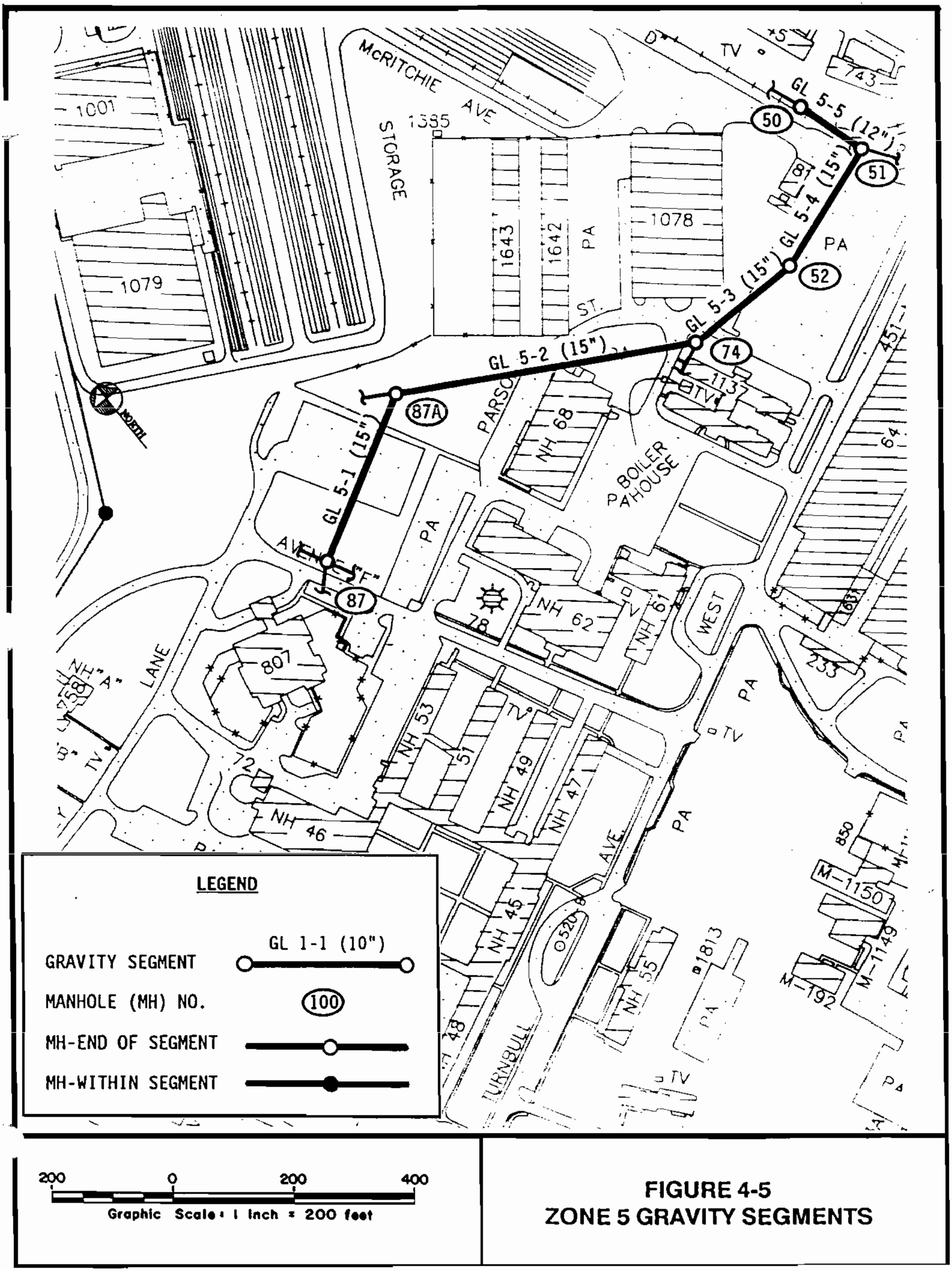
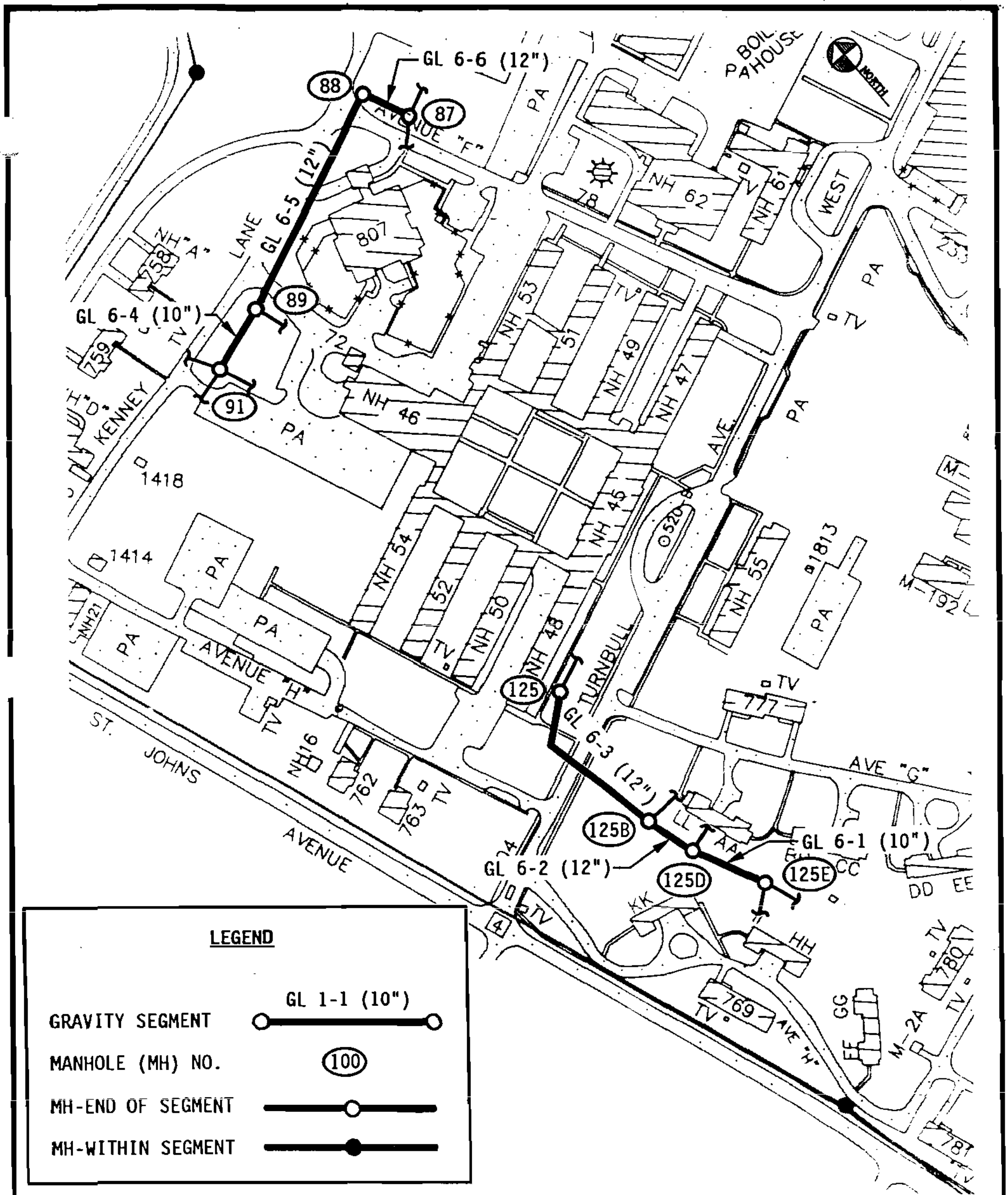


FIGURE 4-5
ZONE 5 GRAVITY SEGMENTS



200 0 200 400

Graphic Scale: 1 inch = 200 feet

FIGURE 4-6
ZONE 6 GRAVITY SEGMENTS

Zone 9

This zone is comprised of eight major gravity segments. As shown in Table 4-5, five of the segments are flowing less than 25% full during peak periods. The other three lines are approximately 50% full during peak flows.

TABLE 4-5 ZONE 9:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 9-1	15	51	53B	1.252	0.735	59	0.743	59	0.750	60
GL 9-2	15	53B	54	1.252*	0.777	62	0.787	63	0.797	64
GL 9-3	12	152	54A	1.064	0.187	18	0.192	18	0.198	19
GL 9-4	12	54A	54	0.772*	0.187	24	0.192	25	0.198	26
GL 9-5	15	54	55	2.429*	1.150	47	1.170	48	1.190	50
GL 9-6	15	168	166C	1.171	0.138	12	0.141	12	0.144	12
GL 9-7	15	166C	165	1.084	0.177	16	0.182	17	0.187	17
GL 9-8	15	165	54	1.212	0.185	15	0.190	16	0.195	16

*Minimum slopes of 0.0016 for GL 9-2, 0.0020 for GL 9-4, and 0.0010 for GL 9-5 were assumed due to lack of information in the manhole index.

Zone 10

Both major gravity segments in Zone 10 consist of 12-inch DI pipe. The two lines parallel one another, and it is estimated that, cumulatively, they transport approximately 129,000 gpd during peak periods. In order to make a conservative estimate as to the actual peak flow through each line, it was assumed that each line carries 129,000 gpd. Subsequently, both lines were found to be under capacity, and this is expected to continue through 2000.

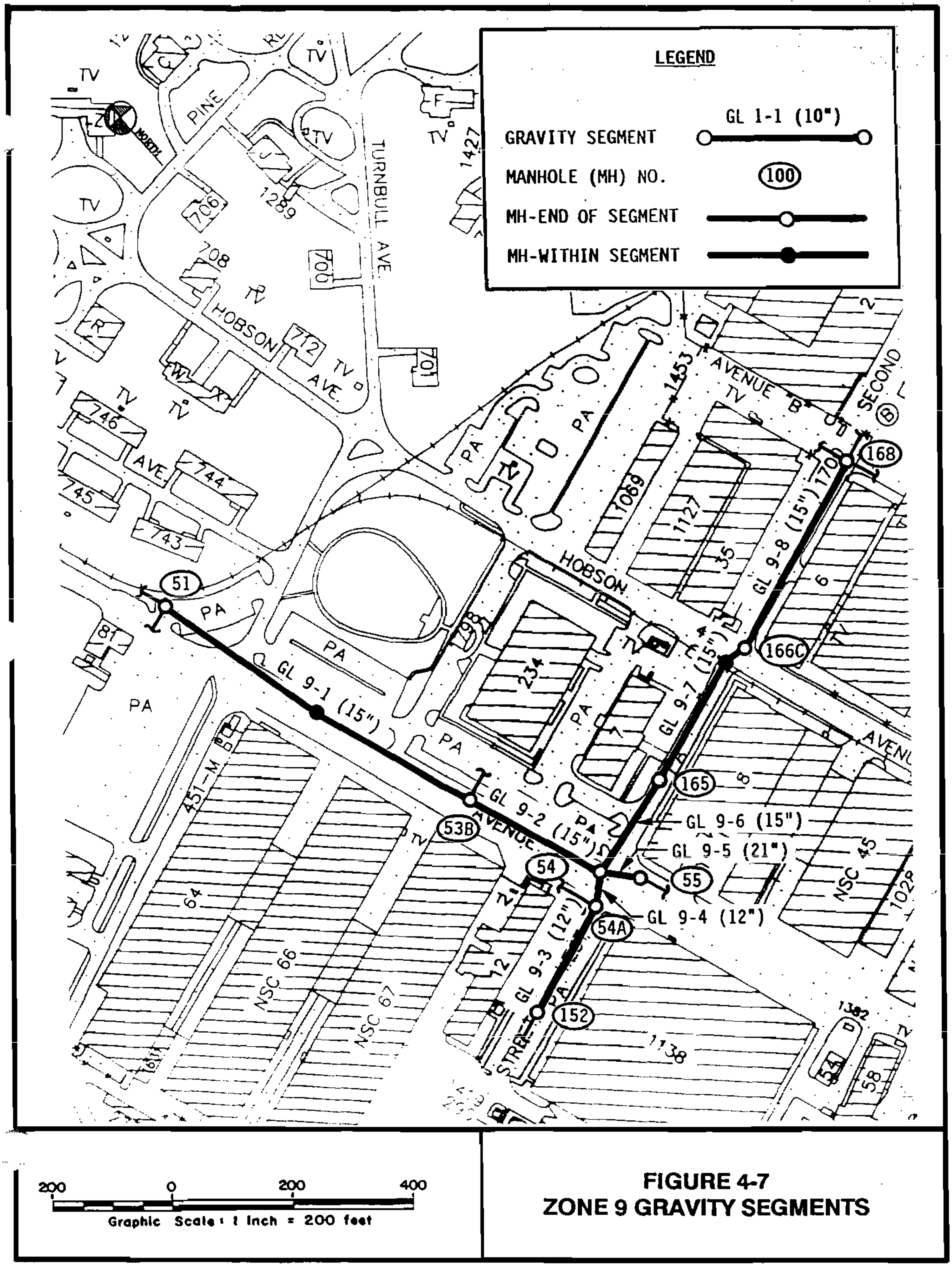
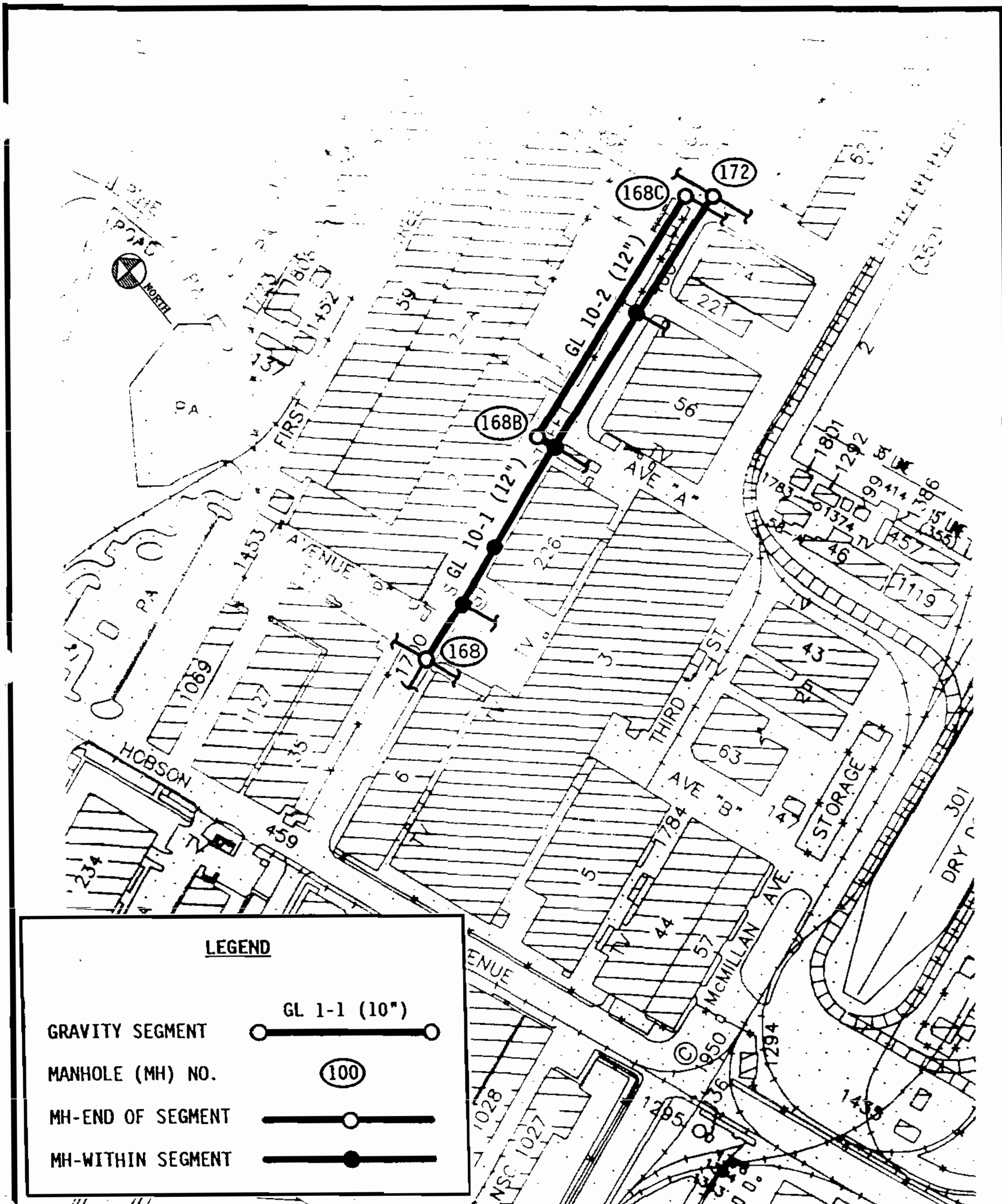


FIGURE 4-7
ZONE 9 GRAVITY SEGMENTS



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Graphic Scale: 1 inch = 200 feet

FIGURE 4-8
ZONE 10 GRAVITY SEGMENTS

TABLE 4-6 ZONE 10:GRAVITY LINE CAPACITY ANALYSIS										
Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990		1995		2000	
					Peak Flow	% Cap.	Peak Flow	% Cap.	Peak Flow	% Cap.
GL 10-1	12	172	168	0.772	0.129	17	0.131	17	0.134	17
GL 10-2	12	168C	168B	0.772	0.122	16	0.124	16	0.127	16

Zone 11

As shown in Table 4-7, most of the Zone 11 gravity lines should be flowing under capacity through 2000. However, the three 10-inch segments adjacent to Dry Dock No. 1 (GL's 11-5, 11-6 and 11-7) will be approaching 60 to 70 percent capacity. With the rehabilitation of several gravity line deficiencies upstream of these segments, the remaining capacity of these lines should increase. Shipyard trunk line segments in this zone are flowing at less than 50% capacity during peak periods.

TABLE 4-7 ZONE 11:GRAVITY LINE CAPACITY ANALYSIS										
Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990		1995		2000	
					Peak Flow	% Cap.	Peak Flow	% Cap.	Peak Flow	% Cap.
GL 11-1	21	55	56B	2.429*	1.150	47	1.170	48	1.190	49
GL 11-2	21	56B	56	2.429*	1.158	48	1.178	49	1.198	49
GL 11-3	10	194	193	0.541	0.142	26	0.145	27	0.149	28
GL 11-4	10	193A	193	0.619	0.092	15	0.093	15	0.095	15
GL 11-5	10	193	192A	0.425	0.290	68	0.296	70	0.302	71
GL 11-6	10	192A	192	0.531	0.290	55	0.296	56	0.302	57
GL 11-7	10	192	56	0.541	0.323	60	0.330	61	0.336	62

*Minimum slope of 0.0010 was assumed for GL 11-1 and GL 11-2 due to erroneous information in the manhole index.

Zone 12

The two Zone 12 gravity line segments are part of the 24-inch DI Shipyard trunk line. As shown in Table 4-8, Zone 12 gravity lines should

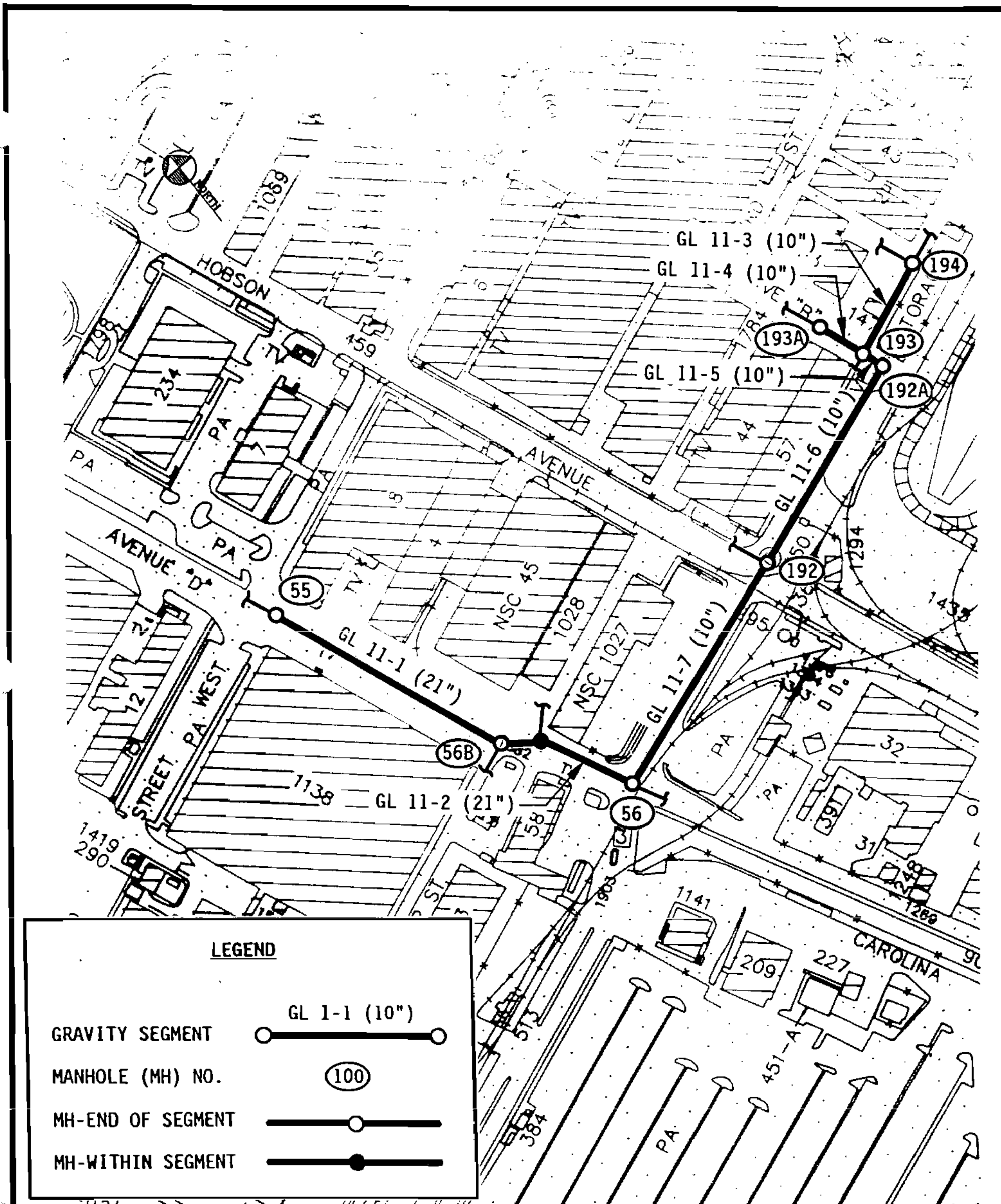
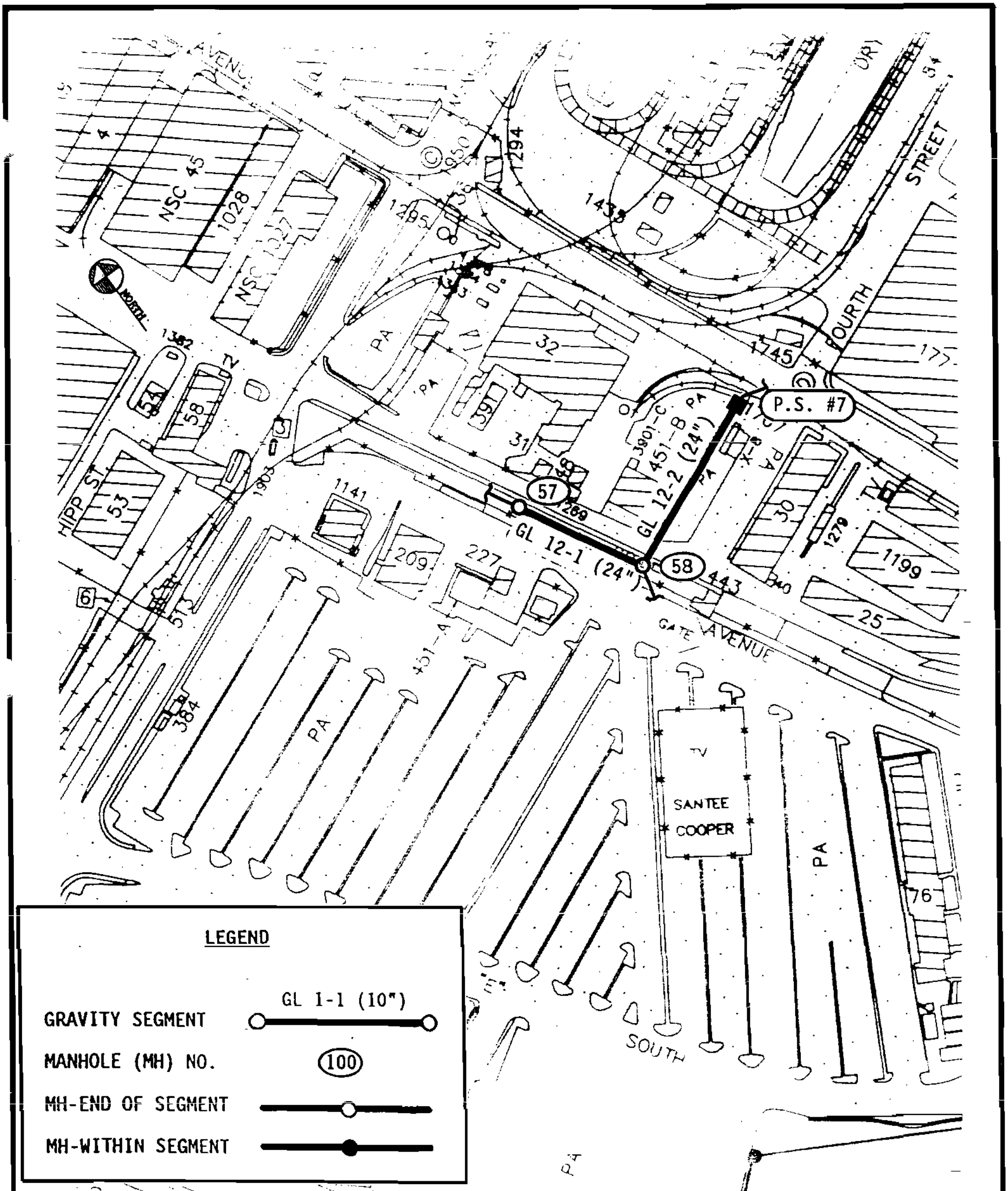


FIGURE 4-9
ZONE 11 GRAVITY SEGMENTS



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Graphic Scale: 1 inch = 200 feet

FIGURE 4-10
ZONE 12 GRAVITY SEGMENTS

remain at approximately 60% capacity for peak flow periods through the year 2000. These peak flows, however, should decrease upon gravity line rehabilitation upstream of Zone 7 and an associated reduction in I/I.

TABLE 4-8 ZONE 12:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 12-1	24	57	58	3.290	1.892	58	1.995	61	2.037	62
GL 12-2	24	58	220A	3.290	1.914	58	2.019	61	2.062	63

Zone 13

Five of the six gravity segments in Zone 13 handle mostly Naval Hospital flows. I/I is relatively insignificant in these segments. The other segment is a 21-inch VC line on Avenue "D", part of the Shipyard trunk line. Flow through Zone 13 should not exceed line capacities through the year 2000.

TABLE 4-9 ZONE 13:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 13-1	10	222A	222	0.531*	0.344	65	0.360	68	0.375	71
GL 13-2	15	222	217A	1.212*	0.344	28	0.360	30	0.375	31
GL 13-3	15	217A	217	1.212*	0.344	28	0.360	30	0.375	31
GL 13-4	15	217	214	1.129	0.346	31	0.362	32	0.377	33
GL 13-5	15	214	57	4.200	0.349	8	0.365	9	0.381	9
GL 13-6	21	56	57	6.239	1.481	24	1.508	24	1.535	25

*Minimum slopes of 0.0025 for GL 13-1 and 0.0015 for GL 13-2 and GL 13-3 were assumed due to lack of information in the manhole index.

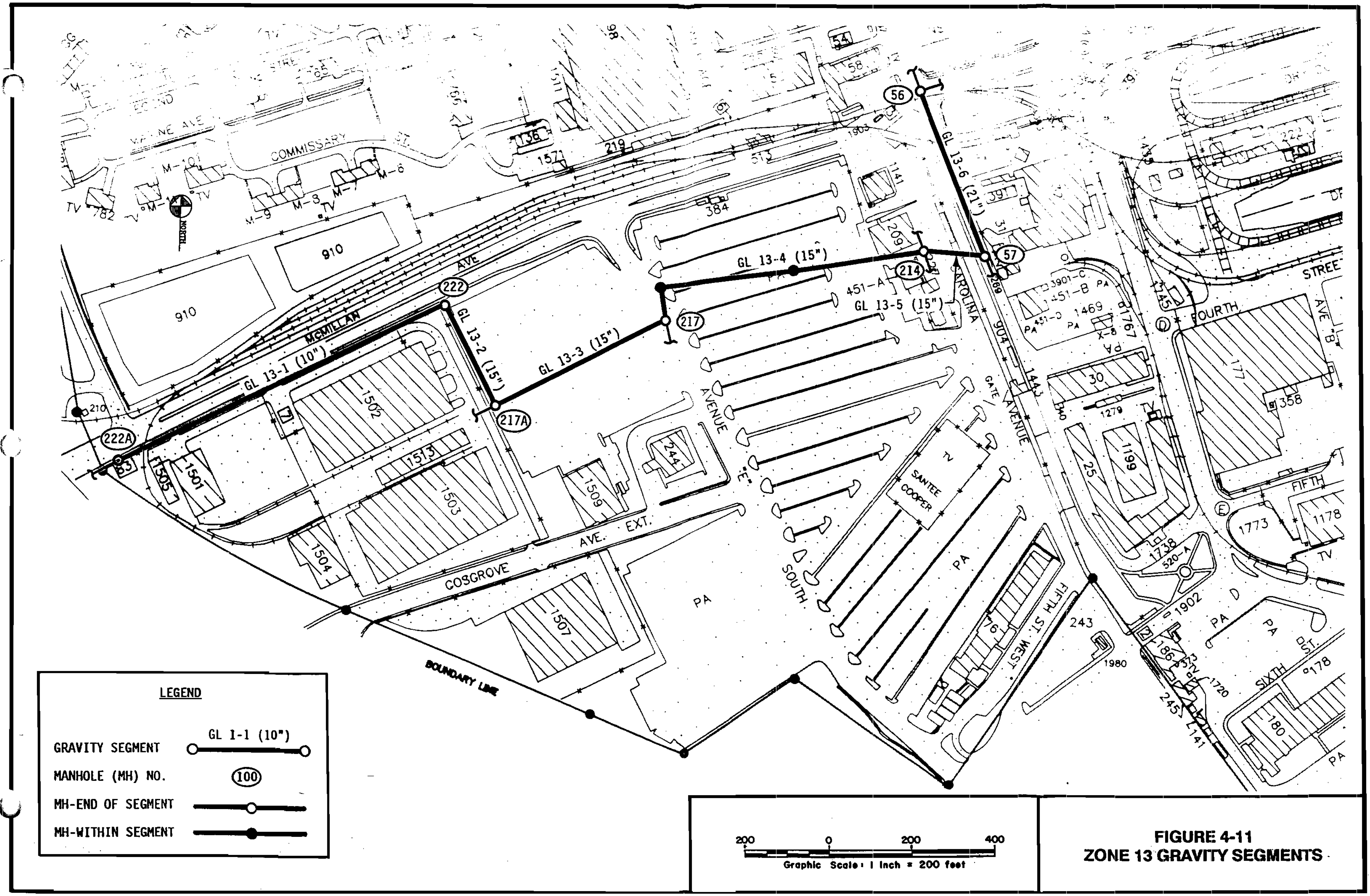


FIGURE 4-11
ZONE 13 GRAVITY SEGMENTS

Zone 14

Zone 14 segments transport mainly Navy Hospital flows; GL 14-3 and GL 14-4 also handle Bachelor's Enlisted Quarters flows. Because it was impossible to determine the exact amount of flow through GL 14-1, it was assumed that the entire peak flow from the hospital was transported through this line. This provided a conservative estimate. As shown in Table 4-10, peak flows through GL 14-3 and GL 14-4 are nearing respective line capacities.

TABLE 4-10 ZONE 14:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 14-1	10	507	506	0.671	0.276	41	0.290	43	0.304	45
GL 14-2	10	506	504	0.671	0.276	41	0.290	43	0.304	45
GL 14-3	10	504	503	0.300	0.276	92	0.290	97	0.304	101
GL 14-4	10	503	222A	0.383	0.344	90	0.360	94	0.375	98

Zone 15

Gravity lines evaluated in Zone 15 consist of 10 and 12-inch lines adjacent to Building 177 and two 24-inch Shipyard trunk line segments on Hobson Avenue. Lines in this zone are within capacity, and should remain so through the year 2000.

TABLE 4-11 ZONE 15:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capecity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 15-1	10	248	235	0.531	0.027	5	0.028	5	0.030	6
GL 15-2	10	235	231A	0.438	0.131	30	0.135	31	0.140	32
GL 15-3	12	234	60	0.772	0.131	17	0.136	18	0.140	18
GL 15-4	24	59	60	6.670	2.065	31	2.185	33	2.232	33
GL 15-5	24	60	61	7.437	2.197	30	2.321	31	2.372	32

FIGURE 4-12
NAVAL HOSPITAL BASE MAP (ZONE 14)
NOT AVAILABLE

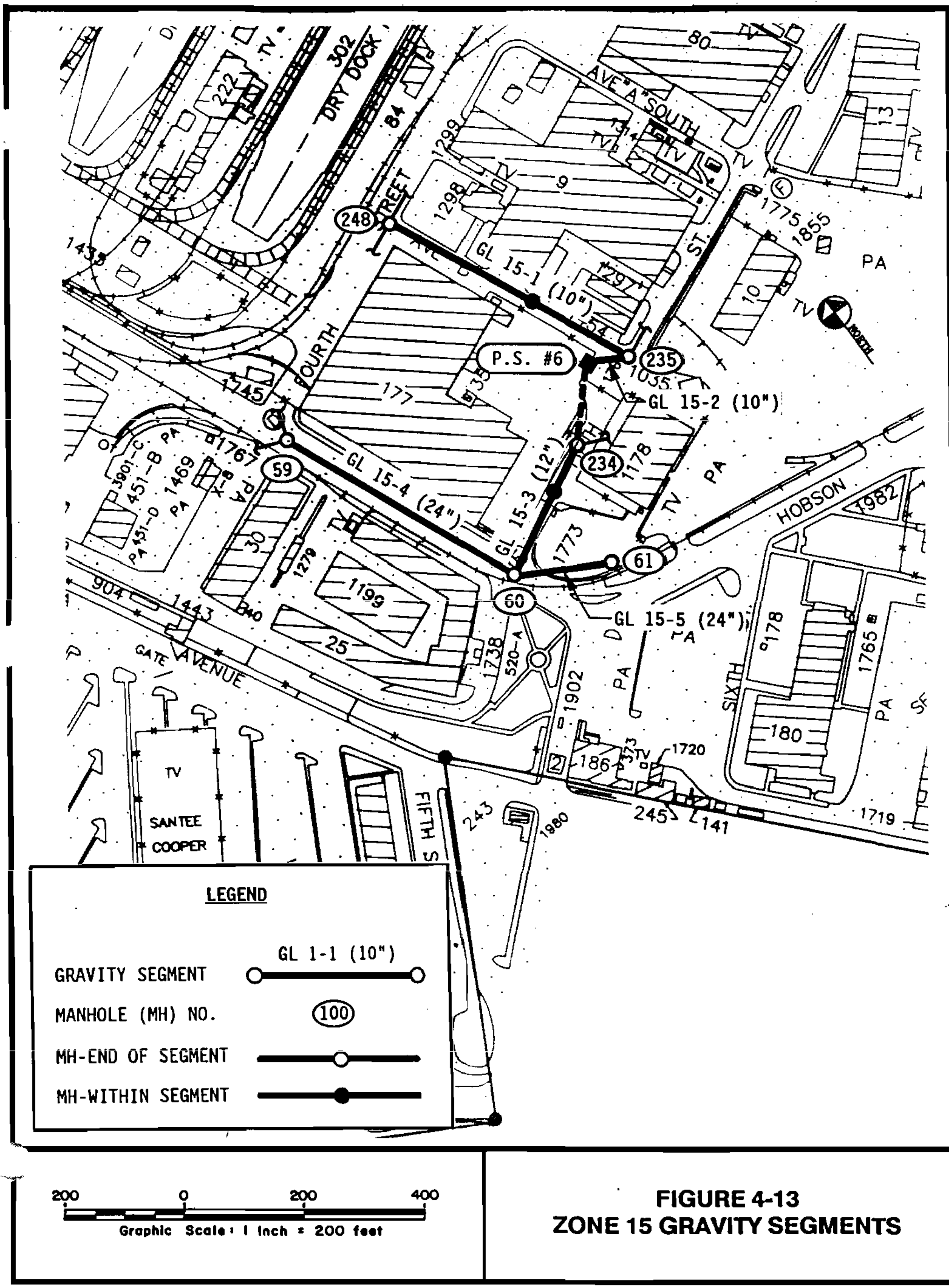


FIGURE 4-13
ZONE 15 GRAVITY SEGMENTS

Zone 16

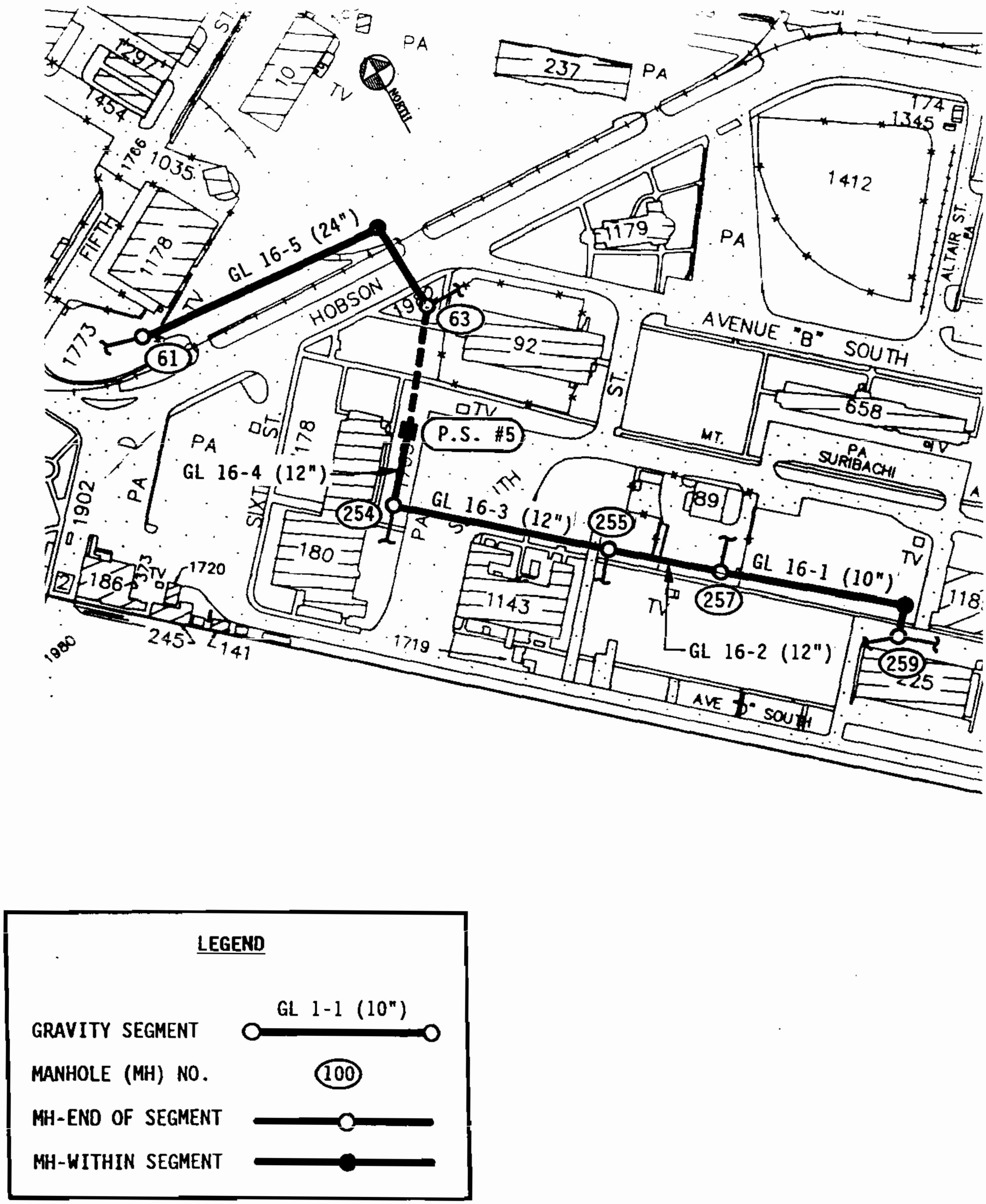
The gravity segments in Zone 16 are flowing at less than 25% of their capacities. As shown in Table 4-12, line capacities should be sufficient to handle peak flows through the year 2000.

TABLE 4-12 ZONE 16:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
CL 16-1	10	259	257	0.450	0.015	3	0.016	4	0.016	4
GL 16-2	12	257	255	0.772	0.057	7	0.060	8	0.063	8
GL 16-3	12	255	254	0.733	0.068	9	0.071	10	0.074	10
GL 16-4	12	254	253	0.733	0.125	17	0.138	19	0.144	20
CL 16-5	24	61	63	9.174	2.197	24	2.321	25	2.372	26

Zone 17

Zone 17 has nine gravity segments, seven of which are flowing under capacity. Segments GL 17-8 and GL 17-9 are presently flowing at 75% capacity, and this is expected to increase to greater than 80% capacity by 2000. Problems should not develop, however, if sufficient gravity line deficiencies upstream of Zone 17 are corrected.



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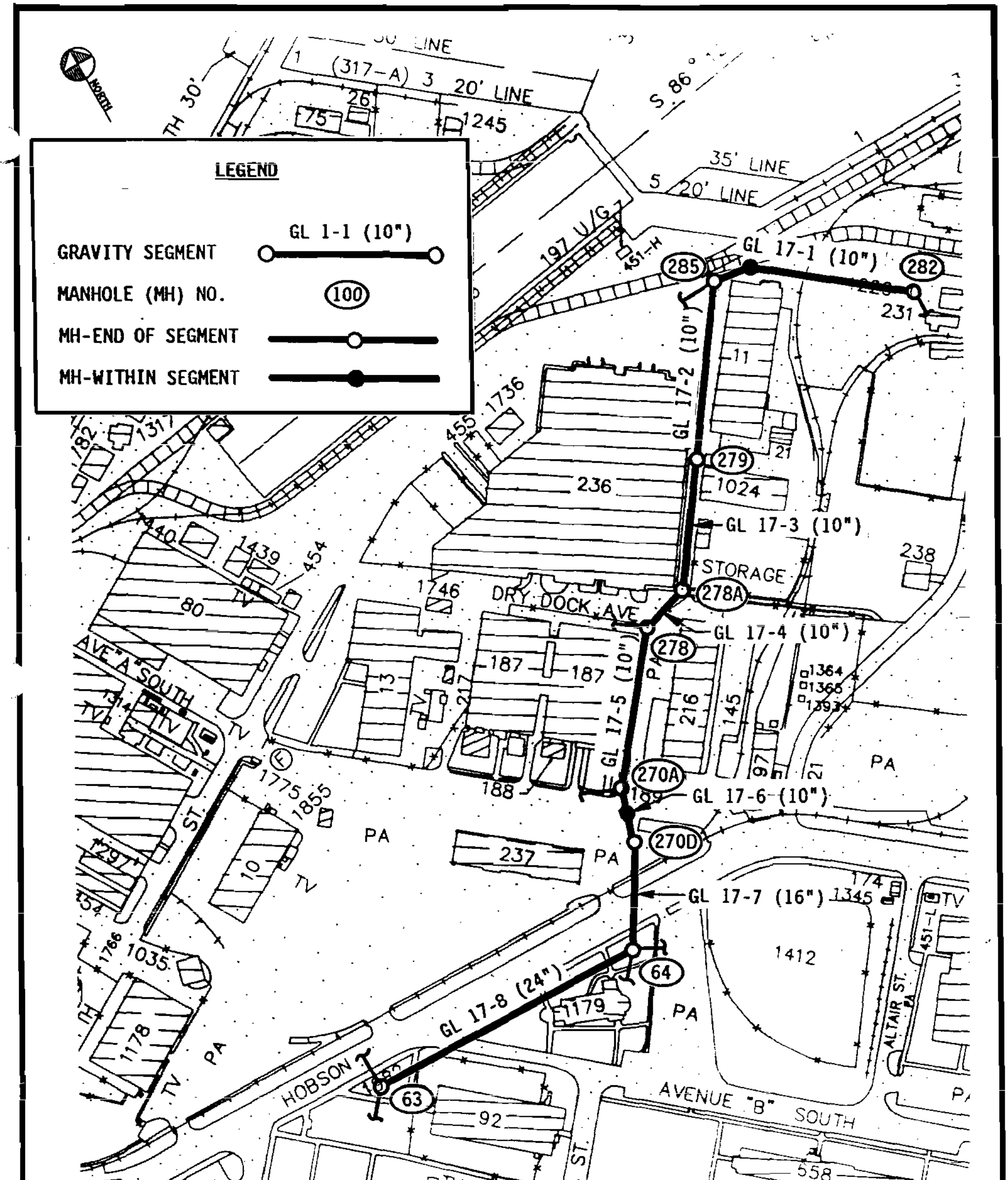
Graphic Scale: 1 inch = 200 feet

FIGURE 4-14
ZONE 16 GRAVITY SEGMENTS



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Graphic Scale: 1 inch = 200 feet

FIGURE 4-15
ZONE 17 GRAVITY SEGMENTS

TABLE 4-13 ZONE 17:GRAVITY LINE CAPACITY ANALYSIS										
Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990		1995		2000	
					Peak Flow	% Cap.	Peak Flow	% Cap.	Peak Flow	% Cap.
GL 17-1	10	282	285	0.541	0.009	2	0.009	2	0.010	2
GL 17-2	10	285	279	0.475	0.026	5	0.027	6	0.028	6
GL 17-3	10	279	278A	0.475	0.042	9	0.043	9	0.045	9
GL 17-4	10	278A	278	0.352	0.042	12	0.043	12	0.045	13
GL 17-5	10	278	270A	0.531	0.048	9	0.050	9	0.052	10
GL 17-6	10	270A	270D	0.601	0.066	11	0.069	11	0.072	12
GL 17-7	16	270D	64	1.391*	0.066	5	0.069	5	0.072	5
GL 17-8	24	63	64	3.101*	2.337	75	2.475	80	2.533	82

*Minimum slopes of 0.0014 for GL 17-7 and 0.0008 for GL 17-8 were assumed due to lack of information in the manhole index.

Zone 18

Major gravity lines in this zone are the four 12-inch DI segments that serve Piers "G", "H" and "J". All four segments are under capacity and should remain so through the year 2000.

TABLE 4-14 ZONE 18:GRAVITY LINE CAPACITY ANALYSIS										
Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990		1995		2000	
					Peak Flow	% Cap.	Peak Flow	% Cap.	Peak Flow	% Cap.
GL 18-1	12	-	-	0.772*	0.021	3	0.021	3	0.021	3
GL 18-2	12	-	-	0.772*	0.043	6	0.044	6	0.046	6
GL 18-3	12	-	-	0.772*	0.020	3	0.021	3	0.021	3
GL 18-4	12	-	66B	0.772*	0.092	12	0.095	12	0.098	13

*The minimum slope of 0.0020 was assumed for all four gravity lines due to a lack of information in the manhole index.

Zone 20

The three gravity segments in Zone 20 are 24-inch DI lines which are part of the Shipyard trunk line along Hobson Avenue. Two of the lines are estimated to flow in the range of 85 to 95 percent capacity by the year

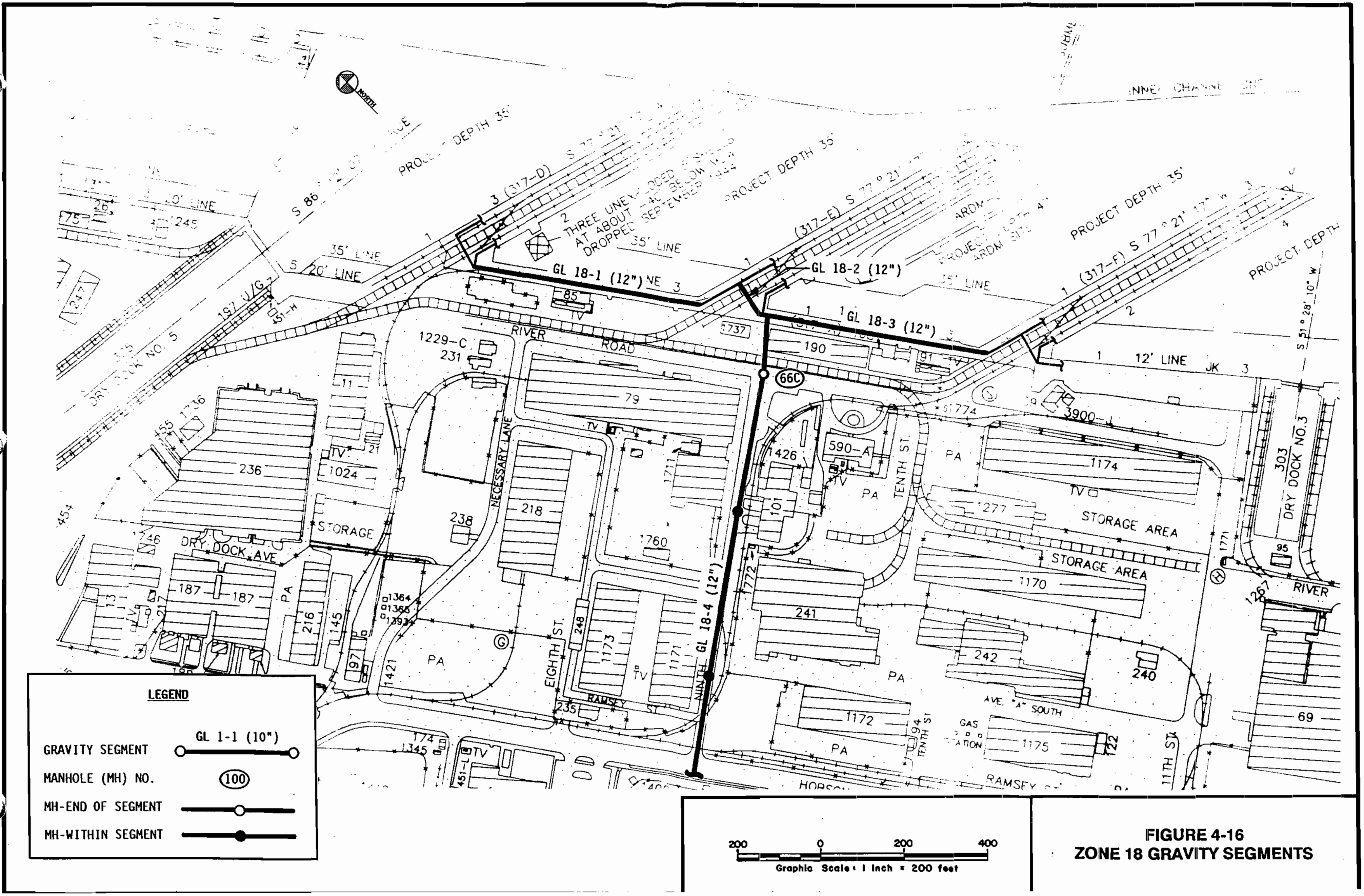


FIGURE 4-16
ZONE 18 GRAVITY SEGMENTS

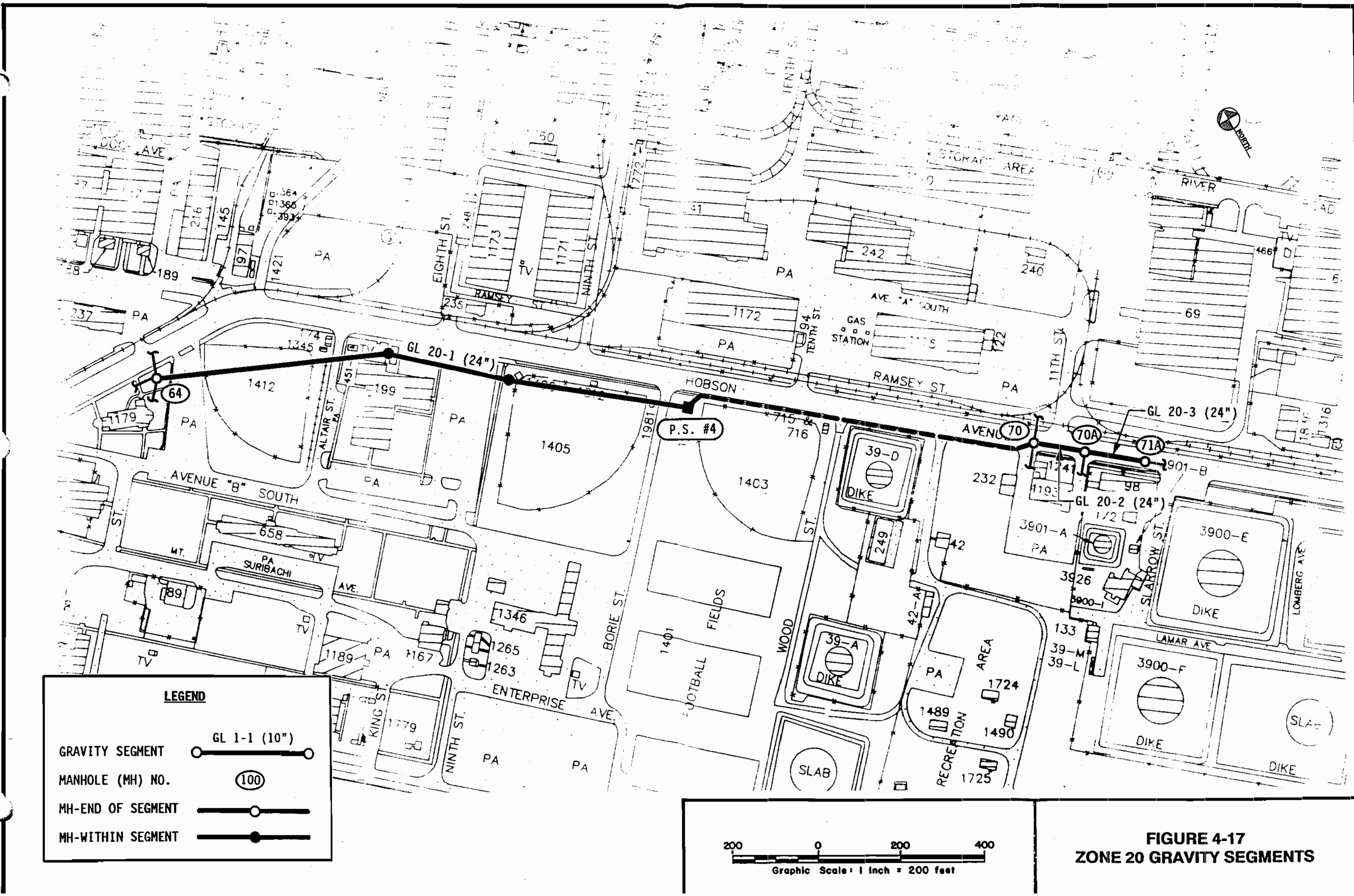


FIGURE 4-17
ZONE 20 GRAVITY SEGMENTS

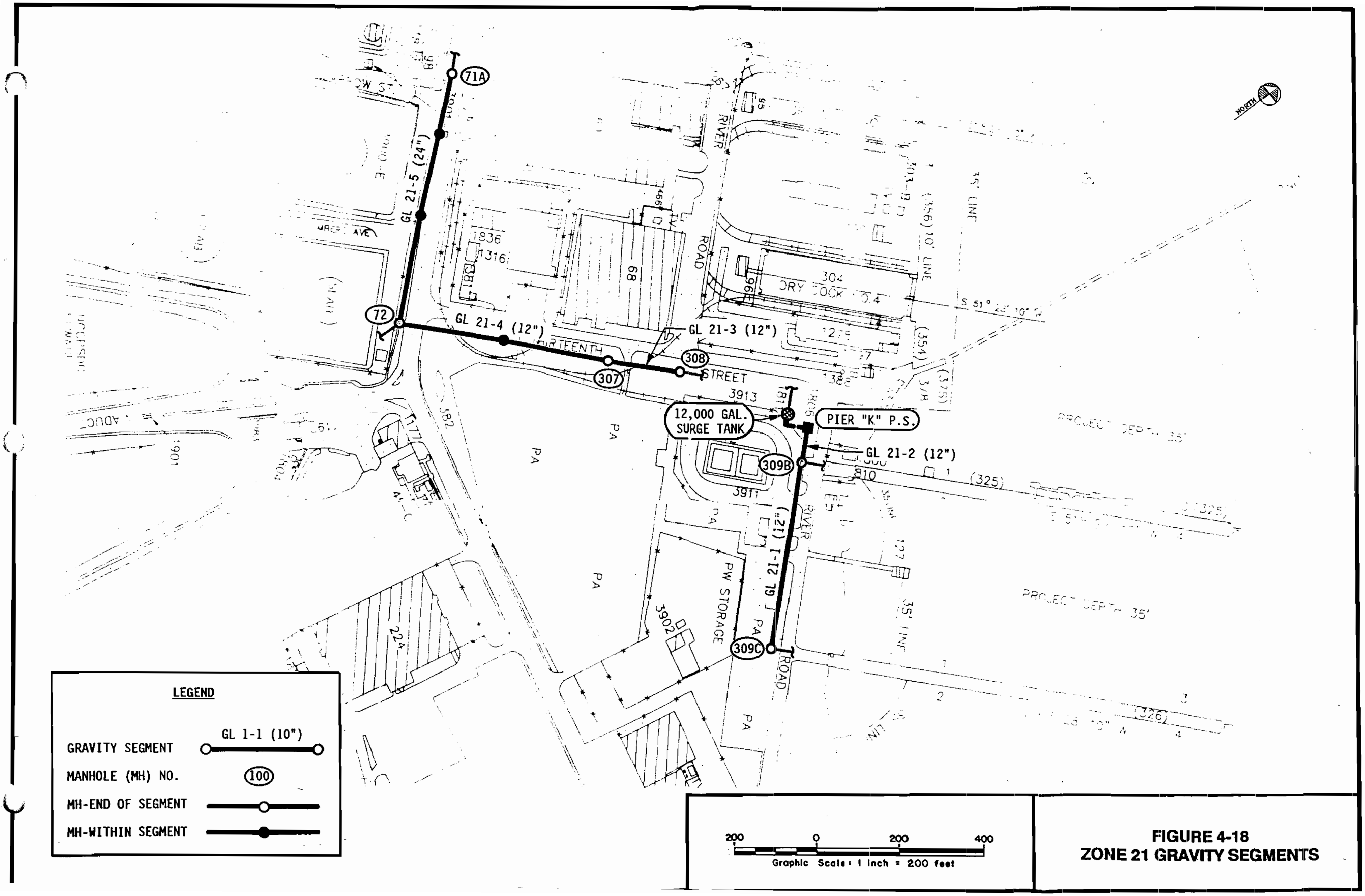
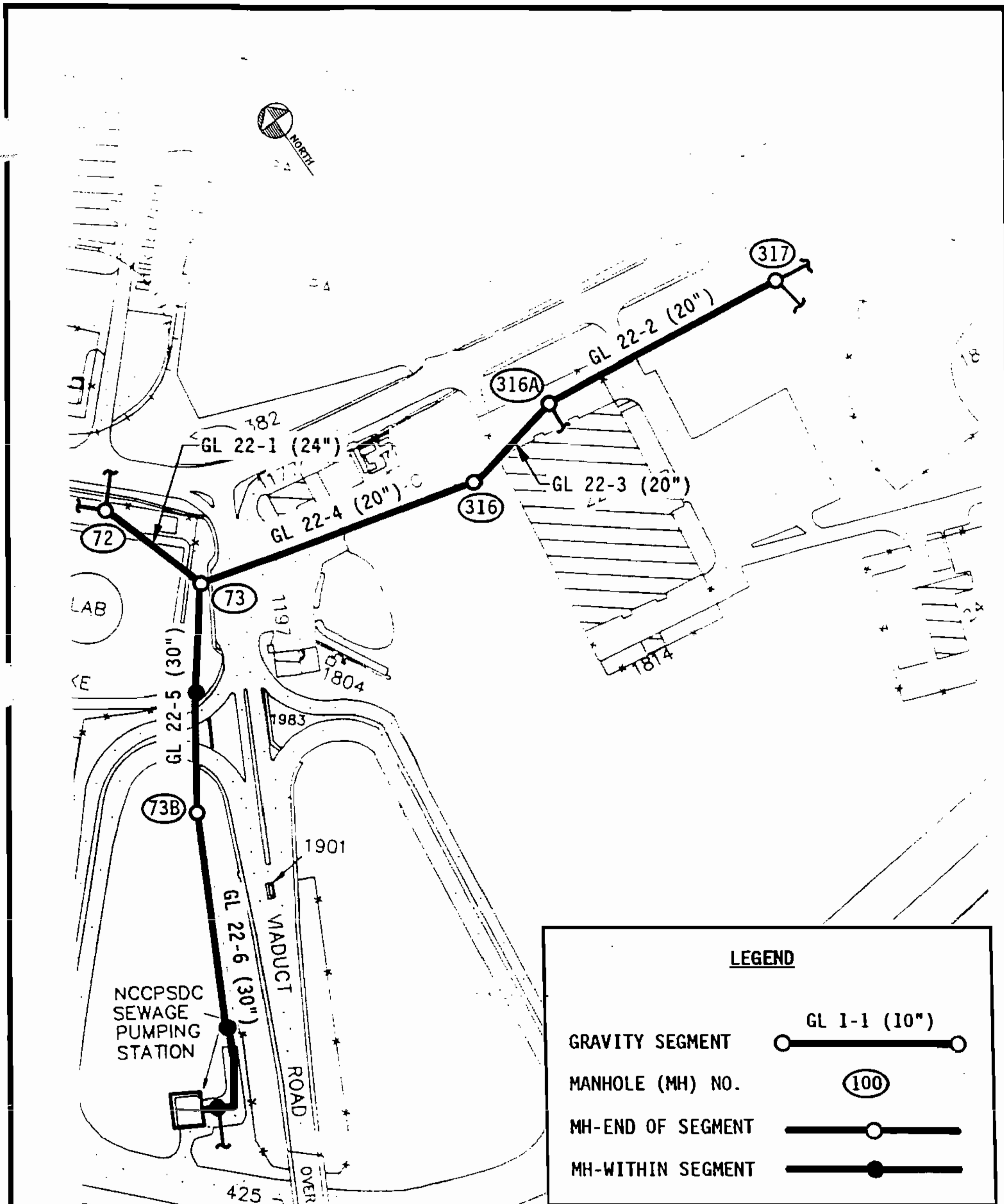


FIGURE 4-18
ZONE 21 GRAVITY SEGMENTS



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Graphic Scale: 1 inch = 200 feet

FIGURE 4-19
ZONE 22 GRAVITY SEGMENTS

part of the 20-inch DI Naval Station trunk line on Hobson Avenue or the 30-inch Naval Base discharge line along Viaduct Road. Suggested improvements for these over-capacity segments are presented at the end of this chapter.

TABLE 4-17 ZONE 22:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 22-1	24	72	73	4.652	2.882	62	3.062	66	3.129	67
GL 22-2	20	317	316A	2.023	2.207	109	2.498	123	2.708	134
GL 22-3	20	316A	316	1.652	2.207	134	2.498	151	2.708	164
GL 22-4	20	316	73	2.336	2.207	94	2.498	107	2.708	116
GL 22-5	30	73	73B	6.594	5.100	77	5.572	85	5.848	89
GL 22-6	30	73B	73C	5.624	5.100	91	5.572	99	5.848	104

Zone 23

With the exception of the 12-inch DI lines that serve Piers "M" and "Z", all of the Zone 23 gravity segments are projected to be over capacity by 2000; three segments are currently over capacity. These segments are part of the Naval Station trunk line. Recommended improvements for these lines are discussed at the end of this chapter.

TABLE 4-18 ZONE 23:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 23-1	12	-	318A	0.772*	0.042	5	0.044	6	0.045	6
GL 23-2	12	321A	321	0.772*	0.223	29	0.234	30	0.245	32
GL 23-3	20	323A	323	2.132*	2.031	95	2.316	109	2.520	118
GL 23-4	20	323	322	2.023	2.039	100	2.324	115	2.528	125
GL 23-5	20	322	321	2.236	2.039	91	2.324	104	2.528	113
GL 23-6	20	321	320	2.023	2.090	103	2.376	117	2.582	128
GL 23-7	20	320	319	2.431	2.090	86	2.376	98	2.582	106
GL 23-8	20	319	318A	1.907	2.090	110	2.376	125	2.582	135
GL 23-9	20	318A	317	2.431	2.104	87	2.391	98	2.597	107

*Minimum slopes of 0.0020 for GL 23-1 and GL 23-2 and 0.0010 for GL 23-3 were assumed due to lack of information in the manhole index.

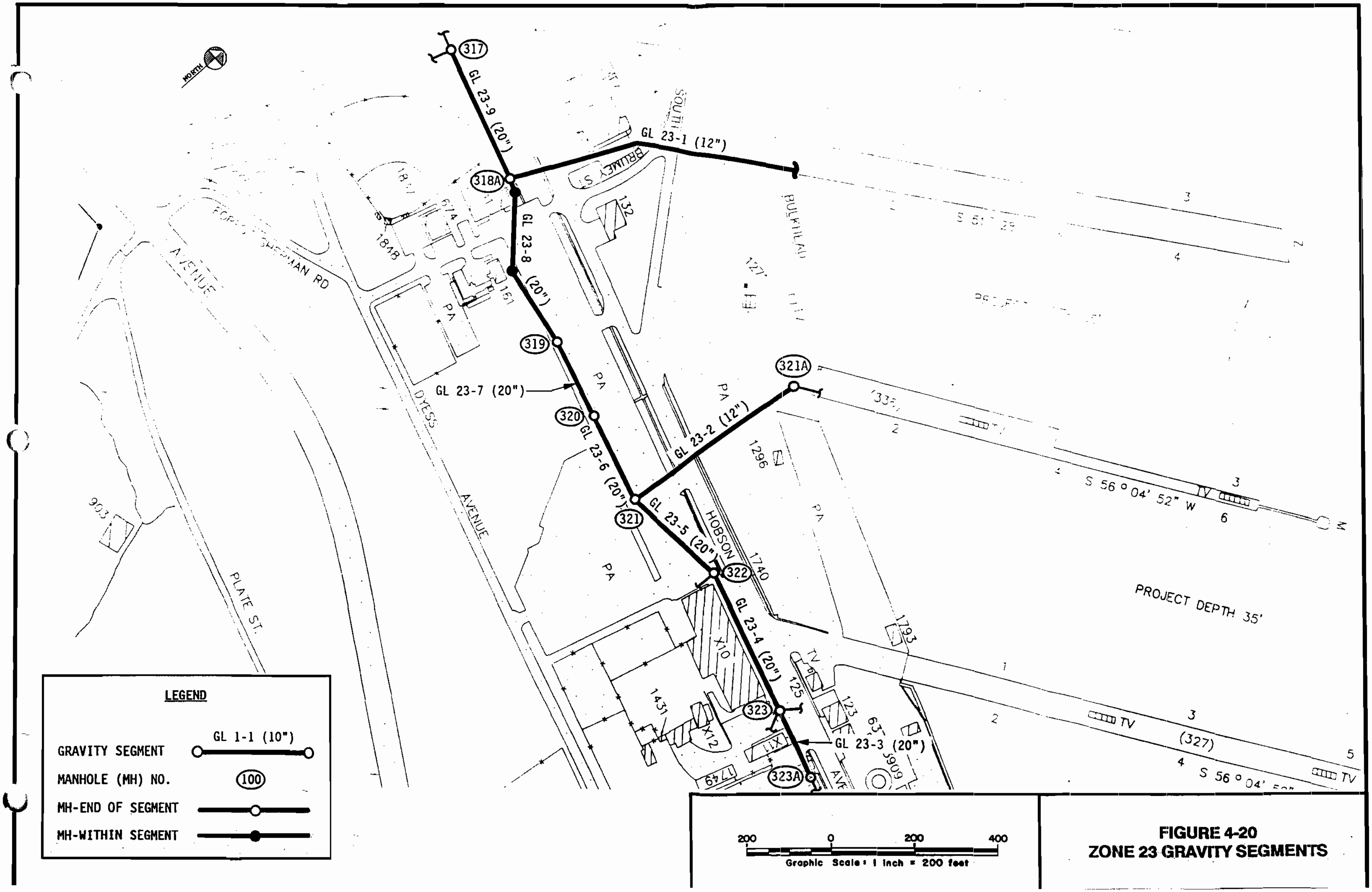


FIGURE 4-20
ZONE 23 GRAVITY SEGMENTS

Zone 24

Most of the Zone 24 gravity segments, which serve Piers "N", "P", and "Q", are under capacity. The exception is the 20-inch GL 24-8, part of the Naval Station trunk line. This segment is currently near capacity and is projected to reach capacity by 2000. Improvements for GL 24-8 are presented at the end of this chapter.

TABLE 4-19 ZONE 24:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 24-1	12	-	323B	0.772*	0.053	7	0.055	7	0.058	8
GL 24-2	12	323M	323L	0.946	0.114	12	0.116	12	0.119	13
GL 24-3	12	323L	323K	0.772	0.114	15	0.116	15	0.119	15
GL 24-4	12	323K	323J	1.445	0.114	8	0.116	8	0.119	8
GL 24-5	16	323J	323E	1.663	0.170	10	0.174	10	0.179	11
GL 24-6	16	323E	323B	1.663	0.243	15	0.250	15	0.258	16
GL 24-7	12	-	323A	0.772*	0.302	39	0.311	40	0.321	42
GL 24-8	20	324	323A	2.132*	1.832	86	2.109	99	2.306	108

*Minimum slopes of 0.0020 for GL 24-1 and GL 24-7 and 0.0010 for GL 24-8 were assumed due to lack of information in the manhole index.

Zone 25

As shown in Table 4-20, most of the trunk line gravity segments in this zone are nearing their capacities. Four of the six lines are expected to be over capacity by 2000. Improvements for Zone 25 gravity lines are presented at the end of this chapter.

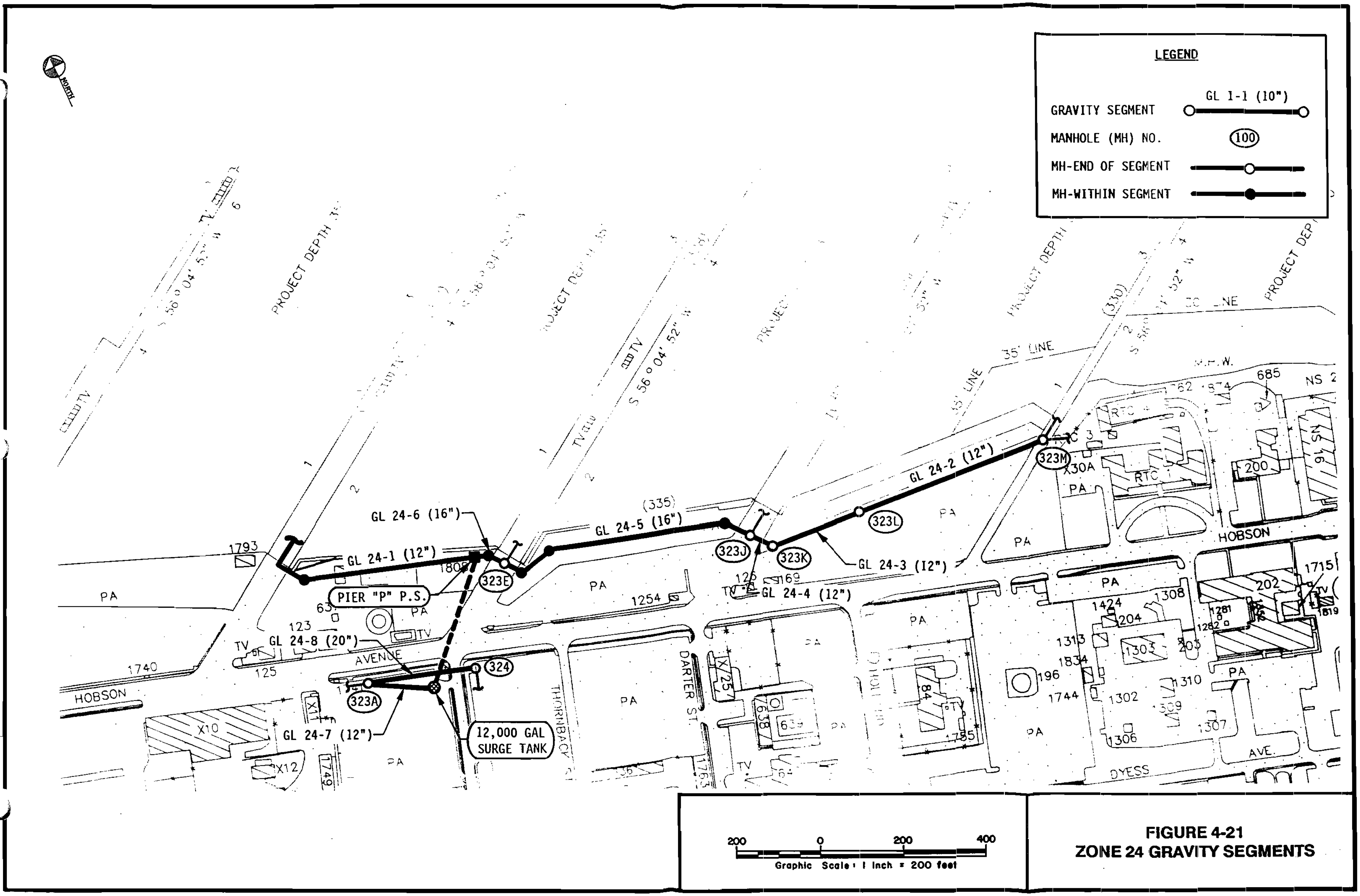
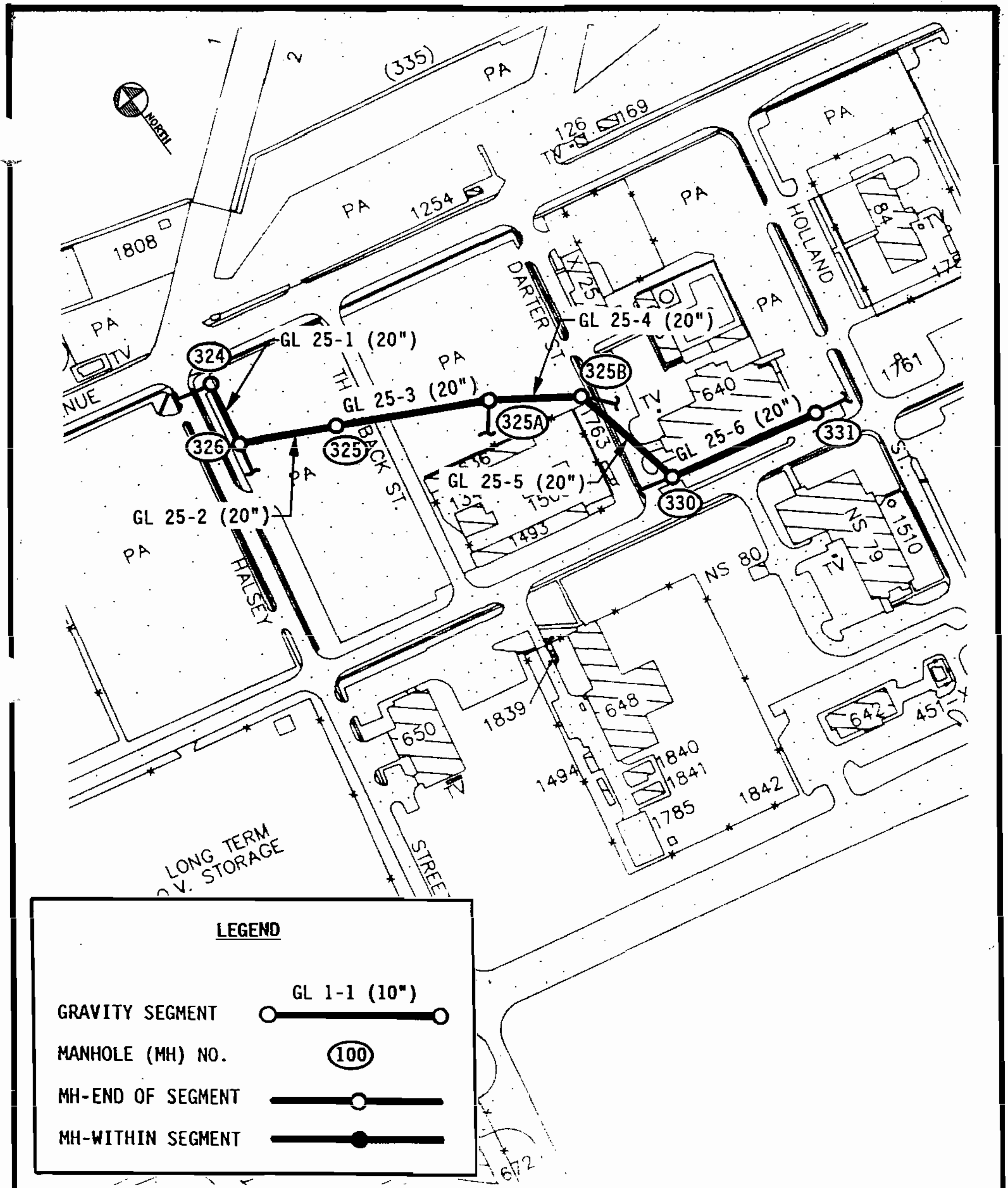


FIGURE 4-21
ZONE 24 GRAVITY SEGMENTS



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Graphic Scale: 1 inch = 200 feet

FIGURE 4-22
ZONE 25 GRAVITY SEGMENTS

TABLE 4-20 ZONE 25: GRAVITY LINE CAPACITY ANALYSIS										
Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990		1995		2000	
					Peak Flow	% Cap.	Peak Flow	% Cap.	Peak Flow	% Cap.
GL 25-1	20	326	324	2.697	1.832	68	2.109	78	2.306	86
GL 25-2	20	325	326	2.023	1.830	90	2.107	104	2.304	114
GL 25-3	20	325A	325	1.784	1.830	103	2.107	118	2.304	129
GL 25-4	20	325B	325A	2.336	1.824	78	2.101	90	2.297	98
GL 25-5	20	330	325B	2.023	1.786	88	2.088	103	2.262	112
GL 25-6	20	331	330	2.023	1.650	82	1.923	95	2.117	105

Zone 26

With the exception of GL 26-4 (the 12-inch DI line that serves the Fire Training Facility oil separator), all Zone 26 gravity segments are expected to be over capacity by the year 2000. These lines are part of the 20-inch trunk line along Dyess Avenue. Recommended improvements for these segments are discussed at the end of this chapter.

TABLE 4-21 ZONE 26: GRAVITY LINE CAPACITY ANALYSIS										
Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990		1995		2000	
					Peak Flow	% Cap.	Peak Flow	% Cap.	Peak Flow	% Cap.
GL 26-1	18	334	334A	1.764	1.347	76	1.614	91	1.802	102
GL 26-2	18	334A	333	1.527	1.461	96	1.734	114	1.919	126
GL 26-3	18	333	332	1.527	1.465	96	1.738	114	1.924	126
GL 26-4	12	-	334A	0.772*	0.150	19	0.158	20	0.165	21

*The minimum slope of 0.0020 was assumed for GL 26-4 due to a lack of information in the manhole index.

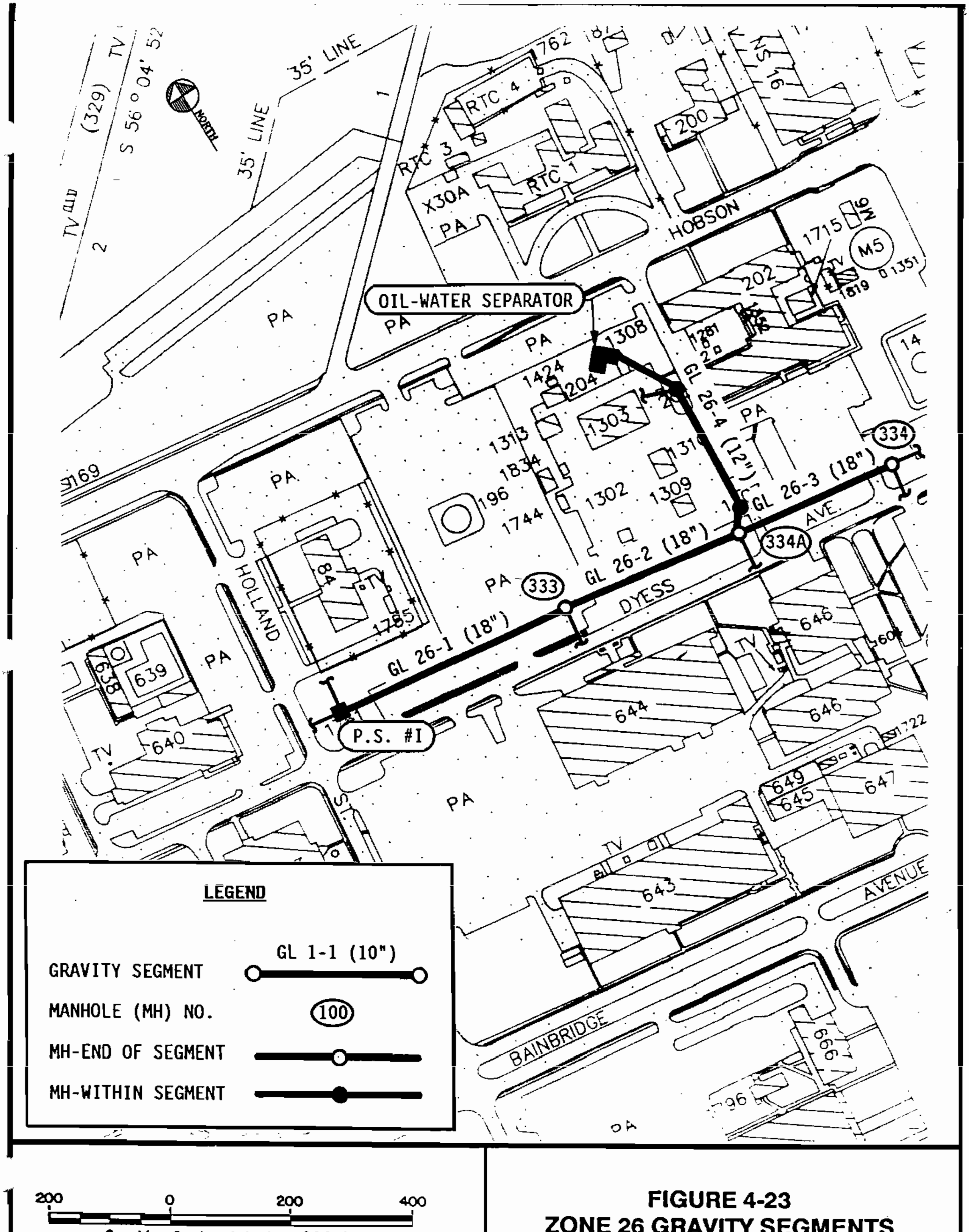


FIGURE 4-23
ZONE 26 GRAVITY SEGMENTS

Zone 27

Major gravity segments in Zone 27 consist of seven 10 and 16-inch DI gravity lines. As shown in Table 4-22, peak flows in these lines are expected to be within capacities through the year 2000.

TABLE 4-22 ZONE 27:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 27-1	12	366D	366	0.733	0.357	49	0.372	51	0.516	70
GL 27-2	16	366	365	1.440	0.419	29	0.436	30	0.582	40
GL 27-3	10	379	378	0.646	0.021	3	0.022	3	0.023	4
GL 27-4	10	378	377	0.475	0.021	4	0.022	5	0.023	5
GL 27-5	10	377	365	0.562	0.021	4	0.022	4	0.023	4
GL 27-6	16	365	334	1.341	0.446	33	0.464	35	0.611	46
GL 27-7	16	335	334	1.341	0.702	52	0.939	70	0.972	72

Zone 28

Zone 28 gravity segments include three 10-inch DI lines. As shown in Table 4-23, GL 28-3 is expected to be near its capacity by 2000. However, due to the length of this line (approximately 50 feet) and the low utilization of the lines on either end of GL 28-3 (less than 80 percent in 2000), no improvements are necessary.

TABLE 4-23 ZONE 28:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 28-1	10	370A	370	0.520	0.251	48	0.260	50	0.399	77
GL 28-2	10	370	368	0.541	0.275	51	0.286	53	0.426	79
GL 28-3	10	368	366D	0.531*	0.357	67	0.372	70	0.516	97

*The minimum slope of 0.0025 was assumed for GL 28-3 due to a lack of information in the manhole index.

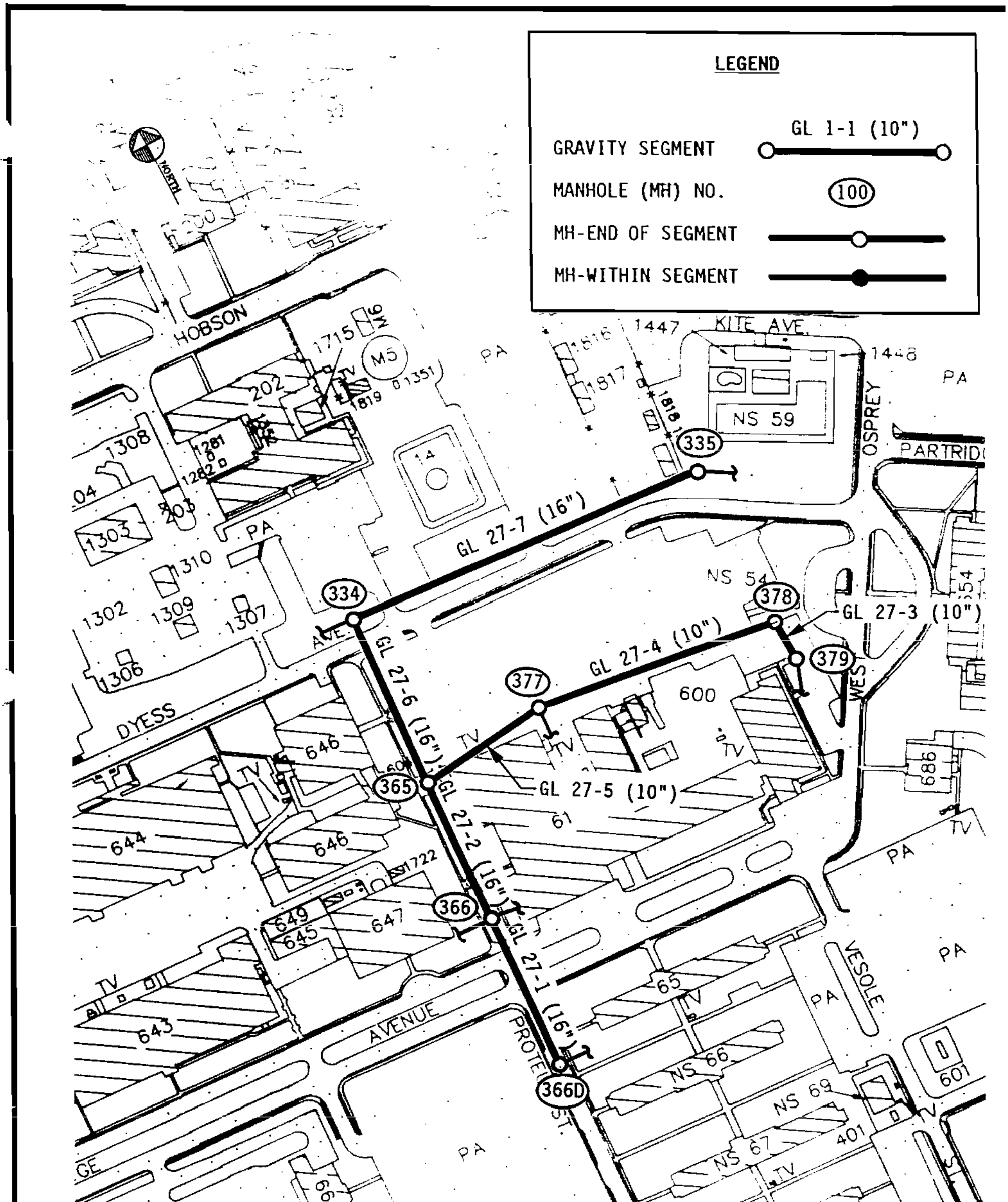


FIGURE 4-24
ZONE 27 GRAVITY SEGMENTS

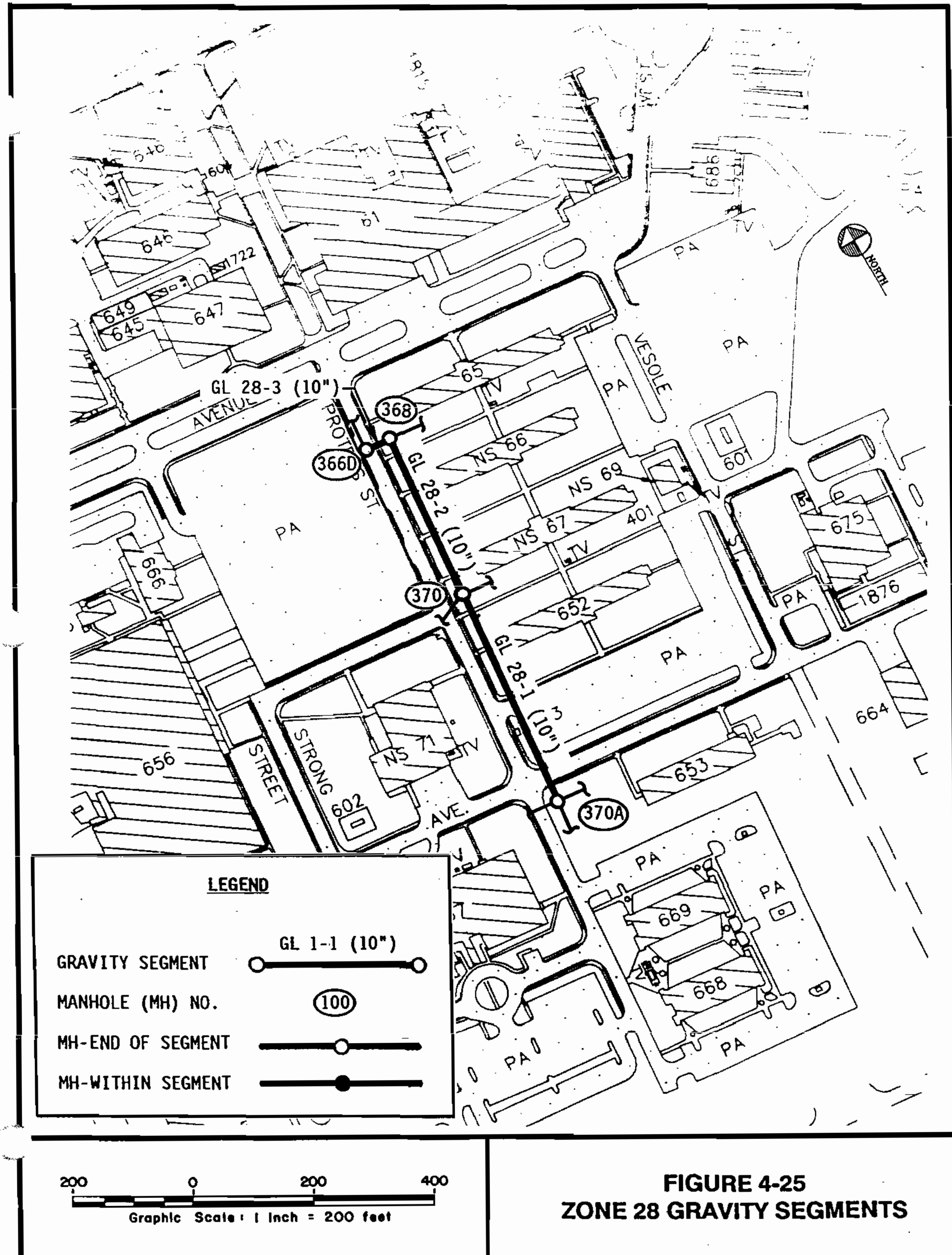


FIGURE 4-25
ZONE 28 GRAVITY SEGMENTS

Zone 29

The three major gravity segments in Zone 29 are 10- and 12-inch DI lines that serve Piers "S", "T" and "U". All of the lines are presently flowing under capacity, and this should continue through 2000.

TABLE 4-24 ZONE 29:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 29-1	10	323R	323N	0.688	0.017	2	0.017	2	0.017	2
GL 29-2	10	323U	323T	0.541	0.034	6	0.035	6	0.036	7
GL 29-3	10	323T	323S	0.822	0.034	4	0.035	4	0.036	4
GL 29-4	10	323S	323N	0.772*	0.031	4	0.032	4	0.032	4

*The minimum slope of 0.0020 for GL 29-4 was assumed due to a lack of information in the manhole index.

Zone 30

Major gravity segments in this zone consist of two 16-inch DI lines that are part of the Naval Station trunk line. Both lines should remain under capacity through 2000.

TABLE 4-25 ZONE 30:GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 30-1	16	336	335A	1.440	0.539	37	0.773	54	0.803	56
GL 30-2	16	335A	335	1.341	0.702	52	0.939	70	0.972	72

Zone 31

The five major gravity segments in Zone 31 are presently under capacity. As shown in Table 4-26, peak flows in the lines should remain at less than 50% capacity through 2000.

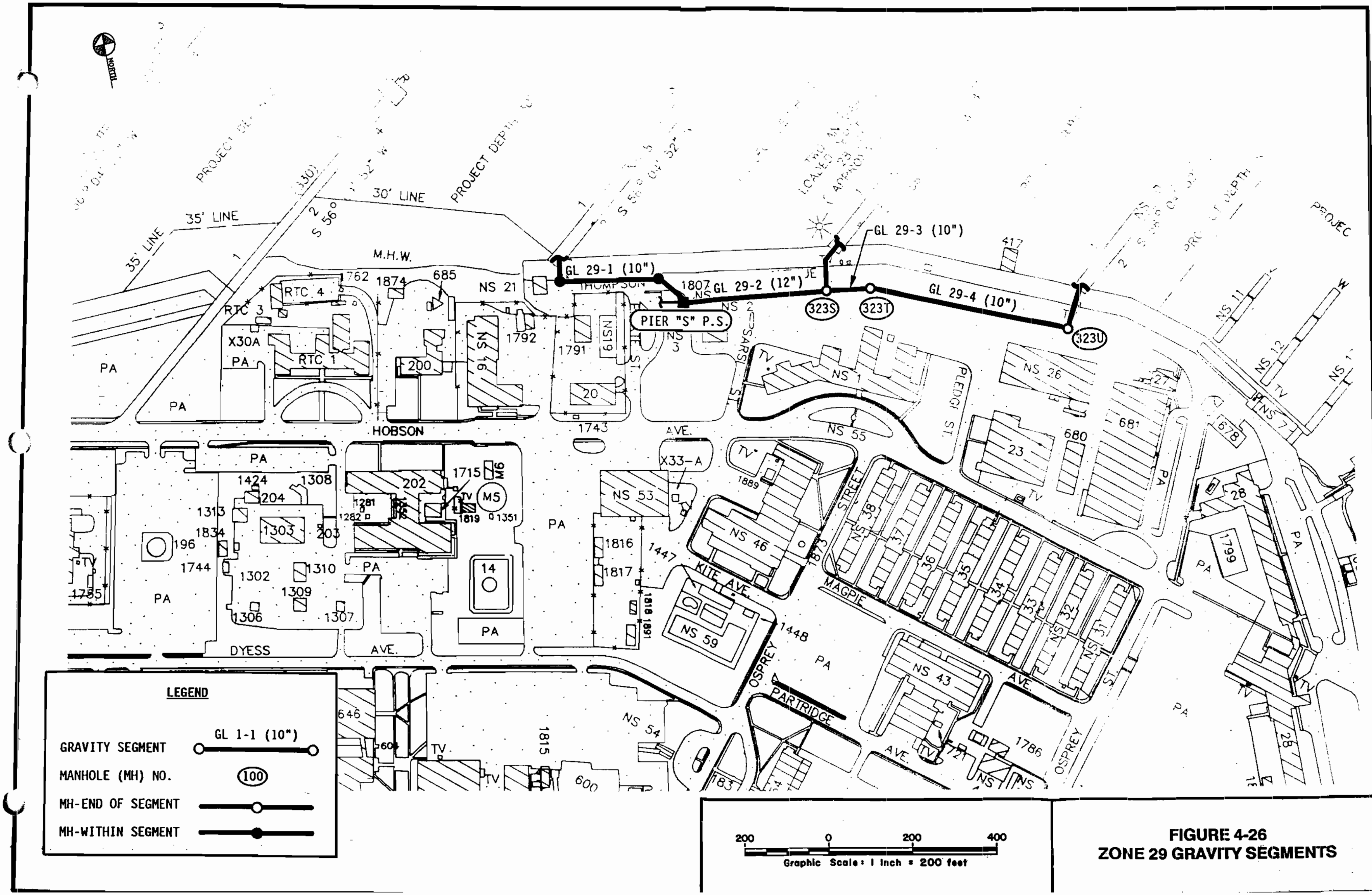
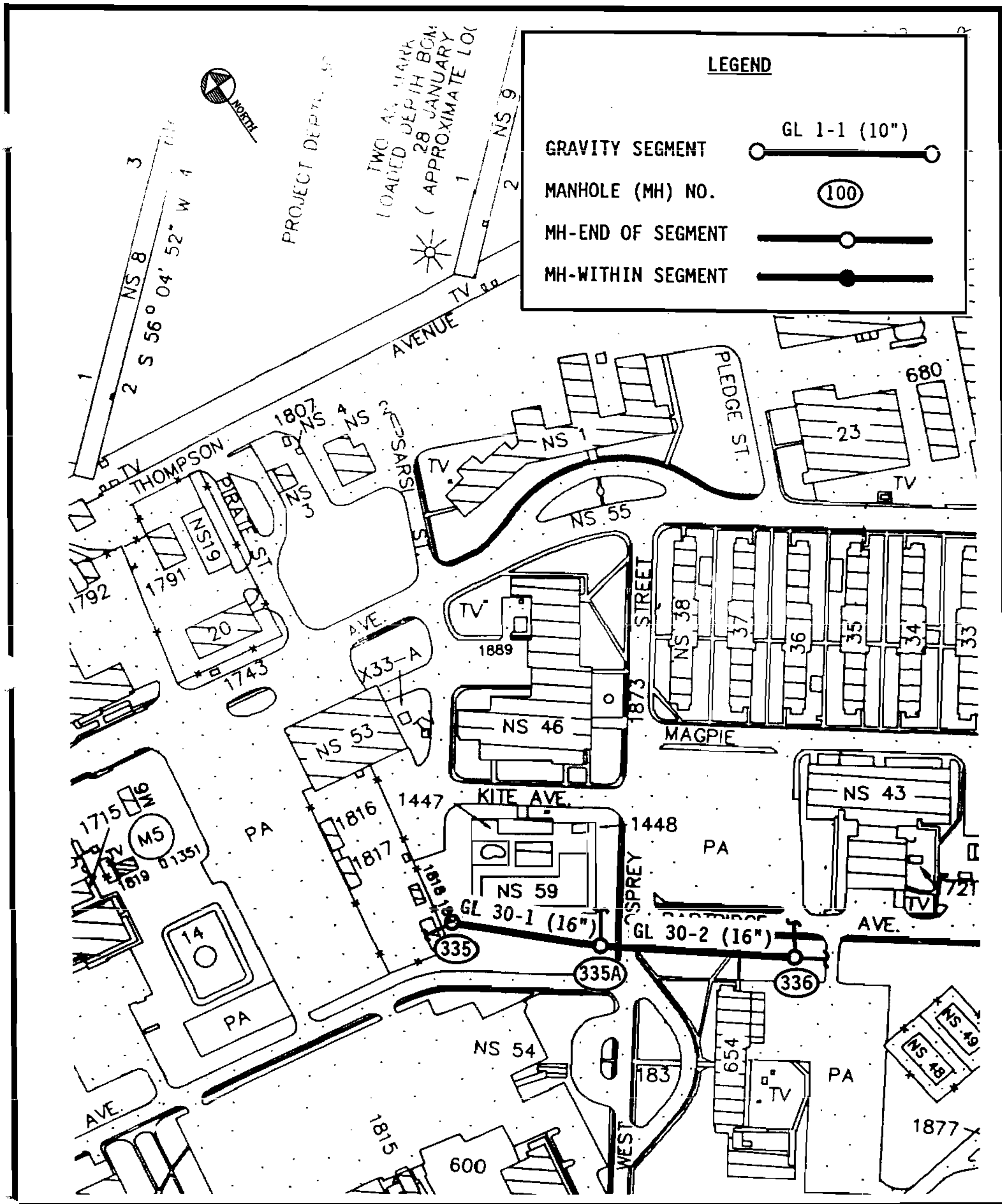


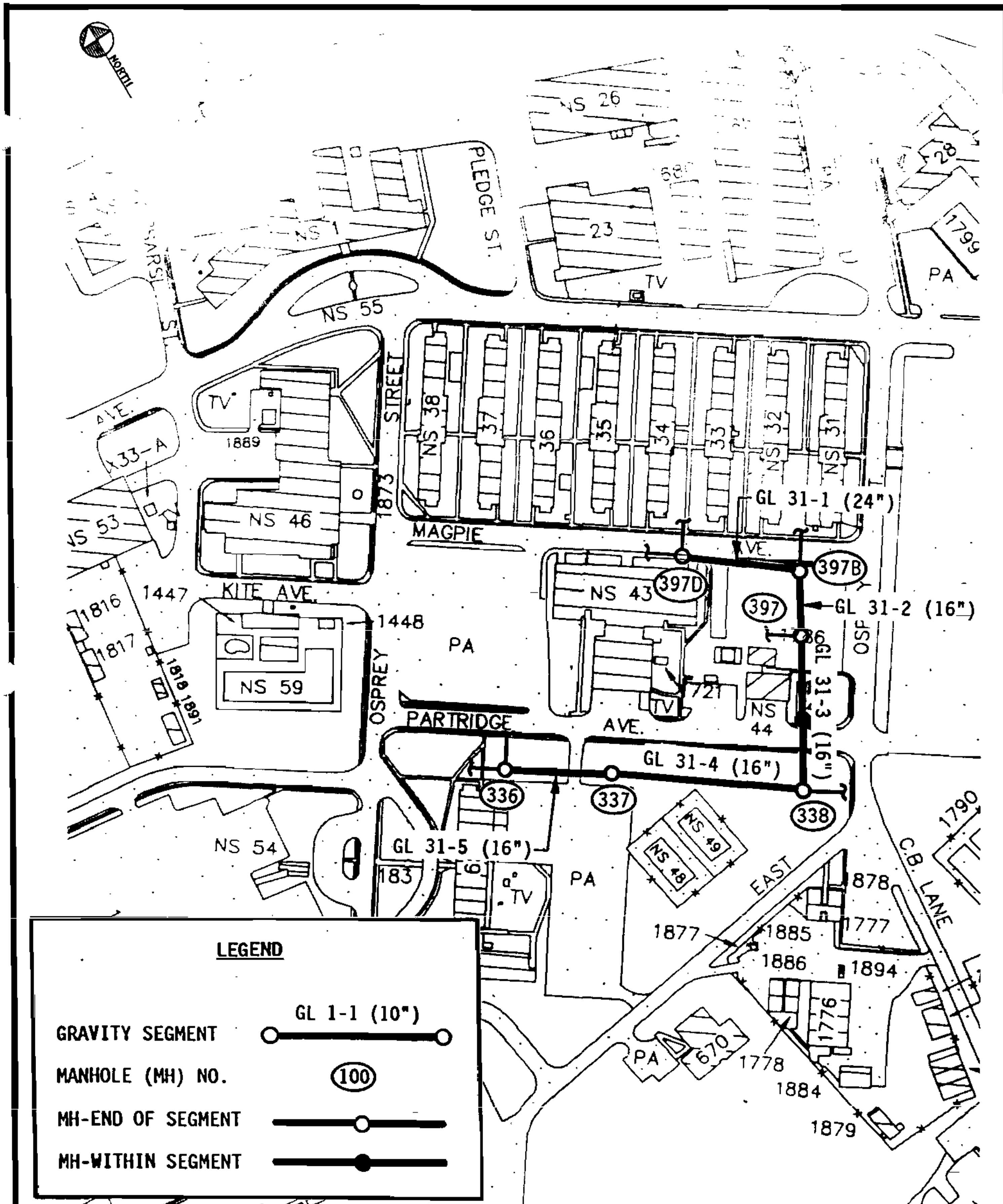
FIGURE 4-26
ZONE 29 GRAVITY SEGMENTS



200 0 200 400

Graphic Scale: 1 inch = 200 feet

FIGURE 4-27
ZONE 30 GRAVITY SEGMENTS



LEGEND

GRAVITY SEGMENT — GL 1-1 (10")

MANHOLE (MH) NO. — 100

MH-END OF SEGMENT

MH-WITHIN SEGMENT

200 0 200 400

Graphic Scale: 1 inch = 200 feet

FIGURE 4-28
ZONE 31 GRAVITY SEGMENTS

TABLE 4-26 ZONE 31: GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 31-1	24	397D	397B	3.101*	0.173	6	0.179	6	0.185	6
GL 31-2	16	397B	397	1.487	0.199	13	0.206	14	0.212	14
GL 31-3	16	397	338	1.391	0.206	15	0.213	15	0.221	16
GL 31-4	16	338	337	1.288	0.338	26	0.548	43	0.569	44
GL 31-5	16	337	336	1.487	0.338	23	0.548	37	0.569	38

*The minimum slope of 0.0008 for GL 31-1 was assumed due to a lack of information in the manhole index.

Zone 32

The only major gravity segment in Zone 32 is a 10-inch DI line that runs between Magpie Avenue and Partridge Avenue. As shown in Table 4-27, this line is flowing at less than 50% capacity, and this should continue through 2000.

TABLE 4-27 ZONE 32: GRAVITY LINE CAPACITY ANALYSIS

Segment	Diameter (in)	From MH	To MH	Capacity (mgd)	1990 Peak Flow	1990 % Cap.	1995 Peak Flow	1995 % Cap.	2000 Peak Flow	2000 % Cap.
GL 32-1	10	386	336	0.531*	0.193	36	0.217	41	0.226	43

*The minimum slope of 0.0025 for GL 32-1 was assumed due to a lack of information in the manhole index.

RECOMMENDED IMPROVEMENTS

There were several areas that have gravity lines near, or over, their capacities. To simplify this discussion of line improvements, the over-capacity gravity lines were divided into four groups:

- The Navy Hospital Line (Zone 14)
- The Shipyard Trunk Line (Zones 20-21)

FIGURE 4-29

- o The Naval Station Trunk Line (Zones 23-26)
- o The Naval Base Discharge Line (Zone 22).

The following is a discussion of each of the four groups that are listed above.

Navy Hospital Line

Because the two near-capacity segments in Zone 14 are presently flowing at approximately 90% full during peak flow, these lines should be monitored to ensure that surcharging is infrequent. Because the capacity analysis in Table 4-10 projects that both of these segments will be near 100% capacity by 2000, there will be a need to upgrade sewer service within the zone. This would be especially important if Navy Hospital facilities are expanded.

Shipyard Trunk Line

As shown in Tables 4-15 and 4-16, the trunk line from MH 70A (near Building 98) to MH 72 (near the intersection of Hobson Avenue and Thirteenth Street) will be near its capacity by the year 2000.

The Shipyard gravity line rehabilitation measures that are suggested in Chapter 3, however, should reduce I/I flows enough that the estimated peak flows would not be reached. Thus, the need for line upgrading could be eliminated. It is recommended that this line be monitored by Work Center 44 personnel during peak periods to ensure its adequacy. Should surcharging be common, line upgrading is recommended.

Naval Station Trunk Line

As shown in Tables 4-17 through 4-21, the entire Naval Station trunk line from MH 334A to MH 73 is expected to be over capacity by 2000. Many segments are presently over capacity. In the gravity sewer line evaluation of Chapter 3, it is noted that much of this trunk line was flowing completely full at the time of manhole inspections, which confirms the figures in Table 4-17 through 4-21.

One concern regarding this trunk line is the 1993 addition of the Submarine Berthing Pier near Pier "Y". The line cannot handle the additional (estimated) 60,000 gpd flow that the pier will generate. However, the remainder of the trunk line upstream of MH 334A (the trunk line terminates at MH 339) should have sufficient capacity to allow the additional load from the new pier.

Based on the information gathered for this study, there are four viable alternatives for improving the condition of the Naval Station trunk line. All four assume the Submarine Berthing Pier will be connected to the existing trunk line at MH 338. The alternatives are as follows:

- Alternative No. 1: The trunk line upstream of MH 334A can be upgraded to meet the present and future flow demands. Due to the depth and layout of this line, this alternative would likely be the most costly of the four.
- Alternative No. 2: A new gravity line could be installed from some point on Dyess Avenue directly to the NCSD pump station. Pump Station No. 1 can be upgraded (an improvement suggested in Chapter 5) and its force main extended to discharge into the new gravity line. This would require that the 700-foot line

between MH 334A and Pump Station No. 1, projected to be over capacity by 1995, be upgraded. This alternative is favorable for four reasons: 1) all flow upstream of Pump Station No. 1 would be diverted from the existing 20-inch trunk line, allowing it to flow within capacity; 2) all new facilities (including the Pump Station No. 1 upgrade) could be sized to handle future flows, including that from the new pier; 3) by transporting much of the Naval Station flow directly to the NCSD pump station, the 30-inch Naval Base discharge line, presently over capacity, could then handle its peak flow demands; 4) construction of the new force main and gravity sewer would be performed within a relatively uncongested area.

- <u>Alternative No. 3</u>: This alternative is similar to No. 2, except that a force main would be extended from Pump Station No. 1 directly to the NCSD pump station. The cost of this alternative would be significantly lower than No. 2; however, the proposed gravity line of Alternative 2 would offer more dependable service for serving growth in the Bainbridge Avenue - Dyess Avenue area.

- <u>Alternative No. 4</u>: A new pump station would be constructed in the vicinity of MH 334A, discharging into a new gravity line on Dyess Avenue. This gravity line would be the same line as discussed in Alternative No. 2. Upon completion of the new pump station, Pump Station No. 1 could be abandoned. One advantage of this alternative is that the need to upgrade the line between MH 334A and Pump Station No. 1 is eliminated.

Also, all of the advantages listed for Alternative No. 2 would apply.

Based on preliminary observations, Alternative No. 3 is the most feasible option, due mainly to lower cost of construction.

The proposed sewage flow meter and flume in the 30-inch base discharge line must also be taken into account. Alternatives 2, 3 and 4 would bypass the new meter, which is being installed to measure total Naval Base flow. Hence, any lines bypassing the Base discharge line must be equipped with some type of flow monitoring device, to ensure that all flow from the base is metered. Siting the metering flume to accommodate the existing and possible future line layout would require extensive line re-alignment due to the influent piping configuration at the Navy Yard pump station.

Naval Base Discharge Line

This 30-inch line will be over capacity by 2000, as shown in Table 4-17. The line is presently near its capacity; flow observations during the gravity sewer evaluation have confirmed that estimate.

Public Works has suspected for several years that the Base discharge line contained a bend between Manholes 73-D and 73-C not indicated on Base drawings. Field investigation confirmed that suspicion. It appears that this line segment contains two 45^{0} bends. The downstream bend is at the inlet to Manhole 73-C. The upstream bend can be located by following the tangent through Manhole 73-D downstream, approximately 80 feet. That point is approximately 30′ upstream of the bend at Manhole 73-C. It should also be noted that the short gravity segment, between Manhole 73-C and the pump station, increases to 36-inch pipe.

No improvements are recommended for the Naval Base discharge line. Instead, the previously discussed Naval Station and Shipyard trunk line improvements should reduce the peak flows through the line and allow it to remain within capacity.

SUMMARY

In this chapter, the capacities of all 10-inch and larger gravity sewers were discussed. It was found that most gravity lines are handling flows that are within their capacities. However, gravity segments in four areas - the Navy Hospital, the Shipyard trunk line, the Naval Station trunk line, and the Naval Base discharge line - were found to be near or over capacity. Though three of these four segments probably do not require a line-size increase, recommendations for increasing capacity of the Naval Station trunk line are outlined.

CHAPTER 5

PUMP STATION EVALUATIONS

INTRODUCTION

The overall condition of the gravity sewer lines was discussed in Chapters 3 and 4. In order to perform a corresponding evaluation of the conditions of the system's pump stations, an engineering inspection was conducted on each station to determine structural, mechanical, electrical and hydraulic characteristics. Consultation with utilities personnel in the Shipyard Public Works Department provided a history of maintenance on each pump station.

The sewer system consists of 22 sewage pump stations, two of which are located on piers and fall outside the scope of this study. Of the 20 that were inspected, fourteen are the wet well-dry well type, five are submersible, and one is the aboveground type. The stations range anywhere from 3 to 15 years old, and their actual capacities vary from 20 to 3,050 gallons per minute (gpm). Figures 5-1 and 5-2 show the locations of the 20 pump stations evaluated.

Pumping rates are also a function of force main characteristics. Naval Base force mains vary from 3 to 16 inches in diameter, and from 30 to 2500 feet in length.

This chapter presents a station-by-station discussion of deficiencies found in the evaluations. Pump station capacities will be compared to their estimated peak flows to judge which stations are at or near their capacities.

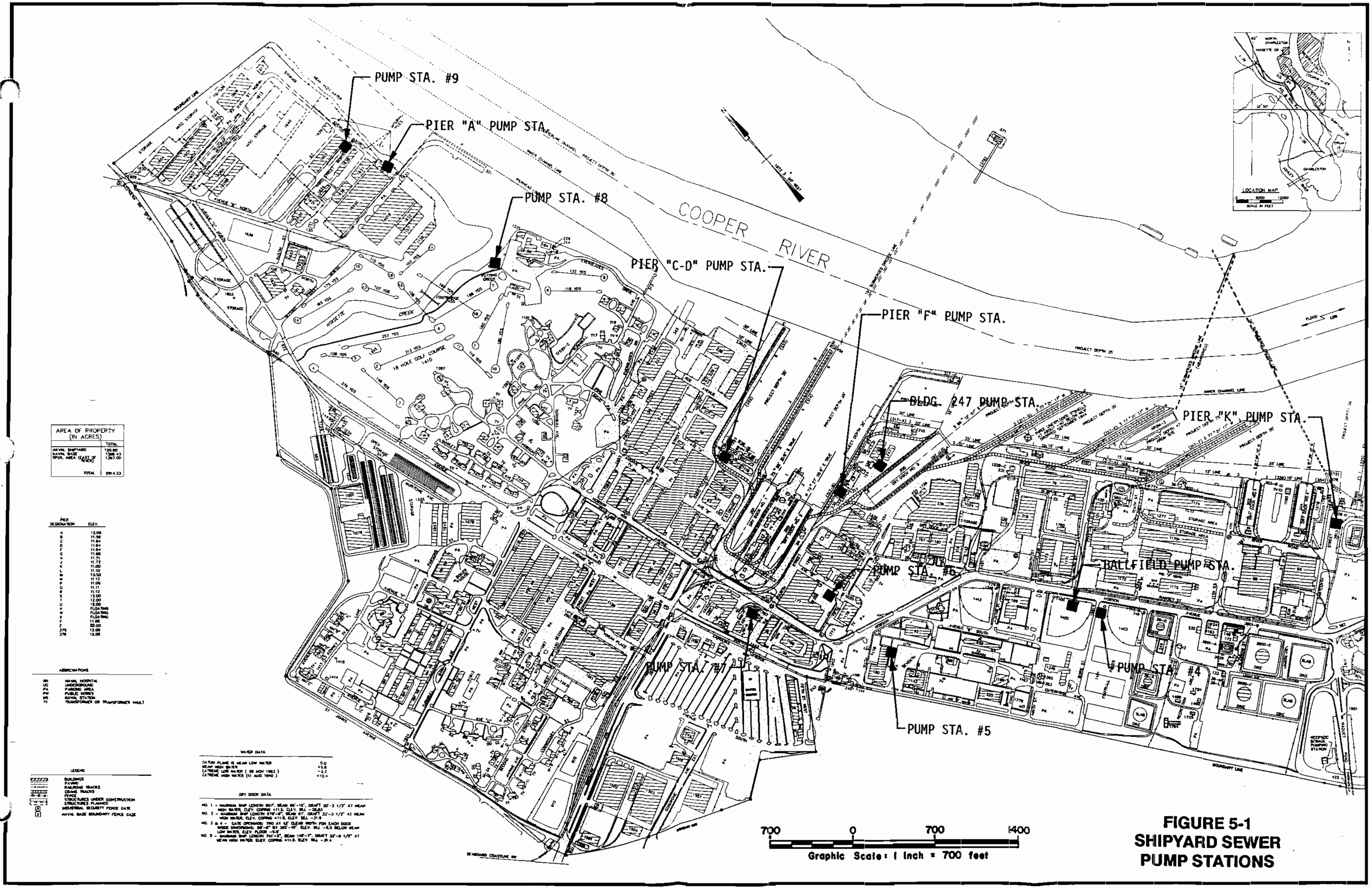


FIGURE 5-1
SHIPYARD SEWER
PUMP STATIONS

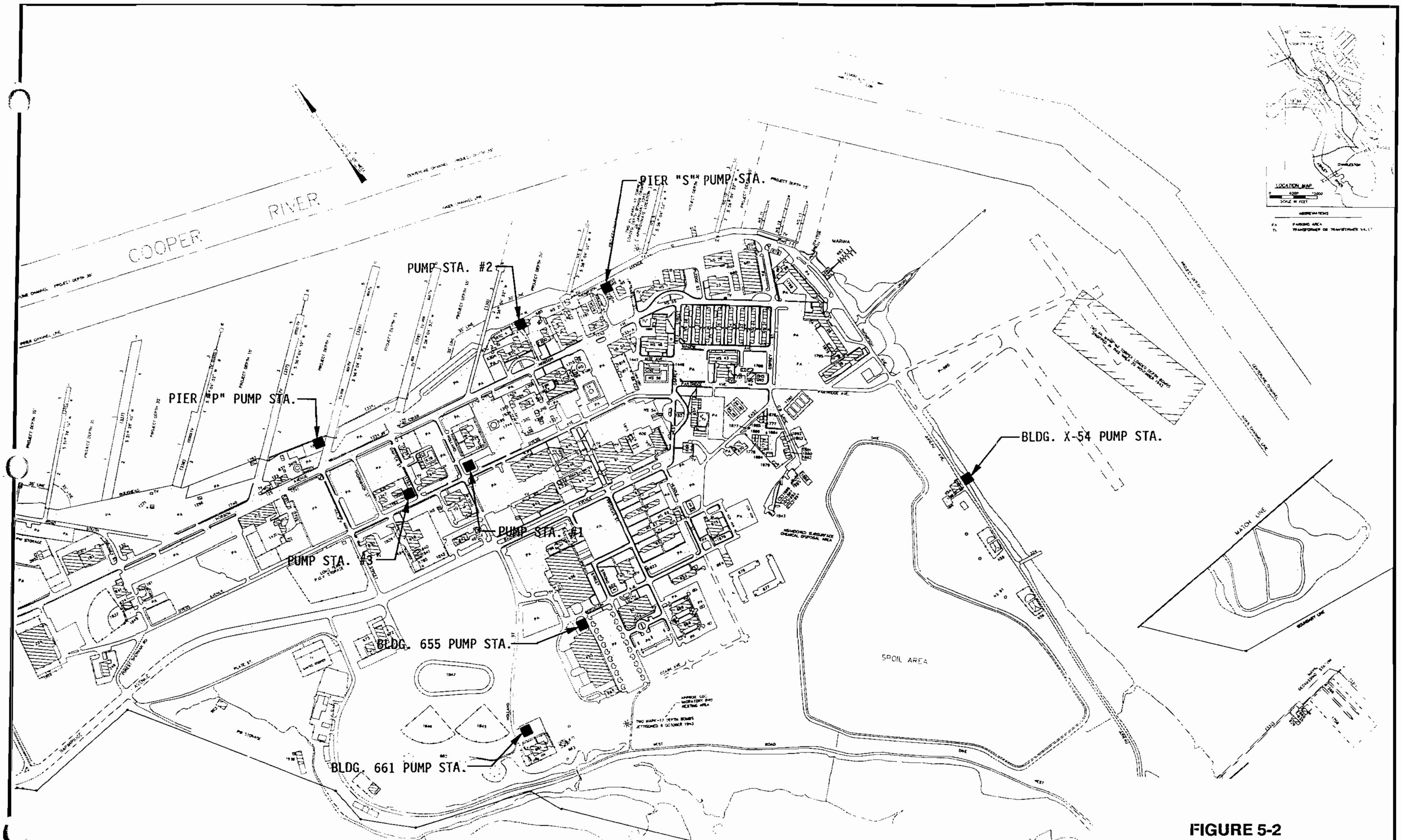


FIGURE 5-2
NAVAL STATION SEWER PUMP STATIONS

METHODOLOGY

All 20 pump stations were individually inspected in order to observe their physical characteristics. Structural, mechanical and electrical deficiencies were noted and are discussed herein. In addition, pumping rates were determined using pump drawdown tests, and those rates have been compared to estimated flows entering the pump stations to indicate which stations are at or near their capacities. Pump test calculation sheets are included in Appendix "D".

Table 5-1 presents the pumping characteristics of all 20 pump stations evaluated in this study. These characteristics were determined by the pump station inspections, pump tests, consultation with Shipyard Public Works personnel, and Shipyard file drawings. Actual capacities are those ascertained by the pump tests, and are they presented in Table 5-1 as minimum and maximum capacities. Minimum capacities are the station pumping rates with the largest pump out of service. Maximum capacities are pumping rates with all pumps operating simultaneously.

Pump station evaluations describe deficiencies noted at each pump station. A capacity analysis for each pump station is included. Actual flows through each pump station were estimated using information from the wastewater flow estimates from Chapter 2. Projected flows were compared to pump run-time records to verify that estimates were within an acceptable range. Calculations used in determining these flows are included in Appendix "E".

LIMITATIONS

The major limitation to this evaluation is lack of area-specific flow data to base flow estimates on. Flow estimates were required in determining peak flows and, consequently, assessing the capability of individual pump stations to handle those peaks.

Additionally, a comparison of current pumping rates with design rates would be helpful. However, reliable design information could not be found. Work Center 44 personnel indicate that available design information is not usable due to pump change-out and other system modifications.

GENERAL DEFICIENCIES

Wet Well-Dry Well Pump Stations

Several deficiencies were found to be common in wet well-dry well type pump stations. To avoid repetition, these general problems will be discussed prior to a station-by-station description of deficiencies.

Several of the wet well-dry well stations have experienced dry well flooding due to electrical failures and resulting overflows. Piers "K", "P", and "S" pump stations have experienced this problem most frequently, and since all electrical equipment - pump motors, electrical control panel, sump pump, dehumidifier - is located in the dry wells, much of this equipment must be periodically replaced due to water damage. The stations normally require several hundred man-hours of repair work to correct the problems, and by-pass pumping must be initiated during repairs. In some cases, total equipment replacement has been necessary.

TABLE 5-1: NAVAL BASE SEWER PUMP STATIONS

Station	Type	No. Pumps	Capacity (gpm) Min.	Capacity (gpm) Max.	Force Main Ln.(ft)	Force Main Dia.(in)
No. 1	Wet Well-Dry Well	3	900	1,375	130	10
No. 2	Wet Well-Dry Well	2	100	200	270	4
No. 3	Wet Well-Dry Well	2	125	200	50	4
No. 4	Wet Well-Dry Well	3	2,725	3,050	850	16
No. 5	Wet Well-Dry Well	2	250	300	200	6
No. 6	Wet Well-Dry Well	2	225	400	120	6
No. 7	Wet Well-Dry Well	3	1,275	1,825	100	12
No. 8	Wet Well-Dry Well	2	75	90	930	4
No. 9	Wet Well-Dry Well	2	20	30	2,500	4
Pier "A"	Submersible	2	N/A	N/A	30	1.5
Pier "C-D"	Submersible	1	350	350	40	4
Pier "F"	Wet Well-Dry Well	2	800	1,075	1,200	8
Pier "K"	Wet Well-Dry Well	2	525	525	50	8
Pier "P"	Wet Well-Dry Well	2	1,250	1,250	300	12
Pier "S"	Wet Well-Dry Well	2	425	550	1,200	8
Bldg. X-54	Submersible	2	100	200	1,400	3
Bldg. 655	Aboveground	2	30	200	550	8
Bldg. 661	Submersible	2	145	170	1,360	4
Bldg. 247	Submersible	2	25	125	350	4
Ballfield	Submersible	2	950	1,675	230	12

*NOTE: Two additional pump stations are located on piers and were excluded from this study.

Electrical failure that leads to pump station flooding is normally due to one of two causes: 1) a faulty electrical component causing pump shutdown, or 2) a buildup of grease and oil on the pump-on float, preventing the float from initiating pumping at the desired level.

Force Mains

Several force mains are known to be corroded and/or restricted due to oil and grease accumulation on the pipe walls. Either condition increases friction loss through the pipe, resulting in decreased pumping rates. That fact makes it difficult to determine whether reduced pumping rates are due to pump problems, force main problems, or some combination of the two.

GENERAL RECOMMENDATIONS

Wet Well-Dry Well Pump Stations

The client should consider replacing wet well-dry well type pump stations with submersible pumps. This is particularly advisable for pump stations at Piers "K", "P", and "S", which flood frequently. In addition, as Pump Station Nos. 1 and 9 may require upgrading or replacement (discussed later in this chapter), submersible pump installations are recommended in those stations. Replacement would generally involve modifying or replacing the existing wet wells and abandoning the dry wells.

Replacement of wet well-dry well stations with submersible stations is advantageous for several reasons: 1) if pump failure occurs, no equipment damage results from flooding, 2) station replacement would, over a period of years, likely be less expensive than the cost of maintenance and repairs on wet well-dry well stations (the exact cost of these repairs cannot be ascertained because repair records and costs are not kept), 3) maintenance and routine inspections of the pump stations would be much more convenient (submersible pumps can be removed without entering the wet well), and 4) no dry well entry required (entry is hazardous due to the possible presence of hydrogen sulfide, methane, carbon monoxide, or other dangerous gases). Work Center 44 maintains that the present submersible pump stations are more efficient and require less maintenance than the wet well-dry well stations. There are also benefits to standardization of equipment.

One functional improvement recommended for all wet well-dry wells stations is the relocation of electrical control panels to the outside of the station. Mounting the panels aboveground in weathertight boxes is desirable for several reasons: 1) in the event of wet well flooding, no damage to the control panel (a very expensive item) would result, 2) wet well entry would not be required for weekly preventative maintenance checks, and 3) maintenance and inspections of the electrical components would be more convenient.

All Pump Stations

At least one Base pump station (Station 7) has level-control floats set above gravity inlets due to turbulence created when floats are set lower. This practice guarantees continuous surcharge. Public Works should investigate switching to a level-control system not affected by turbulence or oil and grease accumulation. A stilling well for floats designed to prevent entry of oil and grease may be feasible and would allow lowering floats, eliminating the continuous surcharge.

Additionally, failure of check and gate valves is common, generally due to corrosion. Public Works should investigate the availability of corrosion-resistant valves and appurtenances and use them accordingly. Valves should be removed from wet well and placed in adjacent valve pits wherever possible.

Force Mains

Pressure cleaning (Pigging) of force mains suspected to be deficient should be considered. Pigging is has become quite common for line-cleaning and can usually be done at a fraction of the cost of line replacement. The Shipyard Public Works Department should consider training utilities personnel in pigging procedures and incorporating periodic force main pigging into preventative maintenance practices. General information on pigging is provided in Appendix F.

INDIVIDUAL PUMP STATION EVALUATIONS

Pump Station No. 1

Pump Station No. 1 is located off Dyess Avenue near Building 84. The only physical deficiency noted during the inspection of this station was a slight leak in discharge line check valves which, according to Work Center 44 personnel, is a routine problem in this pump station.

Work Center 44 personnel say that this wet well surcharges during heavy rains. The presence of oil and heavy trash (cans, bottles, etc.) is common in the wet well (aluminum cans have been found around pump impellers). The debris is introduced by numerous upstream storm sewer cross-connections and service to facilities that discharge oil and grease. These problems are discussed in detail in Chapter 3.

The discharge force main from Station 1 is suspected to be impaired due to corrosion and build-up on the pipe walls. Pigging is recommended to restore line capacity.

TABLE 5-2:PUMP STATION NO. 1 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
1,296,000	1,980,000	1,464,600	113	74	1,557,600	120	79	1,743,750	135	88
(900 gpm)	(1375 gpm)									

Current estimated peak flows at Pump Station No. 1 are over minimum capacity. By the year 2000, they will be near maximum capacity. Because most of these peak flows can be attributed to I/I, the improvements recommended in Chapter 3 should alleviate some peak sewer loads. However, upon correction of line deficiencies upstream of the pump station, Work Center 44 personnel should monitor the station after heavy rains to verify that wet well surcharging does not occur. If surcharging is still present, upgrading of pumps may be necessary.

Pump Station No. 2

Pump Station No. 2 is located behind Building RTC-1, between Piers "R" and "S". This station has an overflow in the wet well that, having lost the seal of a wooden plug, is allowing water from the Cooper River into the wet well at high tide. This overflow should be replugged or permanently taken out of service.

TABLE 5-3:PUMP STATION NO. 2 CAPACITY ANALYSIS										
Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
144,000	288,000	17,200	12	6	18,100	13	6	18,900	13	7
(100 gpm)	(200 gpm)									

Estimated peak flows through Pump Station No. 2 are well under the station capacity, and this should continue through the year 2000.

Pump Station No. 3

Pump Station No. 3 is located near the intersection of Dyess Avenue and Darter Street. Grease has built up in the wet well and is causing float malfunctions. The nearby McDonald's is the most likely source of grease. Grease build-up has apparently reduced the capacity of the discharge force main, as well. Pigging is recommended.

TABLE 5-4:PUMP STATION NO. 3 CAPACITY ANALYSIS										
Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
180,000	288,000	136,200	76	47	140,700	78	49	145,500	81	51
(125 gpm)	(200 gpm)									

Pump Station No. 3 should be able to handle peak flows through the year 2000.

Pump Station No. 4

Pump Station No. 4 is located on Hobson Avenue adjacent to Cochrane Field. This is the largest pump station in the Base sewer system. One structural deficiency in this pump station is a badly corroded floor, most likely due to the buildup of water caused by a sloping of the floor away from the sump pump. This floor should be repaired and sloped to drain to the sump. Check valve leakage is common in this station, and according to Work Center 44 personnel, requires periodic valve replacement.

TABLE 5-5: PUMP STATION NO. 4 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
3,924,000 (2725 gpm)	4,392,000 (3050 gpm)	2,680,700	68	61	2,824,500	72	64	2,889,900	74	66

Pump Station No. 4 should be able to handle peak flows through 2000.

Pump Station No. 5

Pump Station No. 5 is located outside the Sterret Hall Gym (Building 180). No major deficiencies were noted at this pump station.

TABLE 5-6: PUMP STATION NO. 5 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
360,000 (250 gpm)	432,000 (300 gpm)	124,500	35	29	138,000	38	32	144,000	40	33

Pump Station No. 5 should be able to handle peak flows through the year 2000.

Pump Station No. 6

Pump Station No. 6 is located in the CIA near Building 177. No major deficiencies were noted at this pump station.

TABLE 5-7: PUMP STATION NO. 6 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
324,000 (225 gpm)	576,000 (400 gpm)	131,100	40	23	135,300	42	23	139,800	43	24

Estimated peak flows are within minimum capacities for Pump Station No. 6. This should continue through 2000.

Pump Station No. 7

Pump Station No. 7 is located off Hobson Avenue near Building 30. One deficiency noted during the evaluation of this pump station is a buildup of grease and oil in the wet well that is hindering the station's level-control (float) system. Because of the large flow handled by this pump station, dry well flooding is a possibility due to float malfunctions.

TABLE 5-8: PUMP STATION NO. 7 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
1,836,000 (1275 gpm)	2,628,000 (1825 gpm)	2,016,900	110	77	2,134,500	116	81	2,178,600	119	83

Estimated peak flows through Pump Station No. 7 are over minimum capacity and are approaching maximum capacity. However, run-time data for this pump station indicates that the station is pumping within an acceptable range. Furthermore, overflows have not recently occurred in this station. Hence, no upgrades or improvements due to capacity constraints are recommended for this pump station; however, the station's pump run times should be monitored to ensure that they do not increase significantly. Pump run times will evidence when upgrade is advisable.

Pump Station No. 8

Pump Station No. 8 is located adjacent to Noisette Creek at the Shipyard Golf Course. Two deficiencies were noted upon inspection of this pump station. First, a wet well overflow to the nearby creek has a faulty check valve and allows river water into the wet well. This overflow should be sealed. Secondly, grease buildup in the wet well is causing float malfunctions and clogging of the force main. Public Works should consider purchasing "pigging" equipment and periodically cleaning this, and other, problem force mains.

TABLE 5-9:PUMP STATION NO. 8 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
108,000 (75 gpm)	129,600 (90 gpm)	103,500	96	80	103,500	96	80	105,000	97	81

Estimated peak flows through Pump Station No. 8 are near its minimum capacity. However, upon review of the station's pump run time records, it is apparent that estimated peak flows are rarely reached. Therefore, no upgrades are recommended for inside this station. The capacity of the discharge force main appears to be limited by corrosion and grease accumulation. Pigging is recommended.

Pump Station No. 9

Pump Station No. 9, located near Pier "A" in the Naval Supply Center, has serious deficiencies. Heavy infiltration in the gravity line upstream of the station (discussed in Chapter 3) has caused considerable sand buildup in the wet well. Approximately three feet of sand is in the wet well, and it severely restricts flow into the pumps. Secondly, the pumps are hydraulically impaired, probably due to worn impellers. Finally, this station's ductile iron force main is suspected to be badly corroded, due to infiltration as well as being buried in corrosive soils (coalash).

TABLE 5-10:PUMP STATION NO. 9 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
28,800 (20 gpm)	43,200 (30 gpm)	142,500	495	330	144,000	500	333	144,000	500	333

As shown in Table 5-10, estimated peak flows through Pump Station No. 9 are much greater than the station's capacity. Though no overflows have been reported at this station, pump run-time records verify that the pumps run virtually 100% of the time. Line storage may be sufficient to handle peak flows without overflows. Force main replacement may increase pumping capacity sufficiently to handle peak flows without line surcharge.

It is recommended that, as discussed in Chapter 3, the source of I/I into the gravity line upstream of the pump station be verified and the line rehabilitated. Pump station rehabilitation is recommended, and due to the inefficiency of the existing pumps, it is suggested that pump replacement considered. Impeller replacement may be sufficient, however. Conversion to a submersible pump station is also advised.

The Station No. 9 force main is corroded to the point that replacement is necessary. Replacement pipe should be PVC to withstand corrosivity of area soils.

This pump station has proven to be the most inefficient station in the entire sewer system. The improvements discussed above should be initiated immediately.

Pier "A" Pump Station

Pier "A" Pump Station is a submersible station near the foot of Pier "A". This station has been shut down since Hurricane Hugo due to submergence of the Pier "A" gravity line in the Cooper River. According to Work Center 44 personnel, this pump station is rarely used because supply ships docked at the pier have their own treatment systems and do not utilize the Naval Base sewer system. This station will probably be shut down permanently. It is suggested should the Pier "A" sewer line return to use, the shipyard consider abandoning this pump station and transporting the wastewater by gravity from the existing wet well to Manhole No. 7 and into Pump Station No. 9. Based upon visual observation of manhole depths and distance between the manholes, this appears to be a viable alternative.

The only deficiency noted during the inspection of this station is a control panel open to the weather. The panel enclosure should be replaced with a weathertight enclosure to prevent damage to electrical components.

Pump tests could not be performed at this station due to the submergence of the Pier "A" gravity line. Thus, no capacity analysis is presented below.

Pier "C-D" Pump Station

The Pier "C-D" Pump Station is a submersible simplex pump station near Building 58-A in the CIA. The only deficiency noted in this station is corrosion of the 4-inch discharge line and flanges inside the wet well.

It should be noted, however, that SCDHEC requires dual pumps in wastewater pumping stations to ensure continuous operability.

TABLE 5-11:PIER "C-D" PUMP STATION NO. 9 CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
504,000	504,000	13,500	3	3	14,200	3	3	14,900	3	3
(350 gpm)	(305 gpm)									

This pump station serves three small industrial buildings; thus peak flows are well under the capacity of this pump station. This should continue beyond the year 2000.

Pier "F" Pump Station

The Pier "F" Pump Station is located in the CIA near Building 1317. The Pier "F" gravity line is submerged in the Cooper River as a result of Hurricane Hugo, and salt water is entering the pump station. As discussed in Chapter 3, this line should be repaired to eliminate further saltwater inflow into the system. Also, check valves on both discharge lines are faulty and replacement is recommended.

TABLE 5-12:PIER "F" PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
1,152,000 (800 gpm)	1,548,000 (1075 gpm)	48,600	4	3	66,000	6	4	68,400	6	4

Pier "F" Pump Station capacities are sufficient to handle estimated peak flows through 2000.

Pier "K" Pump Station

The Pier "K" Pump Station is located on River Road South near the foot of Pier "K". This pump station has a history of flooding, and it is recommended that the corrective actions described in the general deficiencies section be carried out. At the time of inspection, the station was undergoing total equipment replacement due to Hurricane Hugo. Only one pump was operable, and the capacity analysis reflects the pumping rate of that pump.

TABLE 5-13:PIER "K" PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
756,000 (525 gpm)	756,000 (525 gpm)	37,500	5	5	63,300	8	8	66,600	9	9

Actual flows through this pump station are well under its minimum capacity. However due to the history of problems associated with the pump station, rehabilitation should be considered.

Pier "P" Pump Station

The Pier "P" Pump Station is located off Hobson Avenue, near the foot of Pier "P". This pump station also has a history of flooding and the improvements recommended in the general deficiencies section are advised. Like the Pier "K" Pump Station, only one pump was operable due to station equipment replacement caused by Hurricane Hugo.

TABLE 5-14:PIER "P" PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
1,800,000 (1250 gpm)	1,800,000 (1250 gpm)	301,500	17	17	310,500	17	17	321,000	18	18

Pier "P" Pump Station capacities are sufficient to handle estimated flows through the station; however, improvements are recommended for this station due to its history of maintenance problems.

Pier "S" Pump Station

The Pier "S" Pump Station, located near Building NS-2 at the foot of Pier "S", also has a history of flooding. However, this station withstood the hurricane without major dry well flooding, and both pumps were operable when inspected.

No major structural, mechanical, or electrical deficiencies were noted during inspection of this station. This is probably due to the fact that the station was rebuilt last summer after dry well flooding.

TABLE 5-15:PIER "S" PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
612,000	792,000	98,100	16	12	99,500	16	13	102,300	17	13
(425 gpm)	(550 gpm)									

Pier "S" Pump Station capacities are sufficient to handle flows through the station into the year 2000. But rehabilitative measures are recommended due to the station's periodic flooding.

Building X-54 Pump Station

Building X-54 is located at the south end of the Naval Base on Juneau Avenue. A pump station serves this building (a correctional custody unit) only. Because the station is relatively new, no major deficiencies were noted, with the exception of a bad check valve in the Pump No. 2 discharge line. This check valve is allowing pumped water to flow back into the wet well after the pumps shut off; valve replacement is recommended.

TABLE 5-16:BUILDING X-54 PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
144,000	288,000	5,600	4	2	5,900	4	2	6,200	4	2
(100 gpm)	(200 gpm)									

Building X-54 peak flows are well within the capacity of the pump station. This should continue through 2000.

Building 655 Pump Station

Building 655, the Naval Station Commissary, is equipped with two aboveground sewage pumps. The pumps lose prime frequently, apparently due to a hole in the suction piping. This problem should be repaired immediately. The pumps are located inside the building's utility room, and they pump from the wet well just outside the building. Access to the pumps is limited. Better access to the pumps would ease pump maintenance and repair.

TABLE 5-17:BUILDING 655 PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
43,200 (30 gpm)	288,000 (200 gpm)	3,800	9	1	4,000	9	1	4,200	10	1

The capacities for this pump station are sufficient to handle peak flows from Building 655 through the year 2000.

Building 661 Pump Station

Building 661, the Communications Center, is located on the south end of Holland Street. A pump station, consisting of two submersible pumps, serves this building only. A partially crushed force main at the discharge into MH 370H was noted. This is most likely due to shifting of the discharge manhole, and excavation is recommended to determine the extent of the damage. If it is ascertained that the hydraulic capacity of the force main is diminished, the damaged line portion should be replaced.

From a practical standpoint, it is also recommended that the electrical control panel be moved closer to the pump station. At present, the panel is located about 150 feet away inside a fenced high-security area. Operation of the electrical control panel requires that the operator first obtain permission to enter the security area. Access to the control panel should be enhanced.

TABLE 5-18: BUILDING 661 PUMP STATION CAPACITY ANALYSIS

Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
208,800 (145 gpm)	244,800 (170 gpm)	3,400	2	1	3,600	2	1	3,800	2	2

This pump station's capacities are sufficient to handle peak flows through the year 2000.

Building 247 Pump Station

Building 247, located near Pier "F" in the CIA, is equipped with a submersible pump station that serves this building only. This station is relatively new, and only one deficiency was noted during the evaluation. The electrical control panel is mounted in a non-weatherproof box outside of Building 247 and should be made weathertight.

TABLE 5-19:BUILDING 247 PUMP STATION CAPACITY ANALYSIS										
Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
36,000	180,000	600	2	0.3	630	2	0.4	660	2	0.4
(25 gpm)	(125 gpm)									

This station is well under capacity, and this should continue through the year 2000.

Ballfield Pump Station

The Ballfield Pump Station is located next to Cochrane Field on Hobson Avenue. Three deficiencies were noted during the inspection of this pump station. Bottom flanges on both discharge lines are leaky and need new gaskets. Secondly, the electrical control panel enclosure is not weathertight and should be sealed off appropriately. Finally, the continuous presence of oil in the wet well is a problem. As discussed in Chapter 3, a plan should be implemented that would eliminate or minimize the entrance of oil into the sewer system.

TABLE 5-20:BALLFIELD PUMP STATION CAPACITY ANALYSIS										
Capacity (gpd)		1990			1995			2000		
Minimum	Maximum	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.	Peak Flow	% Min.	% Max.
1,368,000	2,412,000	93,000	7	4	94,500	7	4	97,500	7	4
(950 gpm)	(1675 gpm)									

Peak flows through this pump station are well within the station's capacity.

SUMMARY

On the whole, most of the sewage pump stations are handling flows within their capacities. Only minor repairs (most of which are routine repairs performed by Work Center 44) are recommended for most of the stations; however, rehabilitative measures are suggested for all wet well-dry well stations. In addition, an investigation as to the feasibility of pump replacement is recommended for the following pump stations: Pier "K", Pier "P", Pier "S", No. 1 and No. 9.

Force main pigging should be considered for problem force mains and, ultimately, for routine line maintenance.

APPENDIX "A"
SMOKE TEST PHOTOGRAPHS

PHOTO NO. 1-1

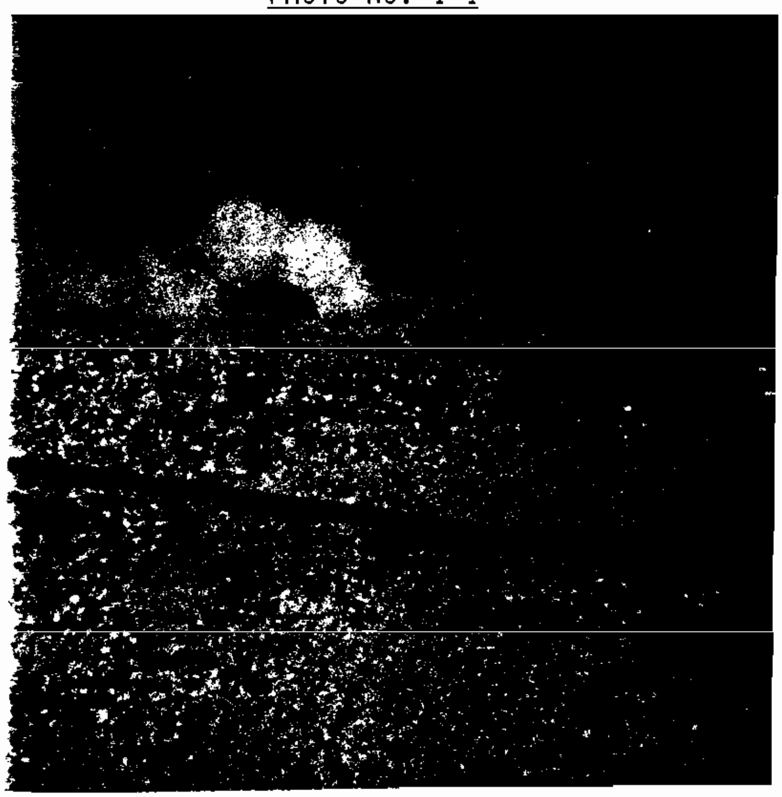


PHOTO NO. 1-2

PHOTO NO. 2-1

PHOTO NO. 2-2

PHOTO NO. 2-3

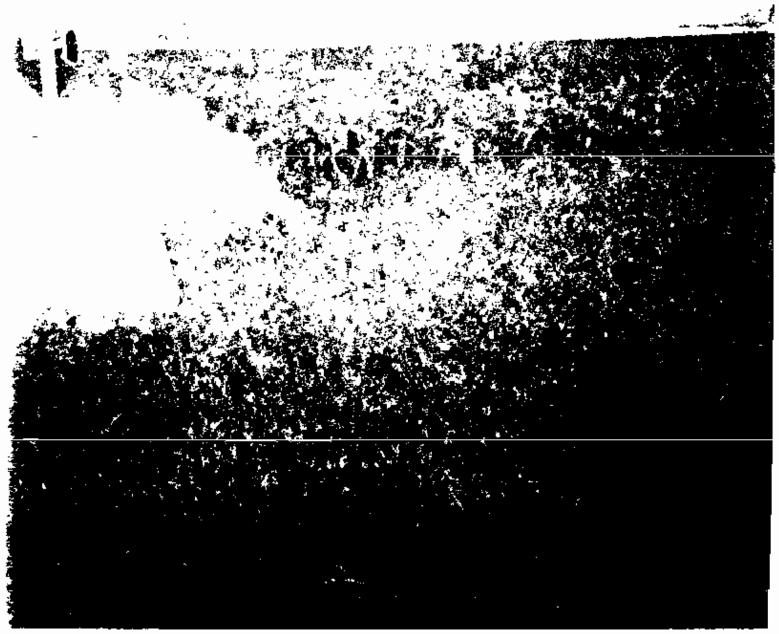
PHOTO NO. 2-4

PHOTO NO. 2-5

PHOTO NO. 2-6

PHOTO NO. 2-7

PHOTO NO. 2-8



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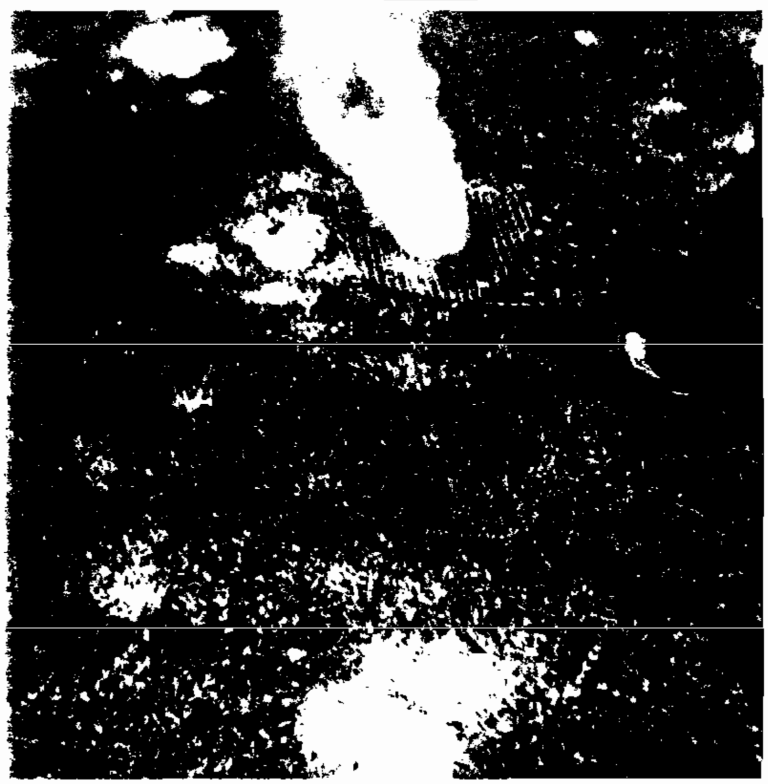

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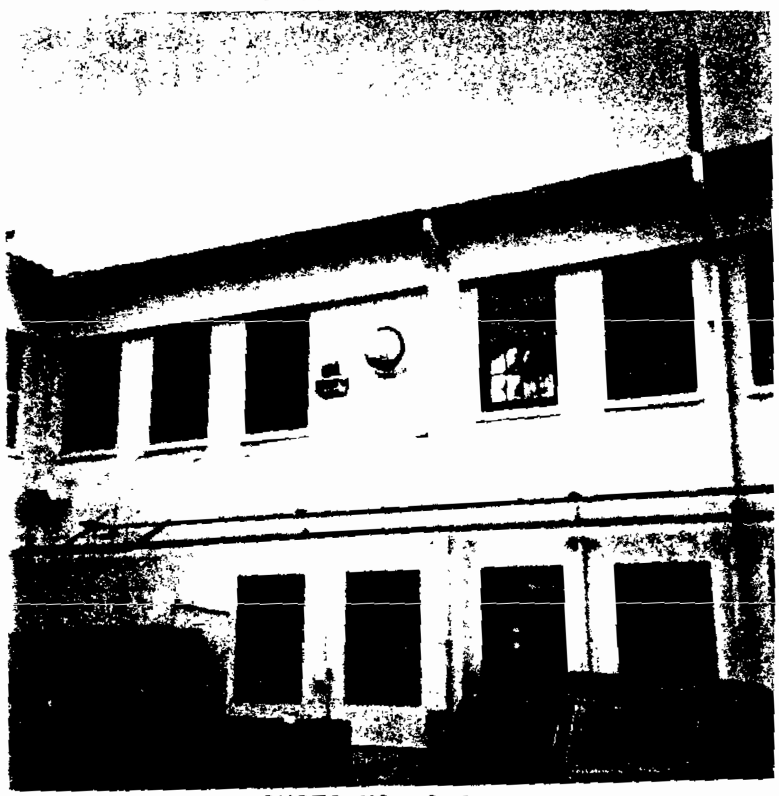

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PHOTO NO. 3-5

PHOTO NO. 3-6

PHOTO NO. 3-7

PHOTO NO. 3-8

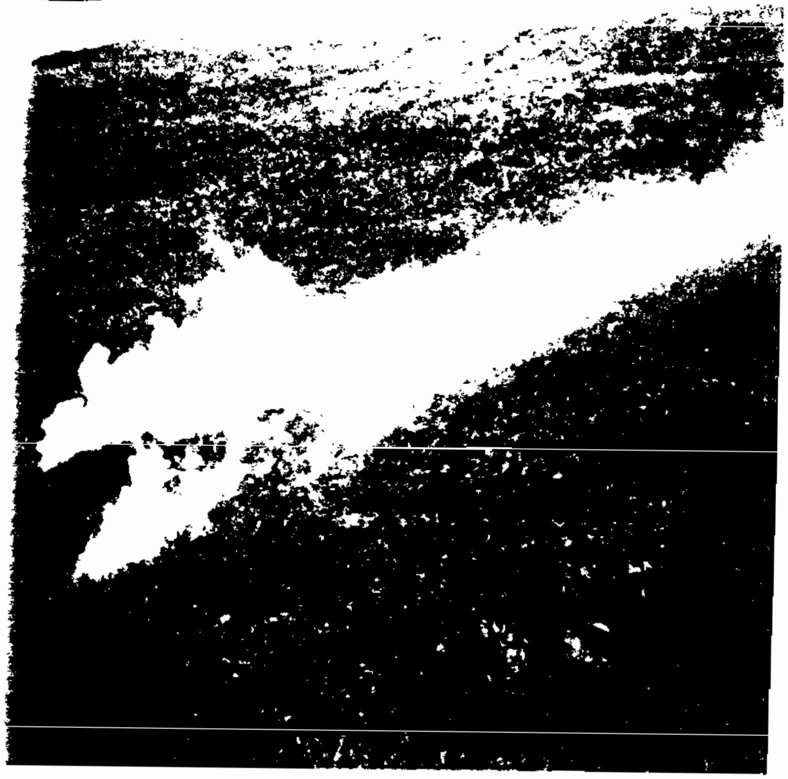

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PHOTO NO. 3-10

PHOTO NO. 3-11

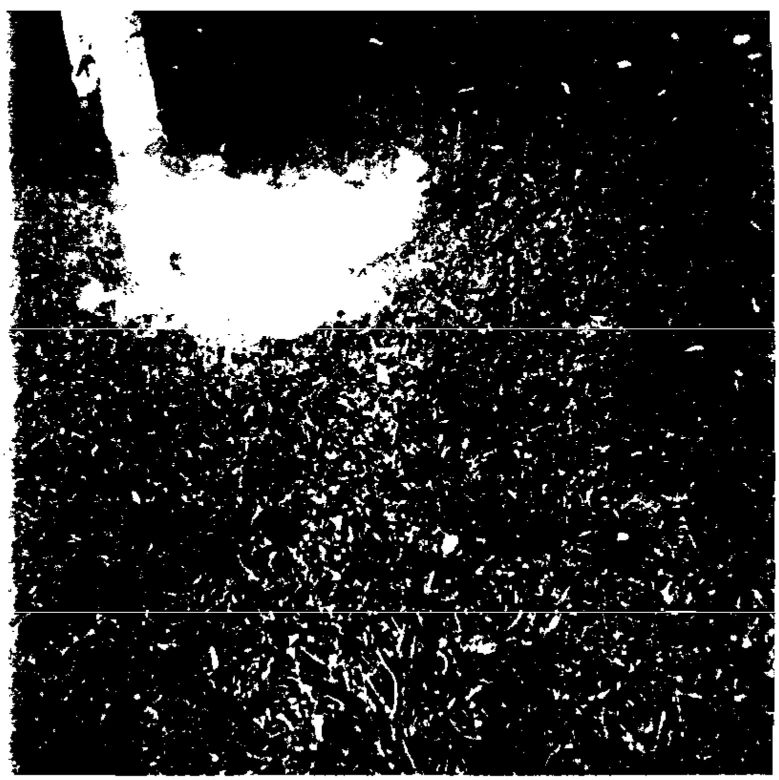

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PHOTO NO. 3-13

PHOTO NO. 4-1

PHOTO NO. 4-2

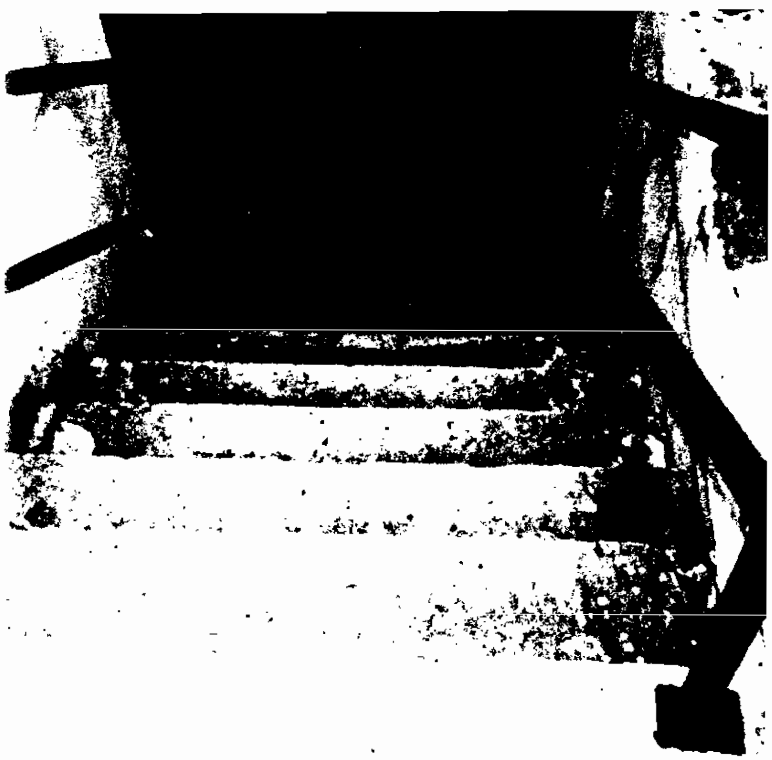

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PHOTO NO. 5-1

PHOTO NO. 5-2

PHOTO NO. 5-3

PHOTO NO. 5-4

PHOTO NO. 5-5

PHOTO NO. 5-6

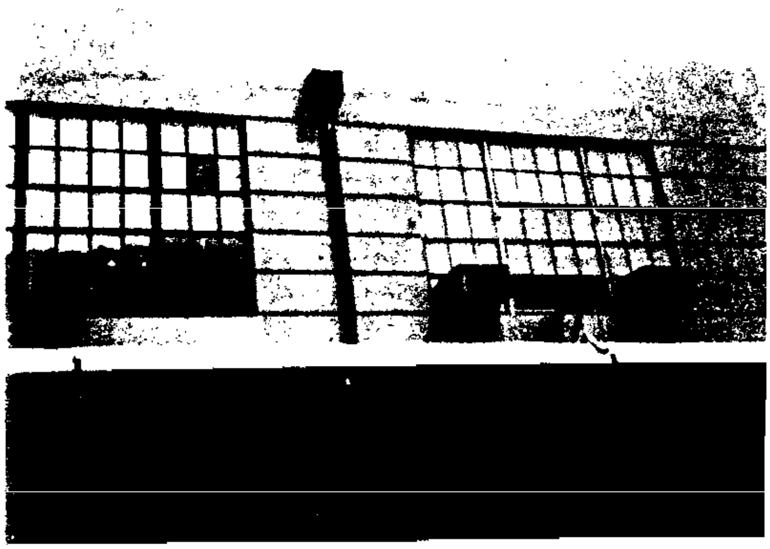

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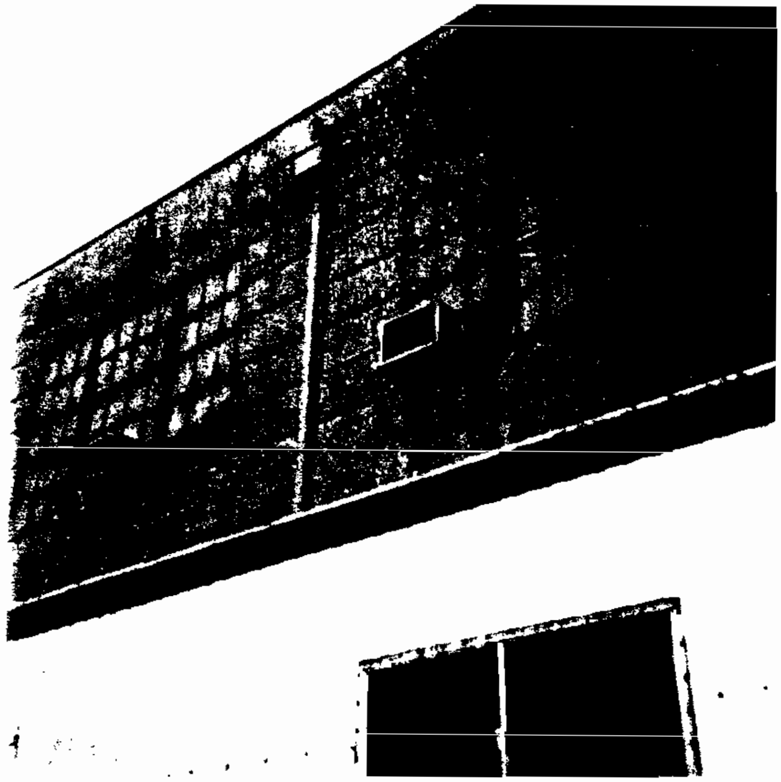
PHOTO NO. 5-8



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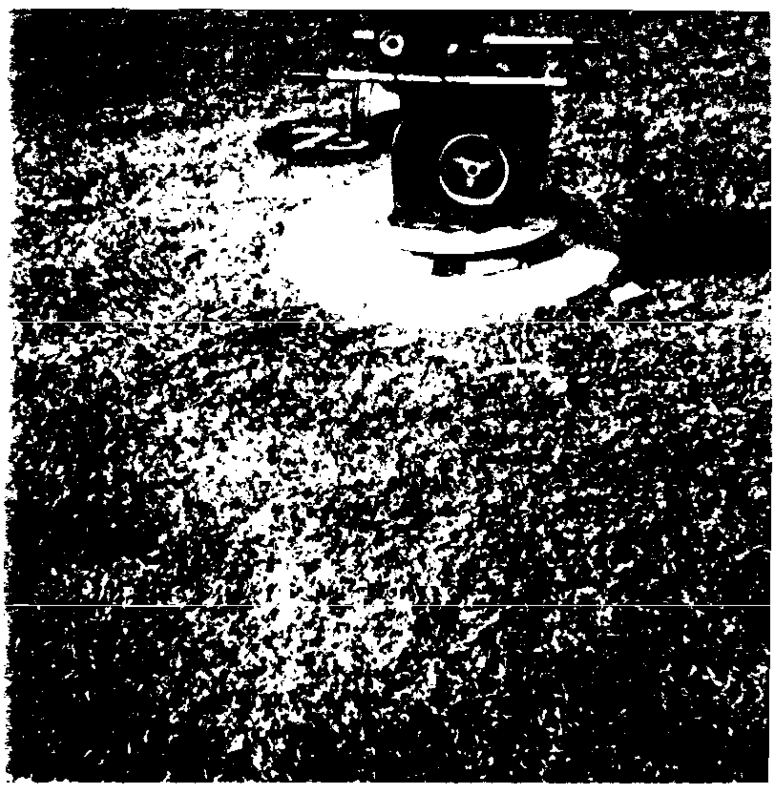

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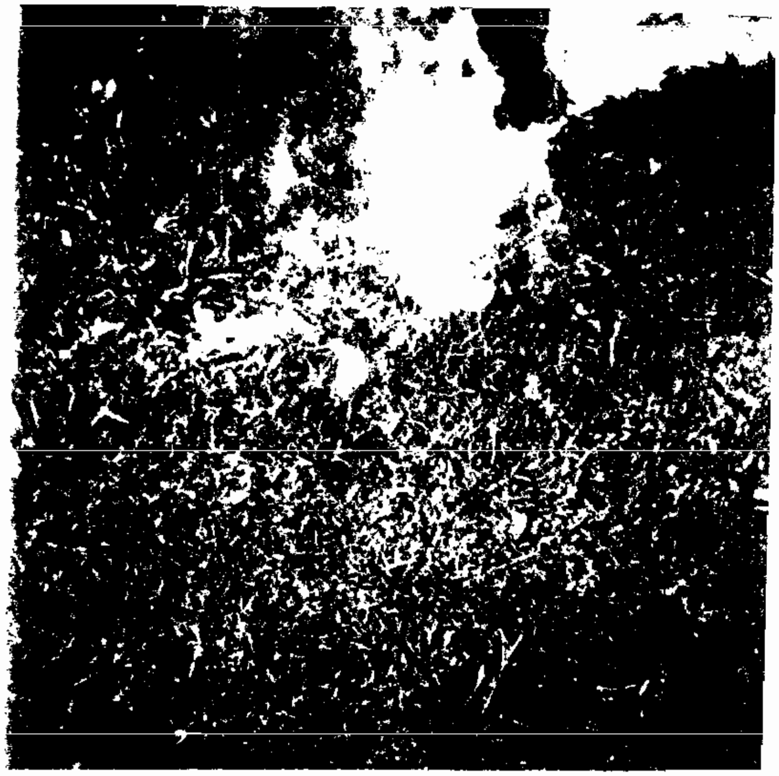
PHOTO NO. 8-1

PHOTO NO. 8-2

PHOTO NO. 8-3

PHOTO NO. 8-4



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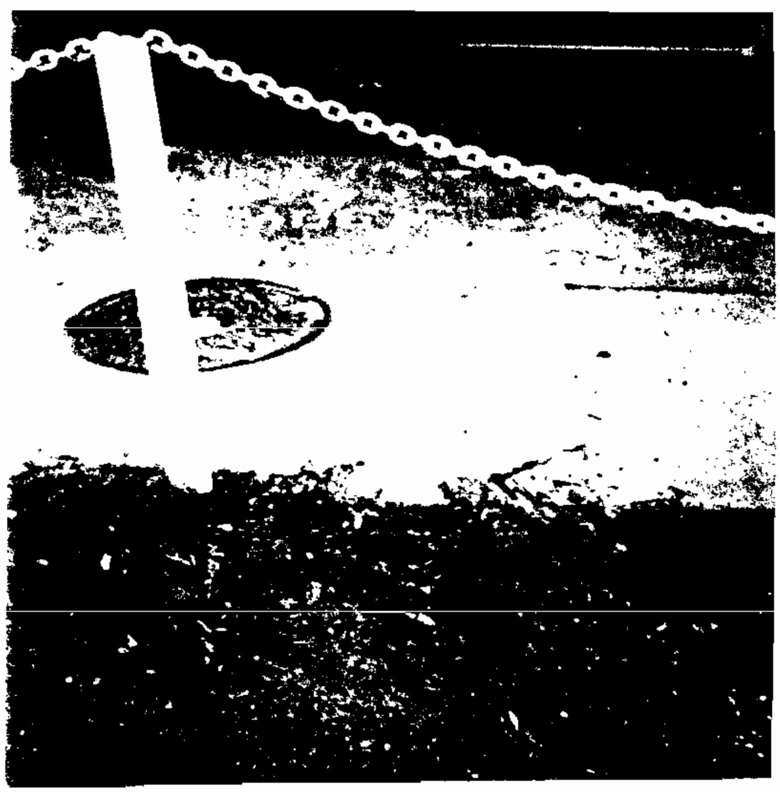

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PHOTO NO. 9-2

PHOTO NO. 9-3

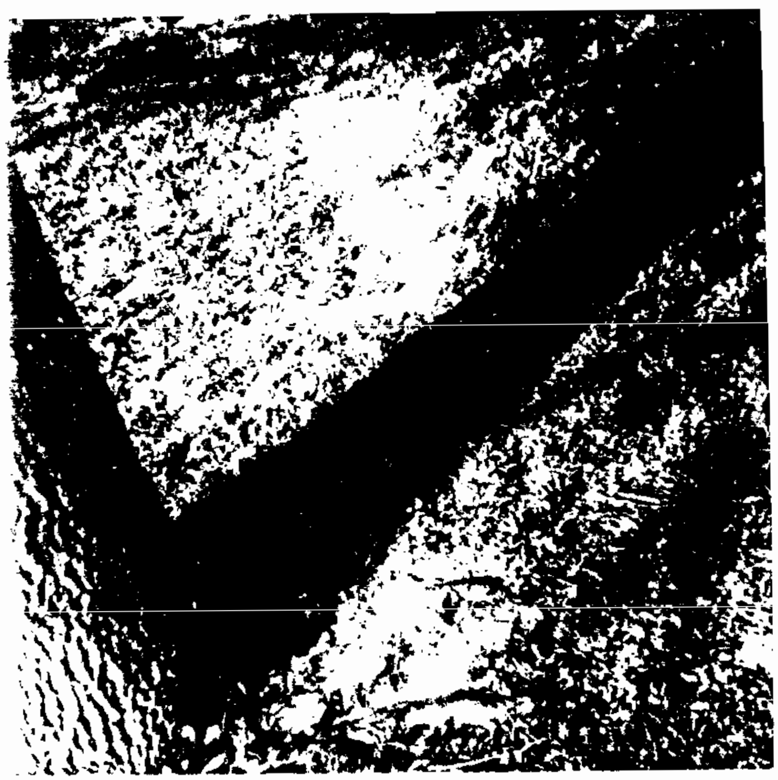

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PHOTO NO. 9-5

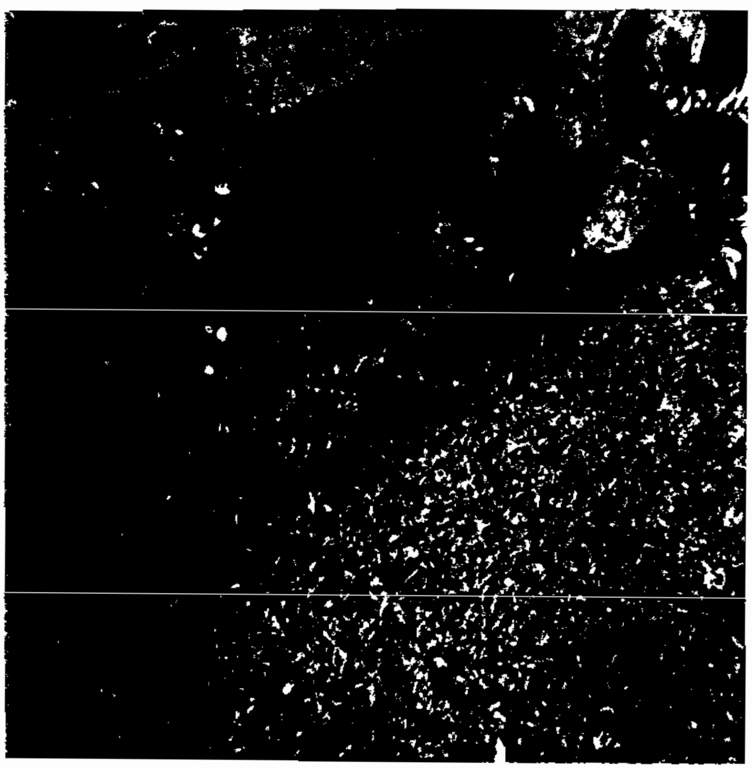

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PHOTO NO. 10-2

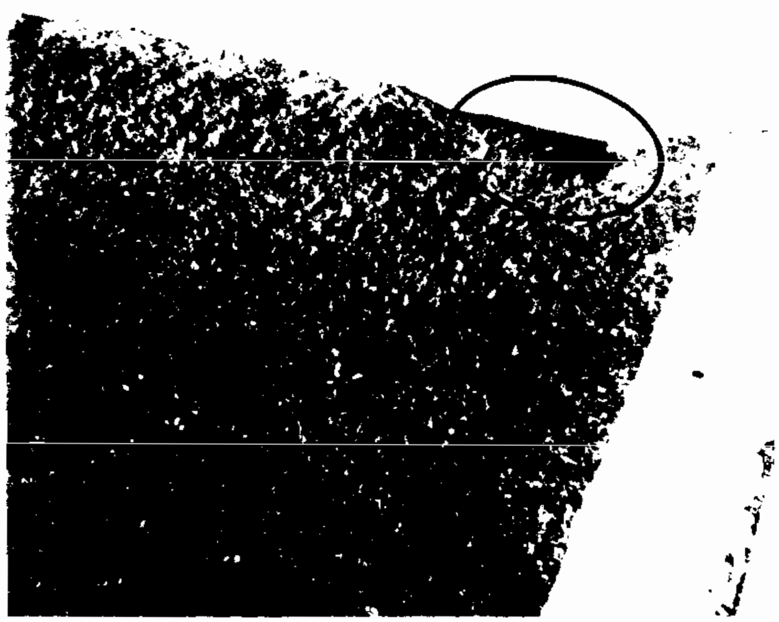


PHOTO NO. 10-3

PHOTO NO. 10-4

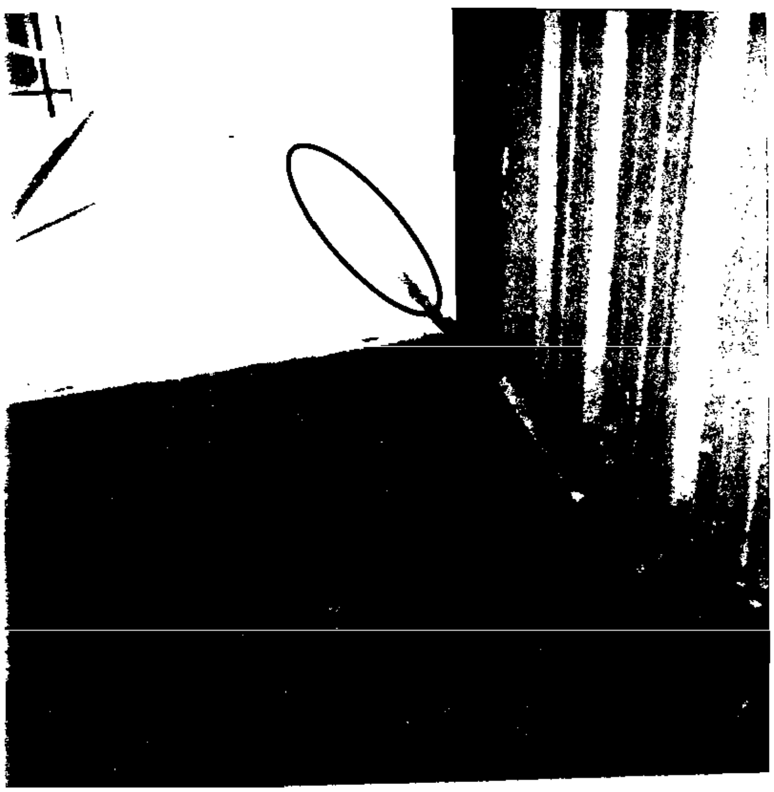


PHOTO NO. 10-5

APPENDIX "B"
MANHOLE INSPECTION RESULTS

APPENDIX "B"

MANHOLE INSPECTION RESULTS

The following is a list of manholes that were found to have one or more structural or functional deficiencies. They are grouped together and presented based on the types of deficiencies observed.

All manholes not listed in this appendix can be assumed to be in satisfactory condition.

Structural Deficiencies

Presented below is a list of manholes that were found to have minor structural deficiencies. Recommended improvements for these manholes consist of patching cracks, holes, etc. as needed with mortar or grout:

- MH 20A (Area 2): Large cracks in wall of MH with evidence of soil seepage.
- MH 154C (Area 4): Crack in wall beneath MH rim; leakage of surface water evident.
- MH 156A (Area 4): Crack in wall beneath MH rim; heavy leakage of surface water evident.
- MH 128 (Area 5): Hole in MH wall.
- MH 192 (Area 5): Crack in MH wall under rim; soil seepage present.
- MH 259 (Area 5): Hole in MH wall with soil seepage present.
- MH 279 (Area 5): Hole in MH wall beneath rim.
- MH 198 (Area 6): Crack in wall allowing significant leakage of groundwater and soil. Heavy buildup of sand in MH.

- <u>MH 327A (Area 8)</u>: Large hole in wall with evidence of heavy soil seepage.
- <u>MH 327B (Area 8)</u>: Hole in wall.
- <u>MH 341 (Area 8)</u>: Hole in wall with soil seepage present.
- <u>MH 338 (Area 9)</u>: Three separate holes in walls of the MH.
- <u>MH 396 (Area 9)</u>: Two holes in MH wall with entrance of soil present.

The following manholes have more serious structural problems:

- <u>MH 54A (Area 2)</u>: The manhole has settled into the soil 6-12 inches, and because pipes are now out of alignment, a severe blockage and surcharge are present. This manhole should be raised to realign pipes and better supported (preferably on pilings) to avoid resettlement.
- <u>MH 337 (Area 9)</u>: Part of the manhole's concrete wall has collapsed and aggregate is exposed. The manhole wall should be repaired.

<u>Functional Deficiencies</u>

Each of the manholes listed below was observed to contain an extreme buildup of debris that is hindering flow through the manhole. For these manholes, it is recommended that Vac-Haul or other means of cleaning debris from the manholes be employed.

- MH 77 (Area 3)
- MH 289 (Area 5)
- MH 300A (Area 5)
- MH 296B (Area 6)

- o MH 309D (Area 7)
- o MH 348A (Area 8)
- o MH 355 (Area 8)
- o MH 363C (Area 8)
- o MH 400B (Area 9)
- o MH 370D (Area 10)

The debris buildup in each of the following manholes is due to encased lines through the manhole (water, stormwater, etc.) that are restricting flow. Vac-Haul cleaning is recommended for these manholes.

- o MH 301 (Area 5)
- o MH 296E (Area 6)
- o MH 313A (Area 6)

The following manholes were found to have defective covers (missing, cracked, broken, etc.); cover replacement is recommended in all cases:

- o MH 7 (Area 1)
- o MH 143 (Area 2)
- o MH 94 (Area 3)
- o MH 126 (Area 4)
- o MH 66A (Area 6)
- o MH 316 (Area 7)
- o MH 334 (Area 8)

One additional problem that should be noted is the extremely high level of explosive gases present in MH 9 (Area 1), which was detected by the gas monitor used in all manhole inspections. These gases are likely due to a leaky gas line near the manhole, the source of the gas should be found and the problem corrected.

General Deficiencies

The following deficiencies were found to exist in most of the manholes:

- o Heavily corroded, and in some cases missing, ladders.
- o Minor cracks, holes, etc., in manhole and manhole-to-pipe joints.

Neither of these deficiencies were considered serious enough to warrant any type of manhole rehabilitation; the cracks are mostly minor. Structural integrity is not generally affected and the ladders are considered obsolete due to the current OSHA laws that require the use of ladders and/or safety equipment to enter manholes and other confined spaces.

APPENDIX "C"
GRAVITY LINE PEAK FLOW CALCULATIONS

APPENDIX "C"

GRAVITY LINE PEAK FLOW CALCULATIONS

The following is a segment-by-segment listing of estimated peak flows through gravity sewer segments that are described in Chapter 4. The flows are broken down into contributory flow from buildings and zones served by each gravity line. All flows are presented as 1000 gallons per day.

Segment		1990	1995	2000
GL 3-1				
Zone 1		47.5	48	48
+ Bldg. 1646		.06	.06	.07
	TOTAL:	47.6	48.06	48.07
	PEAK:	142.7	144.2	144.2
GL 4-1				
Zone 1		47.5	48	48
+ Zone 2		35	35	35.5
+ Zone 3		19	19	19.5
	TOTAL:	101.5	102	103
	PEAK:	304.5	306	309
GL 5-1 & GL 5-2				
Zone 6		44.5	45.5	46.5
+ Zone 7		51	51.5	52
	TOTAL:	95.5	97	98.5
	PEAK:	286.5	291	295.5
GL 5-3 & GL 5-4				
GL 5-1		95.5	97	98.5
+ Bldg. NH-68		.2	.2	.2
+ Bldg. NH-62		.6	.6	.64
+ Bldg. NH-61		1.0	1.1	1.1
+ Bldg. 1137		.5	.5	.5
+ I/I		2.5	2.5	2.5
	TOTAL:	100.3	101.9	103.5
	PEAK:	300.8	305.7	310.5

Segment		1990	1995	2000
GL 5-5				
GL 4-1		101.5	102	103
+ Zone 4		24	24.5	24.5
	TOTAL:	125.5	126.5	127.5
	PEAK:	376.5	379.5	382.5
GL 6-1				
11 Residences		2.5	2.6	2.75
I/I		2	2	2
	TOTAL:	4.5	4.6	4.75
	PEAK:	13.5	13.9	14.3
GL 6-2				
GL 6-1		2.5	2.6	2.75
+ 3 Residences		.7	.7	.75
I/I		1.5	1.5	1.5
	TOTAL:	4.7	4.8	5
	PEAK:	14	14.5	15
GL 6-3				
GL 6-2		4.7	4.9	5.2
+ 2 Residences		.5	.5	.5
I/I		1.5	1.5	1.5
	TOTAL:	6.7	6.9	7.2
	PEAK:	19.9	20.7	21.5
GL 6-4				
Zone 7		51	51.5	52
	PEAK:	153	154.5	156
GL 6-5 & 6-6				
GL 6-4		51	51.5	52
+ Bldg. NH 46		3.4	3.6	3.7
+ I/I		4	4	4
	TOTAL:	58.4	59.1	59.7
	PEAK:	175.2	177.2	179.2

Segment		1990	1995	2000
GL 9-7				
GL 9-5		61.6	63.4	65.1
- Bldg. 7		2.6	2.8	2.9
	TOTAL:	59	60.6	62.2
	PEAK:	176.9	181.8	186.8
GL 9-8				
GL 9-6		59	60.1	62.2
- Bldg. 4		4.6	4.8	5
- Bldg. 8		5.4	5.6	5.9
- Bldg. 3		3	3.2	3.3
	TOTAL:	46	47	48
	PEAK:	138.1	141.1	144.2
GL 10-1				
Zone 10		46	47	48
- Bldg. 212		.08	.08	.09
- Bldg. 2		.76	.8	.8
- Bldg. 6		.32	.34	.35
- I/I		2	2	2
	TOTAL:	42.8	43.8	44.8
	PEAK:	128.5	131.3	134.1
GL 11-1				
GL 9-4		383	390	397
	PEAK:	1150	1170	1190
GL 11-2				
GL 9-4		383.2	389.9	396.7
+ Bldg. 1138		.6	.6	.6
+ Bldg. 58		1.5	1.6	1.6
+ Bldg. 1028		.6	.7	.7
	TOTAL:	385.9	392.8	400
	PEAK:	1158	1178	1199

Segment		1990	1995	2000
GL 11-3				
Pier "D"		17	17.8	18.6
+ Bldg. 43		3.1	3.3	3.4
+ Bldg. 63		4.2	4.5	4.7
+ I/I		23	23	23
	TOTAL:	47.3	48.6	49.7
	PEAK:	141.8	145.5	149.2
GL 11-4				
P.S. "C-D"		4.5	4.7	5
+ Bldg. 3		3	3.2	3.3
+ Bldg. 43		.5	.5	.5
+ Bldg. 5		1.2	1.3	1.3
+ Bldg. 44		.4	.4	.5
+ I/I		21	21	21
	TOTAL:	30.6	31.1	31.6
	PEAK:	91.8	93.2	94.7
GL 11-5 & 11-6				
GL 11-3 & 11-4		77.9	79.6	81.3
+ Bldg. 57		6.8	7.1	7.5
+ I/I		12	12	12
	TOTAL:	96.7	98.7	100.8
	PEAK:	290	296.2	302.4
GL 11-7				
GL 11-5		96.7	98.7	100.8
+ Bldg. 5		.5	.5	.6
+ Bldg. 44		.4	.4	.4
+ Bldg. 45		.2	.2	.2
+ I/I		10	10	10
	TOTAL:	107.8	109.9	112
	PEAK:	323.3	329.6	336
GL 12-1				
Zones 1-11		496	507.5	516.5
+ Zones 13-14		134.5	157.5	162.5
	TOTAL:	630.5	665	679
	PEAK:	1891.5	1995	2037

Segment		1990	1995	2000
GL 12-2				
GL 12-2		630.5	665	679
+ Bldg. 30		2.6	2.7	2.9
+ Bldg. 25		.6	.6	.6
+ Bldg. 76		3	3.1	3.3
+ Bldg. 243		.2	.3	.3
+ Bldg. X-8		1.2	1.3	1.3
	TOTAL:	638.1	673	687.4
	PEAK:	1914.2	2018.9	2062
GL 13-1				
Zone 14		114.5	120	125
	PEAK:	343.5	360	375
GL 13-2				
Zone 14		114.5	120	125
	PEAK:	343.5	360	375
GL 13-3				
GL 13-2		114.5	120	125
+ 3 Warehouses		.2	.2	.2
	TOTAL:	114.7	120.2	125.2
	PEAK:	344.1	360.6	375.7
GL 13-4				
GL 13-3		114.7	120.2	125.2
+ CNS Credit Union		.5	.5	.6
	TOTAL:	115.2	120.7	125.8
	PEAK:	345.6	362.2	377.3
GL 13-5				
GL 13-4		115.2	120.7	125.8
+ Bldg. 1141		.3	.3	.4
+ Bldg. 209		.7	.7	.8
	TOTAL:	116.2	121.7	127
	PEAK:	348.6	365.4	380.6

Segment		1990	1995	2000
GL 13-6				
GL 11-2		385.9	392.8	399.6
+ GL 11-6		107.8	109.9	112
	TOTAL:	493.7	502.7	511.6
	PEAK:	1481	1507.8	1535
GL 14-1 & 14-2				
Navy Hospital		92	96.6	101.4
	PEAK:	276	289.8	304.2
GL 14-2				
Zone 14		114.5	120	125
	PEAK:	343.5	360	375
GL 15-1				
Bldg. 177		4.2	4.4	4.6
+ Bldg. 9		4.8	5.1	5.3
	TOTAL:	9	9.5	9.9
	PEAK:	27	28.4	29.8
GL 15-2				
Flow into P.S. 6		43.7	45.1	46.6
	PEAK:	131.1	135.3	139.8
GL 15-3				
GL 15-2		43.7	45.1	46.6
+ Bldg. 1178		.08	.08	.09
	TOTAL:	43.78	45.18	46.69
	PEAK:	131.3	135.6	140.1

Segment		1990	1995	2000
GL 15-4				
Flow into P.S. 7		672.3	712	726
+ Pier "F"		16	16.8	18
+ Bldg. 247		.2	.2	.2
	TOTAL:	688.5	729	744.2
	PEAK:	2065.4	2185.5	2232
GL 15-5				
GL 15-3		43.8	45.2	46.7
+ GL 15-4		688.5	728.5	744
	TOTAL:	732.3	773.7	790.7
	PEAK:	2196.8	2321	2372.1
GL 16-1				
Bldg. 225		2.8	2.9	3.1
+ Bldg. 1189		.2	.2	.2
+ I/I		2	2.1	2.2
	TOTAL:	5	5.2	5.5
	PEAK:	14.8	15.6	16.3
GL 16-2				
GL 16-1		4.9	5.2	5.4
+ Bldg. 658		11.4	11.9	12.5
+ Bldg. 89		.2	.2	.2
+ I/I		2.5	2.6	2.8
	TOTAL:	19	19.9	20.9
	PEAK:	57.05	59.9	62.9
GL 16-3				
GL 16-2		19.02	20	21
+ Bldg. 1143		.2	.2	.2
+ I/I		3.5	3.5	3.5
	TOTAL:	22.7	23.7	24.7
	PEAK:	68.1	71.03	74.01
GL 16-4				
Zone 16		41.5	46	48
	PEAK:	124.5	138	144

Segment		1990	1995	2000
GL 16-5				
GL 15-5		732.3	773.7	790.7
	PEAK:	2196.8	2321	2372
GL 17-1				
Bldg. 79		1.5	1.6	1.7
+ I/I		1.5	1.5	1.5
	TOTAL:	3	3.1	3.2
	PEAK:	9.1	9.4	9.6
GL 17-2				
GL 17-1		3	3.1	3.2
+ Bldg. 11		2.1	2.2	2.3
+ Dry Dock #5		2.2	2.3	2.4
+ I/I		1.5	1.5	1.5
	TOTAL:	8.8	9.1	9.4
	PEAK:	26.3	27.1	28
GL 17-3 & 4				
GL 17-2		8.8	9	9.3
+ Bldg. 236		3	3.1	3.3
+ Bldg. 1024		.7	.8	.8
+ I/I		1.5	1.5	1.5
	TOTAL:	14	14.4	14.9
	PEAK:	41.8	43.2	44.7
GL 17-5				
GL 17-3		11	11.4	12
+ Bldg. 187		3.5	3.7	3.8
+ I/I		1.5	1.5	1.5
	TOTAL:	16	16.6	17.3
	PEAK:	47.7	49.7	51.8

Segment		1990	1995	2000
GL 17-6 & 7				
GL 17-4		15.9	16.6	17.3
+ Bldg. 13		2.7	2.9	3
+ Bldg. 237		1.5	1.6	1.6
+ I/I		2	2	2
	TOTAL:	22.1	23	23.9
	PEAK:	66.4	69	71.8
GL 17-8				
GL 16-5		732.3	773.7	790.7
+ Zone 16		41.5	46	48
	TOTAL:	773.8	819.7	838.7
	PEAK:	2321.3	2459	2516
GL 17-9				
GL 17-6		773.8	819.7	838.7
+ Bldg. 1179		.3	.3	.3
+ Bldg. 92 (Pool)		4.9	5.1	5.4
	TOTAL:	779	825	844.4
	PEAK:	2336.9	2475.4	2533.3
GL 18-1				
Pier "G"		3.8	3.9	4.1
+ I/I		3	3	3
	TOTAL:	6.8	6.9	7.1
	PEAK:	20.3	20.8	21.4
GL 18-2				
GL 18-1		3.8	3.9	4.1
+ Pier "H"		7.5	7.9	8.3
+ I/I		3	3	3
	TOTAL:	14.3	14.8	15.4
	PEAK:	42.8	44.4	46.2

Segment		1990	1995	2000
GL 18-3				
Pier "J"		3.8	3.9	4.1
+ I/I		3	3	3
	TOTAL:	6.8	6.9	7.1
	PEAK:	20.3	20.8	21.4
GL 18-4				
Flow into "Ballfield" P.S.		31	31.5	32.5
	PEAK:	92	94.5	97.5
GL 20-1				
Zones 1-17		821	867.5	887.5
	PEAK:	2463	2602.5	2662.5
GL 20-2				
Flow from P.S. 4		839.6	941.5	963.3
+ Bldg. 1193		1.2	1.3	1.3
+ Bldg. 69		.2	.2	.2
+ Bldg. 1174		.6	.7	.7
+ Bldg. 1175		.1	.1	.1
+ I/I		2.5	2.5	2.5
	TOTAL:	844.2	946.2	968.1
	PEAK:	2532.5	2838.5	2904.2
GL 20-3				
GL 20-2		844.2	946.2	968.1
+ Bldg. 249		.6	.7	.7
+ Bldg. 98		.1	.2	.2
	TOTAL:	844.9	947.1	969
	PEAK:	2534.8	2840.9	2906.7
GL 21-1				
Pier "L"		4.5	12.8	13
+ I/I		6	6	6
	TOTAL:	10.5	18.8	19
	PEAK:	31.6	55.8	57

Segment		1990	1995	2000
GL 21-3				
GL 21-2		24	32.6	33.2
+ Bldg. 68		.6	.6	.6
+ Bldg. 69		.9	1	1
+ I/I		3	3	3
	TOTAL:	28.5	37.2	37.8
	PEAK:	85.5	111.5	113.5
GL 21-4				
GL 21-3		28.5	37.2	37.8
+ Bldg. 381		.1	.1	.1
+ I/I		3	3	3
	TOTAL:	31.6	40.3	40.9
	PEAK:	94.8	120.8	122.8
GL 21-5				
Zones 1-20		922	973.5	995
+ I/I		3	3	3
	TOTAL:	925	976.5	998
	PEAK:	2775	2930	2994
GL 22-1				
GL 21-5		925	976.5	998
+ GL 21-4		31.6	40.3	41
+ I/I		4	4	4
	TOTAL:	960.6	1020.8	1043
	PEAK:	2881.8	3062.3	3128.8
GL 22-2, 3 & 4				
Zones 23-33		731.5	828.5	898.5
+ I/I		4	4	4
	TOTAL:	731.5	832.5	902.5
	PEAK:	2206.5	2497.5	2707.5

Segment		1990	1995	2000
GL 22-5 & 6				
GL 22-1		960.6	1020.8	1042.9
+ GL 22-2		732.5	832.5	902.5
+ I/I		4	4	4
	TOTAL:	1700.1	1857.3	1949.4
	PEAK:	5100.3	5571.8	5848.3
GL 23-1				
Pier "M"		11	11.5	12.1
+ I/I		3	3	3
	TOTAL:	14	14.5	15.1
	PEAK:	42	43.7	45.3
GL 23-2				
Zones 24-33		677	772	840
	PEAK:	2031	2316	2520
GL 23-3 & 4				
GL 23-2		677	772	840
+ Bldg. X-11		.5	.6	.6
+ I/I		2	2	2
	TOTAL:	679.5	774.6	842.6
	PEAK:	2038.6	2323.7	2527.8
GL 23-5, 6 & 7				
GL 23-1		14	14.6	15.1
+ GL 23-3		679.5	774.6	842.6
+ I/I		3	3	3
	TOTAL:	696.5	792.1	860.7
	PEAK:	2089.6	2376.4	2582.1

Segment		1990	1995	2000
GL 23-8				
GL 23-4		696.5	792.1	860.7
+ Bldg. 161		1.3	1.4	1.4
+ Bldg. 193		.1	.1	.2
+ Bldg. 641		.2	.2	.2
+ I/I		3	3.2	3.3
	TOTAL:	701.1	797	865.8
	PEAK:	2103.5	2391	2597.4
GL 24-1				
Pier "N"		15.7	16.5	17.3
+ I/I		2	2	2
	TOTAL:	17.7	18.5	19.3
	PEAK:	53.1	55.6	57.9
GL 24-2, 3 & 4				
Zone 29		34	34.5	35.5
+ I/1		4	4	4
	TOTAL:	38	38.5	39.5
	PEAK:	114	115.5	118.5
GL 24-5				
GL 24-2		38	38.5	39.5
+ Pier "Q"		14.8	15.5	16.3
+ I/1		4	4	4
	TOTAL:	56.8	58	59.8
	PEAK:	170.4	174.1	179.3
GL 24-6				
GL 24-3		56.8	58	59.8
+ Pier "P"		20.3	21.3	22.3
+ I/1		4	4	4
	TOTAL:	81.1	83.3	86.1
	PEAK:	243.3	250.1	258.3

Segment		1990	1995	2000
GL 24-7				
Flow from Pier "P" P.S.		100.5	103.5	107
	PEAK:	301.5	310.5	321
GL 24-8				
Zones 25-33		610.5	703	768.5
	PEAK:	1831.5	2109	2305.5
GL 25-1				
GL 24-6		610.5	703	768.5
	PEAK:	1831.5	2109	2305.5
GL 25-2 & 3				
GL 25-1		610.5	703	768.5
- Bldg. 650		.5	.5	.6
	TOTAL:	610	702.5	767.9
	PEAK:	1830	2107.4	2303.9
GL 25-4				
GL 25-2		610	702.5	767.9
- Bldg. 636		2	2.1	2.2
	TOTAL:	608	700.4	765.7
	PEAK:	1824	2101.1	2297.2
GL 25-5				
GL 25-6		550	641	705.5
+ P.S. #3 Flow		45.4	46.9	48.5
	TOTAL:	595.4	695.9	754
	PEAK:	1786.2	2087.7	2262
GL 25-6				
Zones 26-33		550	641	705.5
	PEAK:	1650	1923	2116.5

Segment		1990	1995	2000
GL 26-1				
Flow into P.S. #1		488.2	579.2	641.3
	PEAK:	1464.6	1737.6	1923.8
GL 26-2				
GL 26-1		488.2	579.2	641.3
- Bldg. 644		1.3	1.4	1.4
	TOTAL:	486.9	577.8	639.8
	PEAK:	1460.7	1733.5	1919.5
GL 26-3				
Zones 27-33		449	538	600.5
	PEAK:	1347	1614	1801.5
GL 26-4				
FMWTC Fire Training Facility		50	52.5	55
	PEAK:	150	157.5	165
GL 27-1				
Zone 28		119	124	172
	PEAK:	357	372	516
GL 27-2				
GL 27-1		119	124	172
+ Bldg. 656		4.1	4.3	4.5
+ Bldg. 643 & 647		6.6	6.9	7.3
+ FBM 61		4	4.2	4.4
+ I/I		6	6	6
	TOTAL:	139.7	145.4	194.1
	PEAK:	419	436.2	582.4

Segment		1990	1995	2000
GL 27-3, 4 & 5				
FBM 61 + NS-54		4.1	4.3	4.5
+ I/I		3	3	3
	TOTAL:	7.1	7.3	7.5
	PEAK:	21.4	22	22.6
GL 27-6				
GL 27-2		139.7	145.4	194.2
+ GL 27-3		7.1	7.3	7.5
+ I/I		2	2	2
	TOTAL:	148.8	154.7	203.7
	PEAK:	446.4	464.2	611
GL 27-7				
Zones 30-33		234	313	324
	PEAK:	702	939	972
GL 28-1				
GL 28-2		91.8	95.4	142.1
- NS 67		3.5	3.7	3.9
- NS 652		3.5	3.7	3.9
- Bldg. 71		1.2	1.3	1.3
	TOTAL:	83.6	86.8	133.1
	PEAK:	250.8	260.5	399.2
GL 28-2				
GL 28-1		119	124	172
- NS 65		14	14.7	15.4
- NS 66		13.2	13.9	14.5
	TOTAL:	91.8	95.4	142.1
	PEAK:	275.4	286.3	426.2
GL 28-3				
Zone 38		119	124	172
	PEAK:	357	372	516

Segment		1990	1995	2000
GL 29-1				
Pier "S"		.6	.6	.7
+ I/I		5	5	5
	TOTAL:	5.6	5.6	5.7
	PEAK:	16.8	16.9	17
GL 29-2				
Pier "T"		5.3	5.6	5.8
+ I/I		5	5	5
	TOTAL:	10.3	10.6	10.8
	PEAK:	30.9	31.7	32.5
GL 29-3 & 4				
Pier "U"		6.2	6.5	6.8
+ I/I		5	5	5
	TOTAL:	11.2	11.5	11.8
	PEAK:	34	34.6	35.6
GL 30-2				
GL 27-5		234	313	324
	PEAK:	702	939	972
GL 30-1				
Zones 31-33		179.5	257.5	267.5
	PEAK:	538.5	772.5	802.5
GL 31-1				
NS 33		9.5	9.9	10.5
+ NS 34		9.5	9.9	10.5
+ NS 35		9.5	9.9	10.5
+ NS 36		9.5	9.9	10.5
+ I/I		20	20	20
	TOTAL:	57.8	59.7	61.6
	PEAK:	173.5	179.1	184.8

Segment		1990	1995	2000
GL 31-2				
GL 31-1		57.8	59.7	61.6
+ NS 31		3.5	3.7	3.9
+ NS 32		4.9	5.1	5.3
	TOTAL:	66.7	68.5	70.8
	PEAK:	198.6	205.5	212.4
GL 31-3				
GL 31-2		66.2	68.5	70.8
+ Bldg. NS-43		2.5	2.6	2.8
	TOTAL:	68.7	71.1	73.6
	PEAK:	206.1	213.4	220.7
GL 31-4 & 5				
Zone 33		44	51.5	53
+ Submarine Berthing Pier		0	60	63
+ GL 31-3		68.7	71.1	73.6
	TOTAL:	112.7	182.6	189.6
	PEAK:	338.1	547.9	568.7
GL 32-1				
GL 30-2		179.5	257.5	267.5
- GL 31-4		112.7	182.6	189.6
- NS 43		2.4	2.5	2.6
	TOTAL:	64.5	72.4	75.3
	PEAK:	193.4	217.2	226

APPENDIX "D"
PUMP TEST CALCULATION SHEETS

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 1 Date 11/14/89

Pump Tested No. 1

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate: $\frac{1.21' \times 28.27^{\square'}}{2.0}$ = 17.10 cfm

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.38' \times 28.27^{\square'}}{6.}$ = 6.5 cfm

Run 2 $\frac{1.61' \times 28.27^{\square'}}{3.5}$ = 13.0 cfm

Run 3 $\frac{1.52' \times 28.27^{\square'}}{2'50''}$ = 15.57 cfm

Average Drawdown = 13.04 cfm

Filling Rate: $\frac{1.71' \times 28.27^{\square'}}{1'25''}$ = 34.12 cfm

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.17' \times 28.27^{\square'}}{50''}$ = 35.09 cfm

Run 2-3 $\frac{1.5' \times 28.27^{\square'}}{1'15''}$ = 33.92 cfm

Average Filling = 34.38 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 13.04 + 34.38 = 47.42 cfm

47.42 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 354.70 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 1 Date 11/14/89

Pump Tested No. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.7' \times 28.27^{\square'}}{1' 15''}$ = 38.45 cfm

Run 2 $\frac{1.55' \times 28.27^{\square'}}{1' 15''}$ = 35.05 cfm

Run 3 $\frac{1.73' \times 28.27^{\square'}}{1' 25''}$ = 34.52 cfm

Average Drawdown = 36 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.55' \times 28.27^{\square'}}{55''}$ = 47.8 cfm

Run 2-3 $\frac{1.83' \times 28.27^{\square'}}{1.0}$ = 51.73 cfm

Average Filling = 49.77 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 36 + 49.77 = 85.77 cfm

85.77 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 641.56 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 1 Date 11/14/89

Pump Tested No. 3

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.73' \text{ X } 28.27^{\square'}}{2.5}$ = 19.56 cfm

Run 2 $\frac{1.72' \text{ X } 28.27^{\square'}}{2'20''}$ = 20.84 cfm

Run 3 $\frac{1.73' \text{ X } 28.27^{\square'}}{1'50''}$ = 26.68 cfm

Average Drawdown = 22.36 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.80' \text{ X } 28.27^{\square'}}{50''}$ = 61.06 cfm

Run 2-3 $\frac{1.68' \text{ X } 28.27^{\square'}}{50''}$ = 56.99 cfm

Average Filling = 59.03 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 22.36 + 59.03 = 81.39 cfm

81.39 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 608.77 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 1 Date 11/14/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{1.80' \times 28.27\square'}{1'25''} =$ 35.92 cfm

Run 2 $\frac{1.85' \times 28.27\square'}{1.0} =$ 52.30 cfm

Run 3 $\frac{1.95 \times 28.27\square'}{55''} =$ 60.14 cfm

Average Drawdown = 49.45 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{2.10' \times 28.27\square'}{42''} =$ 84.81 cfm

Run 2-3 $\frac{1.60' \times 28.27\square'}{.40''} =$ 67.85 cfm

Average Filling = 76.33 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 49.45 + 76.33 = 125.78 cfm

125.78 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 940.83 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 1 Date 11/14/89

Pump Tested No. 1 & No. 3

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.85' \times 28.27^{\square'}}{35''}$ = 89.66 cfm

Run 2 $\frac{1.88' \times 28.27^{\square'}}{35''}$ = 91.11 cfm

Run 3 $\frac{1.97' \times 28.27^{\square'}}{35''}$ = 95.47 cfm

Average Drawdown = 92.08 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.87' \times 28.27^{\square'}}{1'40''}$ = 31.72 cfm

Run 2-3 $\frac{1.90' \times 28.27^{\square'}}{1'45''}$ = 30.69 cfm

Average Filling = 31.21 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 92.08 + 31.21 = 123.29 cfm

123.29 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 922.18 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 1 Date 11/14/89

Pump Tested No. 2 & No. 3

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.80' \times 28.27^{\square'}}{35''}$ = 87.23 cfm

Run 2 $\frac{1.60' \times 28.27^{\square'}}{0.5}$ = 90.46 cfm

Run 3 $\frac{2.1' \times 28.27^{\square'}}{35''}$ = 101.77 cfm

Average Drawdown = 93.15 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{2.20' \times 28.27^{\square'}}{1.0}$ = 62.19 cfm

Run 2-3 $\frac{2.05' \times 28.27^{\square'}}{1.0}$ = 57.95 cfm

Average Filling = 60.07 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 93.15 + 60.07 = 153.22 cfm

153.22 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1146.10 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 1 Date 11/14/89

Pump Tested No. 1, NO. 2, & No. 3

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 **Elev. X Area / Run Time (min.)** = 1.91' X 28.27□' / 21" = 154.27 cfm

Run 2 1.97' X 28.27□' / 21" = 159.12 cfm

Run 3 2.60' X 28.27□' / 0.5 = 147 cfm

Average Drawdown = 153.46 cfm

Filling Rate:

Run 1-2 Elev. X Area / Idle Time (min.) = 1.96' X 28.27□' / 1'45" = 31.66 cfm

Run 2-3 2.04' X 28.27□' / 1'50" = 31.46 cfm

Average Filling = 31.56 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 153.46 + 31.56 = 185.02 cfm

185.02 cfm X 7.48 gal / cf = 1383.95 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 2 Date 11/15/89

Pump Tested No. 1

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.75' \times 12.57^{\square'}}{27''}$ = 10.48 cfm

Run 2 $\frac{0.90' \times 12.57^{\square'}}{0.5}$ = 22.63 cfm

Run 3 $\frac{0.85' \times 12.57^{\square'}}{0.5}$ = 21.37 cfm

Average Drawdown = 18.16 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.85' \times 12.57^{\square'}}{6.0}$ = 1.78 cfm

Run 2-3 $\frac{0.95' \times 12.57^{\square'}}{6.0}$ = 1.99 cfm

Average Filling = 1.88 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 18.16 + 1.88 = 20.04 cfm

20.04 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 149.94 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 2 Date 11/15/89

Pump Tested No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.45' \times 12.57^{\square'}}{0.5} =$ 11.31 cfm

Run 2 $\frac{0.45' \times 12.57^{\square'}}{0.5} =$ 11.31 cfm

Run 3 $\frac{0.45' \times 12.57^{\square'}}{0.5} =$ 11.31 cfm

Average Drawdown = 11.31 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.45' \times 12.57^{\square'}}{2.5} =$ 2.26 cfm

Run 2-3 $\frac{0.50' \times 12.57^{\square'}}{3.25} =$ 1.93 cfm

Average Filling = 2.10 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 11.31 + 2.10 = 13.41 cfm

13.41 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 100.28 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station: No. 2   Date: 11/15/89

Pump Tested: No. 1 & No. 2

X-Sectional Area, Wet Well: 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.75' \times 12.57^{\square'}}{25''}$ = 22.63 cfm

Run 2 $\frac{0.95' \times 12.57^{\square'}}{0.5}$ = 23.88 cfm

Run 3 $\frac{0.95' \times 12.57^{\square'}}{0.5}$ = 23.88 cfm

Average Drawdown = 23.46 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.70' \times 12.57^{\square'}}{6.0}$ = 1.47 cfm

Run 2-3 $\frac{0.90' \times 12.57^{\square'}}{8'15''}$ = 1.37 cfm

Average Filling = 1.42 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 23.46 + 1.42 = 24.88 cfm

24.88 cfm X $\frac{7.48\text{ gal}}{\text{cf}}$ = 186.10 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 3 Date 11/15/89

Pump Tested No. 1

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.10' \times 12.57^{\square'}}{35''}$ = 23.70 cfm

Run 2 $\frac{1.0' \times 12.57^{\square'}}{0.5}$ = 25.14 cfm

Run 3 $\frac{1.45' \times 12.57^{\square'}}{0.75}$ = 24.30 cfm

Average Drawdown = 24.38 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.15' \times 12.57^{\square'}}{4.0}$ = 3.61 cfm

Run 2-3 $\frac{1.20' \times 12.57^{\square'}}{4.0}$ = 3.77 cfm

Average Filling = 3.69 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 24.38 + 3.69 = 28.07 cfm

28.07 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 209.97 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 3 Date 11/15/89

Pump Tested NO. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.55' \times 12.57^{\square'}}{0.5}$ = 13.83 cfm

Run 2 $\frac{0.55' \times 12.57^{\square'}}{0.5}$ = 13.83 cfm

Run 3 $\frac{0.50' \times 12.57^{\square'}}{0.5}$ = 12.57 cfm

Average Drawdown = 13.41 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.70' \times 12.57^{\square'}}{2.5}$ = 3.52 cfm

Run 2-3 $\frac{0.65' \times 12.57^{\square'}}{2.5}$ = 3.27 cfm

Average Filling = 3.39 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 13.41 + 3.39 = 16.80 cfm

16.80 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 125.69 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 3 Date 11/15/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.95' \times 12.57^{\square'}}{0.5} =$ 23.88 cfm

Run 2 $\frac{1.00' \times 12.57^{\square'}}{0.5} =$ 25.14 cfm

Run 3 $\frac{1.40' \times 12.57^{\square'}}{0.75} =$ 23.46 cfm

Average Drawdown = 24.16 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.95' \times 12.57^{\square'}}{3.25} =$ 3.67 cfm

Run 2-3 $\frac{1.05' \times 12.57^{\square'}}{3.50} =$ 3.77 cfm

Average Filling = 3.72 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 24.16 + 3.72 = 27.88 cfm

27.88 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 208.55 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 4 Date 11/13/89

Pump Tested NO. 1

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{4.50' \times 38.48\square'}{1'20''} =$ 129.87 cfm

Run 2 $\frac{3.85' \times 38.48\square'}{55''} =$ 161.62 cfm

Run 3 $3.60' \times 38.48\square' =$ 173.16 cfm

Average Drawdown = 154.88 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{4.30' \times 38.48\square'}{2'17''} =$ 72.47 cfm

Run 2-3 $\frac{3.75' \times 38.48\square'}{2'45''} =$ 52.47 cfm

Average Filling = 62.47 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 154.88 + 62.47 = 217.35 cfm

217.35 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 1625.78 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 4 Date 1/13/89

Pump Tested No. 2

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1	$\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ =	$\frac{4.10 \text{ X } 38.48^{\square}}{50''}$ =	189.32 cfm
Run 2		$\frac{4.22 \text{ X } 38.48^{\square}}{50''}$ =	194.86 cfm
Run 3		$\frac{4.05 \text{ X } 38.48^{\square}}{1'10''}$ =	133.58 cfm
		Average Drawdown =	172.59 cfm

Filling Rate:

Run 1-2	$\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ =	$\frac{4.17 \text{ X } 38.48^{\square}}{4'45''}$ =	33.78 cfm
Run 2-3		$\frac{4.45 \text{ X } 38.48^{\square}}{4'52''}$ =	35.19 cfm
		Average Filling =	34.48 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 172.59 + 34.48 = 207.07 cfm

207.07 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 1548.90 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station: No. 4 Date: 11/13/89

Pump Tested: NO. 3

X-Sectional Area, Wet Well: 38.48 sq. ft.

Drawdown Rate:

Run 1	Elev. X Area / Run Time (min.)	= 1.85' X 38.48□' / 2' 20" =	30.51 cfm
Run 2		1.70' X 38.48□' / 3.00 =	21.81 cfm
Run 3		2.10' X 38.48□' / 3' 40" =	22.04 cfm
		Average Drawdown =	24.79 cfm

Filling Rate:

Run 1-2	Elev. X Area / Idle Time (min.)	= 3.10' X 38.48□' / 45" =	159.05 cfm
Run 2-3		2.05' X 38.48□ / .30" =	157.77 cfm
		Average Filling =	158.41 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 24.79 + 158.41 = 183.20 cfm

183.20 cfm X 7.48 gal/cf = 1370.33 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 4 Date 11/13/89

Pump Tested No. 1 & NO. 2

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1	Elev. X Area / Run Time (min.)	=	3.60' X 38.48□' / 35" =	237.48 cfm
Run 2			3.30' X 38.48□' / 32" =	238.10 cfm
Run 3			4.25' X 38.48□' / 37" =	265.20 cfm
			Average Drawdown =	246.93 cfm

Filling Rate:

Run 1-2	Elev. X Area / Idle Time (min.)	=	3.80' X 38.48□' / 55" =	159.52 cfm
Run 2-3			2.95' X 38.48□' / 42" =	162.17 cfm
			Average Filling =	160.84 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 246.93 + 160.84 = 407.77 cfm

407.77 cfm X 7.48 gal / cf = 3050.14 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 4 Date 11/13/89

Pump Tested No. 1 & No. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{3.45' \text{ X } 38.48^{\square'}}{40''}$ = 199.13 cfm

Run 2 $\frac{3.85' \text{ X } 38.48^{\square}}{45''}$ = 197.53 cfm

Run 3 $\frac{3.90' \text{ X } 38.48^{\square}}{50''}$ = 180.08 cfm

Average Drawdown = 192.25 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{3.75' \text{ X } 38.48^{\square'}}{50''}$ = 173.16 cfm

Run 2-3 $\frac{3.80' \text{ X } 38.48^{\square'}}{50''}$ = 175.47 cfm

Average Filling = 174.31 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 192.25 + 174.31 = 366.56 cfm

366.56 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 2741.90 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 4 Date 11/13/89

Pump Tested NO. 2 & NO. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1	Elev. X Area / Run Time (min.)	= 4.45' X 38.48□' / 45" =	228.31 cfm
Run 2		4.55' X 38.48□' / 55" =	191.0 cfm
Run 3		3.85' X 38.48□' / 50" =	177.78 cfm
		Average Drawdown =	199.02 cfm

Filling Rate:

Run 1-2	Elev. X Area / Idle Time (min.)	= 4.45' X 38.48□' / 58" =	177.14 cfm
Run 2-3		4.35' X 38.48□' / 52" =	193.14 cfm
		Average Filling =	185.14 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 199.02 + 185.14 = 384.16 cfm

384.16 cfm X 7.48 gal / cf = 2873.52 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 4 Date 11/13/89

Pump Tested No. 1, No. 2, & No. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1	Elev. X Area / Run Time (min.)	= 4.05' X 38.48□' / 30"	=	311.69 cfm
Run 2		4.5' X 38.48□' / 34"	=	305.58 cfm
Run 3		4.55' X 38.48□' / 35"	=	300.14 cfm
		Average Drawdown	=	305.80 cfm

Filling Rate:

Run 1-2	Elev. X Area / Idle Time (min.)	= 4.15' X 38.48□' / 1.00	=	159.69 cfm
Run 2-3		4.55' X 38.48□' / 1.00	=	175.08 cfm
		Average Filling	=	167.39 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 305.80 + 167.39 = 473.19 cfm

473.19 cfm X 7.48 gal/cf = 3539.44 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No 5 Date 11/8/89

Pump Tested No. 1

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.65' \times 19.63^{\square'}}{1.0}$ = 32.39 cfm

Run 2 $\frac{1.67' \times 19.63^{\square'}}{1.0}$ = 32.78 cfm

Run 3 $\frac{1.20' \times 19.63^{\square'}}{42''}$ = 33.65 cfm

Average Drawdown = 32.94 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.3' \times 19.63^{\square'}}{2.0}$ = 2.94 cfm

Run 2-3 $\frac{1.74' \times 19.63}{5.50}$ = 6.21 cfm

Average Filling = 4.58 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 32.94 + 4.58 = 37.52 cfm

37.52 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 280.65 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 5 Date 11/15/89

Pump Tested No. 2

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.80' \times 19.63^{\square'}}{0.5} =$ 31.41 cfm

Run 2 $\frac{0.75' \times 19.63^{\square'}}{0.5} =$ 29.45 cfm

Run 3 $\frac{0.80' \times 19.63^{\square'}}{0.5} =$ 31.41 cfm

Average Drawdown = 30.76 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.50' \times 19.63^{\square'}}{2.50} =$ 3.93 cfm

Run 2-3 $\frac{0.45' \times 19.63^{\square'}}{2.50} =$ 3.53 cfm

Average Filling = 3.73 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 30.76 + 3.73 = 34.49 cfm

34.49 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 258 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 5 Date 11/15/89

Pump Tested NO. 1 & NO. 2

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.95' \times 19.63^2}{0.5}$ = 37.30 cfm

Run 2 $\frac{0.90' \times 19.63^2}{0.5}$ = 35.33 cfm

Run 3 $\frac{1.70' \times 19.63^2}{56''}$ = 35.75 cfm

Average Drawdown = 36.13 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.75' \times 19.63^2}{5.00}$ = 2.94 cfm

Run 2-3 $\frac{.05' \times 19.63^2}{5.50}$ = 3.75 cfm

Average Filling = 3.34 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 36.13 + 3.34 = 39.47 cfm

39.47 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 295.24 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 6 Date 11/8/89

Pump Tested No. 1

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.10' \times 19.63^{\square'}}{1.0}$ = 21.60 cfm

Run 2 $\frac{1.16' \times 19.63^{\square'}}{1.0}$ = 22.80 cfm

Run 3 $\frac{1.03' \times 19.63^{\square'}}{1.0}$ = 20.20 cfm

Average Drawdown = 21.50 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.80' \times 19.63^{\square'}}{1.0}$ = 15.70 cfm

Run 2-3 $\frac{0.61' \times 19.63^{\square'}}{1.0}$ = 12.0 cfm

Average Filling = 13.85 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 21.50 + 13.85 = 35.35 cfm

35.35 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 264.42 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 6 Date 11/8/89

Pump Tested No. 2

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.0' \times 19.63^{\square'}}{1.0}$ = 19.63 cfm

Run 2 $\frac{0.97' \times 19.63^{\square'}}{1.0}$ = 19.04 cfm

Run 3 $\frac{1.02' \times 19.63^{\square'}}{1.0}$ = 20.02 cfm

Average Drawdown = 19.56 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.60' \times 19.63^{\square'}}{1.0}$ = 11.78 cfm

Run 2-3 $\frac{0.63' \times 19.63^{\square'}}{1.0}$ = 12.37 cfm

Average Filling = 12.08 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 19.56 + 12.08 = 31.64 cfm

31.64 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 236.67 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 6 Date 12/22/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.50' \times 19.63^{\square'}}{15''}$ = 39.26 cfm

Run 2 $\frac{0.55' \times 19.63^{\square'}}{15''}$ = 43.19 cfm

Run 3 $\frac{0.60' \times 19.63^{\square'}}{15''}$ = 47.11 cfm

Average Drawdown = 43.19 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.40' \times 19.63^{\square'}}{45''}$ = 10.47 cfm

Run 2-3 $\frac{0.45' \times 19.63^{\square'}}{45''}$ = 11.78 cfm

Average Filling = 11.12 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 43.19 + 11.12 = 54.31 cfm

54.31 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 406.27 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 7 Date 11/13/89

Pump Tested No. 1

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.35' \times 38.48□'}{2.00}$ = 25.97 cfm

Run 2 $\frac{1.40' \times 38.48□}{2.00}$ = 26.94 cfm

Run 3 $\frac{1.30' \times 38.48□'}{2.00}$ = 25.01 cfm

Average Drawdown = 25.97 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.70' \times 38.48□'}{1.00}$ = 65.42 cfm

Run 2-3 $\frac{1.35' \times 38.48□'}{.50''}$ = 62.34 cfm

Average Filling = 63.88 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 25.97 + 63.88 = 89.85 cfm

89.85 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 672.08 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station: No. 7   Date: 11/13/89

Pump Tested: No. 2

X-Sectional Area, Wet Well: 38.48 sq. ft.

Drawdown Rate:

Run 1	$\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.15' \times 38.48^{\square'}}{2.00}$ =	22.13	cfm
Run 2	$\frac{1.50' \times 38.48^{\square'}}{3.00}$ =	19.24	cfm
Run 3	$\frac{1.45' \times 38.48^{\square'}}{3.00}$ =	18.60	cfm
	Average Drawdown =	20	cfm

Filling Rate:

Run 1-2	$\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.1' \times 38.48^{\square'}}{40''}$ =	63.49	cfm
Run 2-3	$\frac{1.55' \times 38.48^{\square'}}{.55''}$ =	65.07	cfm
	Average Filling =	64.28	cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 64.28 + 20 = 84.28 cfm

84.28 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 630.41 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 7 Date 11/13/89

Pump Tested No. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.25' \text{X } 38.48^{\square'}}{3.00}$ = 28.86 cfm

Run 2 $\frac{2.05' \text{X } 38.48^{\square'}}{3.00}$ = 26.29 cfm

Run 3 $\frac{1.90' \text{X } 38.48^{\square'}}{3.00}$ = 24.37 cfm

Average Drawdown = 26.51 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.85' \text{X } 38.48^{\square'}}{1.00}$ = 71.19 cfm

Run 2-3 $\frac{1.75' \text{X } 38.48^{\square'}}{1.00}$ = 67.34 cfm

Average Filling = 69.27 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 69.27 + 26.51 = 95.78 cfm

95.78 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 716.43 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 7 Date 11/15/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.60' \text{ X } 38.48 \square'}{1.00}$ = 100.05 cfm

Run 2 $\frac{2.60' \text{ X } 38.48 \square'}{1.00}$ = 100.05 cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 100.05 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{2.60' \text{ X } 38.48 \square'}{1' 20''}$ = 75.04 cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 75.04 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 100.05 + 75.04 = 175.09 cfm

175.09 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1309.67 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 7 Date 11/13/89

Pump Tested No. 1 & No. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.85' \text{ X } 38.48 \square'}{1.00 \text{ min}}$ = 109.67 cfm

Run 2 $\frac{2.90' \text{ X } 38.48 \square'}{1.00 \text{ min.}}$ = 111.59 cfm

Run 3 ______ X ______ = ______ cfm

Average Drawdown = 110.63 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{2.70' \text{ X } 38.48 \square'}{1' 20''}$ = 73.34 cfm

Run 2-3 ______ X ______ = ______ cfm

Average Filling = 73.34 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 110.63 + 73.34 = 183.97 cfm

183.97 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 1376.10 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 7 Date 11/13/89

Pump Tested No. 2 & No. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.55' \text{X } 38.48^{\square'}}{1.00}$ = 98.12 cfm

Run 2 $\frac{2.70' \text{X } 38.48^{\square'}}{1.00}$ = 103.9 cfm

Run 3 X = cfm

Average Drawdown = 101 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{2.75' \text{X } 38.48^{\square'}}{1.5}$ = 70.55 cfm

Run 2-3 X = cfm

Average Filling = 70.55 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 101 + 70.55 = 171.55 cfm

171.55 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1283.25 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 7 Date 11/13/89

Pump Tested No. 1, No. 2, & No. 3

X-Sectional Area, Wet Well 38.48 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.95' \text{ X } 38.48 \square'}{37''}$ = 184.08 cfm

Run 2 $\frac{3.55' \text{ X } 38.48 \square'}{47''}$ = 174.39 cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 179.24 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{2.85' \text{ X } 38.48 \square'}{1'38''}$ = 67.14 cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 67.14 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 179.24 + 67.14 = 246.38 cfm

246.38 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1842.92 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 8 Date 11/17/89

Pump Tested No. 1

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.54' \times 12.57 \square'}{50''}$ = 8.15 cfm

Run 2 $\frac{0.40' \times 12.57 \square'}{40''}$ = 7.54 cfm

Run 3 $\frac{0.38' \times 12.57 \square'}{0.5}$ = 9.55 cfm

Average Drawdown = 8.41 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.69' \times 12.57 \square'}{5.0}$ = 1.73 cfm

Run 2-3 $\frac{0.68' \times 12.57 \square'}{3.5}$ = 2.44 cfm

Average Filling = 2.09 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 8.41 + 2.09 = 10.50 cfm

10.50 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 78.54 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 8 Date 11/17/89

Pump Tested No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.54' \times 12.57^{\square'}}{50''}$ = 8.15 cfm

Run 2 $\frac{0.40' \times 12.57^{\square'}}{40''}$ = 7.54 cfm

Run 3 $\frac{0.38' \times 12.57^{\square'}}{0.5}$ = 9.55 cfm

Average Drawdown = 8.41 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.69' \times 12.57^{\square'}}{5.0}$ = 1.73 cfm

Run 2-3 $\frac{0.68' \times 12.57^{\square'}}{3.5}$ = 2.44 cfm

Average Filling = 2.09 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 8.41 + 2.09 = 10.50 cfm

10.50 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 78.54 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 8 Date 11/17/89

Pump Tested No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.32' \times 12.57^{\square'}}{0.5} =$ 8.04 cfm

Run 2 $\frac{0.35' \times 12.57^{\square'}}{0.5} =$ 8.80 cfm

Run 3 $\frac{0.36' \times 12.57^{\square'}}{0.5} =$ 9.05 cfm

Average Drawdown = 8.63 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.37' \times 12.57^{\square'}}{1.75} =$ 2.66 cfm

Run 2-3 $\frac{0.36' \times 12.57^{\square'}}{1.50} =$ 3.02 cfm

Average Filling = 2.84 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 8.63 + 2.84 = 11.47 cfm

11.47 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 85.78 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 8 Date 11/17/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.38' \times 12.57□'}{0.5} =$ 9.55 cfm

Run 2 $\frac{0.39' \times 12.57□'}{0.5} =$ 9.80 cfm

Run 3 $\frac{0.37' \times 12.57□'}{0.5} =$ 9.30 cfm

Average Drawdown = 9.55 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.37' \times 12.57□'}{2.0} =$ 2.33 cfm

Run 2-3 $\frac{0.40' \times 12.57□'}{2.0} =$ 2.51 cfm

Average Filling = 2.42 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 9.55 + 2.42 = 11.97 cfm

11.97 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 89.54 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station NO. 9 Date 12/1/89

Pump Tested No. 1

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{-0.10' \text{ X } 12.57^{\square'}}{2.0}$ = −0.63 cfm

Run 2 ____ X ____ = ____ cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = ____ cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.20' \text{ X } 12.57^{\square'}}{40''}$ = 3.77 cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = ____ cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 3.77 + (−0.63) = 3.14 cfm

3.14 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 23.49 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station No. 9 Date 12/1/89

Pump Tested NO. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.10' \times 12.57^{\square'}}{1.50}$ = 0.84 cfm

Run 2 $\frac{0.23' \times 12.57^{\square'}}{3.50}$ = 0.83 cfm

Run 3 $\frac{0.19' \times 12.57^{\square'}}{2.00}$ = 1.19 cfm

Average Drawdown = 0.95 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.30' \times 12.57^{\square'}}{1.25}$ = 3.02 cfm

Run 2-3 $\frac{0.28' \times 12.57^{\square'}}{1' 10''}$ = 3.02 cfm

Average Filling = 3.02 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 0.95 + 3.02 = 3.97 cfm

3.97 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 29.70 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station: No. 9   Date: 12/1/89

Pump Tested: No. 1 & No. 2

X-Sectional Area, Wet Well: 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.35' \times 12.57^{\square'}}{3'50''} =$ 1.15 cfm

Run 2 $\frac{0.25' \times 12.57^{\square'}}{3.00} =$ 1.05 cfm

Run 3 $\frac{0.27' \times 12.57^{\square'}}{3.00} =$ 1.13 cfm

Average Drawdown = 1.11 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.30' \times 12.57^{\square'}}{1.25} =$ 3.02 cfm

Run 2-3 $\frac{0.25' \times 12.57^{\square'}}{1'10''} =$ 2.69 cfm

Average Filling = 2.86 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 1.11 + 2.86 = 3.97 cfm

3.97 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 29.70 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER "C" Date ·/9/89

Pump Tested No. 1

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.98' \text{ X } 12.57^{\square'}}{0.25}$ = 49.27 cfm

Run 2 $\frac{0.97' \text{ X } 12.57^{\square'}}{0.25}$ = 48.77 cfm

Run 3 X = cfm

Average Drawdown = 49.02 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.37' \text{ X } 12.57^{\square'}}{3.00}$ = 1.55 cfm

Run 2-3 X = cfm

Average Filling = 1.55 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 49.02 + 1.55 = 50.57 cfm

50.57 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 378.26 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER "F" Date 1-1??

Pump Tested NO. 1

X-Sectional Area, Wet Well 50.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.65' \text{ X } 50.27^{\square'}}{1.0}$ = 82.15 cfm

Run 2 $\frac{1.90' \text{ X } 50.27^{\square'}}{1.0}$ = 95.51 cfm

Run 3 $\frac{1.95' \text{ X } 50.27^{\square}}{1.0}$ = 99.03 cfm

Average Drawdown = 92.16 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.75' \text{ X } 50.27^{\square'}}{5'40''}$ = 15.52 cfm

Run 2-3 $\frac{2.15' \text{ X } 50.27^{\square'}}{7.25}$ = 14.91 cfm

Average Filling = 15.21 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 92.16 + 15.21 = 107.37 cfm

107.37 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 803.16 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER "F" Date 1-/-/-

Pump Tested No. 2

X-Sectional Area, Wet Well 50.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.0' \text{ X } 50.27^{\square}}{0.5}$ = 100.54 cfm

Run 2 $\frac{1.05' \text{ X } 50.27^{\square}}{0.5}$ = 105.57 cfm

Run 3 $\frac{0.95' \text{ X } 50.27^{\square}}{0.5}$ = 95.51 cfm

Average Drawdown = 100.54 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{1.05' \text{ X } 50.27^{\square}}{3.5}$ = 15.08 cfm

Run 2-3 $\frac{.90' \text{ X } 50.27^{\square}}{2.5}$ = 18.10 cfm

Average Filling = 16.59 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 100.54 + 16.59 = 117.13 cfm

117.13 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 876.12 gpm

PUMP STATION CALCULATION SHEET

OAVIS & FLOYD, INC.

Pump Station PIER "F" Date 1/7/11

Pump Tested NO. 1 & NO. 2

X-Sectional Area, Wet Well 50.27 sq. ft.

Drawdown Rate:

Run 1 (Elev. X Area) / (Run Time (min.)) = (1.05' X 50.27□') / 0.5 = 105.57 cfm

Run 2 (1.05' X 50.27□') / 0.5 = 105.57 cfm

Run 3 (1.00' X 50.27□') / 0.5 = 100.54 cfm

Average Drawdown = 103.89 cfm

Filling Rate:

Run 1-2 (Elev. X Area) / (Idle Time (min.)) = (0.95' X 50.27□') / 1.00 = 47.76 cfm

Run 2-3 (0.75 X 50.27□') / 1.00 = 37.70 cfm

Average Filling = 42.73 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 103.89 + 42.73 = 146.62 cfm

146.62 cfm X 7.48 gal / cf = 1096.73 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station: PIER "K" Date: [illegible]

Pump Tested: No. 1 (ONLY OPERABLE PUMP)

X-Sectional Area, Wet Well: 50.27 sq. ft.

Drawdown Rate:

Run 1: $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.9' \times 50.27}{40''} = 67.86$ cfm

Run 2: $\frac{0.65 \times 50.27'}{0.5} = 65.35$ cfm

Run 3: $\frac{[illegible]' \times 50.27}{0.5} = 77.42$ cfm

Average Drawdown = 70.21 cfm

Filling Rate:

Run 1-2: $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}} = \frac{0.12' \times 50.27'}{4.5} = 1.34$ cfm

Run 2-3: $\frac{0.08' \times 50.27'}{4.0} = 1.00$ cfm

Average Filling = 1.17 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 70.21 + 1.17 = 71.38 cfm

71.38 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 533.92 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER 'P' Date [illegible]

Pump Tested No. 1 (ONLY PUMP OPERABLE)

X-Sectional Area, Wet Well 78.54 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.05' \text{ X } 78.54^{ft^2}}{1.00}$ = 161 cfm

Run 2 $\frac{1.50' \text{ X } 78.54^{ft^2}}{0.75}$ = 157.08 cfm

Run 3 $\frac{1.85' \text{ X } 78.54^{ft^2}}{1.00}$ = 145.30 cfm

Average Drawdown = 154.46 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = $\frac{0.70' \text{ X } 78.54^{ft^2}}{4.00}$ = 13.74 cfm

Run 2-3 $\frac{1.00' \text{ X } 78.54^{ft^2}}{5.00}$ = 15.71 cfm

Average Filling = 14.72 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 154.46 + 14.72 = 169.18 cfm

169.18 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1265.50 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER "S" Date 11/17/84

Pump Tested No. 1

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.15' \text{ X } 28.27}{0.5}$ = 65.02 cfm

Run 2 ____ X ____ = ____ cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 65.02 cfm

Filling Rate:

(NO FILLING OCCURRED)

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 65.02 + 0 = 65.02 cfm

65.02 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 486.36 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER 'S' Date 1/17/89

Pump Tested NO. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.05' \text{ X } 28.27^{\square'}}{0.5}$ = 59.37 cfm

Run 2 ______ X ______ = ______ cfm

Run 3 ______ X ______ = ______ cfm

Average Drawdown = 59.37 cfm

Filling Rate: (NO FILLING OCCURRED)

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ______ X ______ = ______ cfm

Run 2-3 ______ X ______ = ______ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 59.37 + - 0 = 59.37 cfm

59.37 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 444.07 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station PIER "S" Date 1/7/19

Pump Tested NO. 1 & NO. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.35' \text{ X } 28.27 \text{ sf}}{0.5}$ = 76.33 cfm

Run 2 X = cfm

Run 3 X = cfm

Average Drawdown = cfm

Filling Rate: (NO FILLING OCCURRED)

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = X = cfm

Run 2-3 X = cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 76.33 + 0 = 76.33 cfm

76.33 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 570.94 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. X-54 Date 11/9/89

Pump Tested NO. 1

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.37' \times 28.27\square'}{40''}$ = 15.69 cfm

Run 2 $\frac{0.42' \times 28.27\square'}{40''}$ = 17.81 cfm

Run 3 $\frac{0.41' \times 28.27\square'}{40''}$ = 17.39 cfm

Average Drawdown = 16.96 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 16.96 + -0 = 16.96 cfm

16.96 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 126.88 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. X-54 Date 11/9/89

Pump Tested No. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.21' \times 28.27^{\square'}}{0.5}$ = 15.27 cfm

Run 2 $\frac{0.24' \times 28.27^{\square'}}{0.5}$ = 13.57 cfm

Run 3 $\frac{0.23' \times 28.27^{\square'}}{0.5}$ = 13.0 cfm

Average Drawdown = 13.95 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 13.95 + 0 = 13.95 cfm

13.95 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 104.33 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. X-54 Date 1/17/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.84' \times 28.27^{\square'}}{50''}$ = 28.50 cfm

Run 2 $\frac{0.77' \times 28.27^{\square'}}{45''}$ = 29.02 cfm

Run 3 ______ X ______ = ______ cfm

Average Drawdown = 28.76 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ______ X ______ = ______ cfm

Run 2-3 ______ X ______ = ______ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 28.76 + -0 = 28.76 cfm

28.76 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 215.14 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 655 Date 12/21/89

Pump Tested No. 1

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.60' \times 12.57\square'}{15''}$ = 30.17 cfm

Run 2 $\frac{0.50' \times 12.57\square'}{15''}$ = 25.14 cfm

Run 3 $\frac{0.30' \times 12.57\square'}{10''}$ = 22.63 cfm

Average Drawdown = 25.98 cfm

Filling Rate: (NO FILLING OCCURRED)

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = X = cfm

Run 2-3 X = cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 25.98 + 0 = 25.98 cfm

25.98 cfm X 7.48 gal/cf = 194.32 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 655 Date 12/21/89

Pump Tested No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1	Elev. X Area / Run Time (min.)	= 0.15' X 12.57□' / 15" =	7.54	cfm
Run 2		0.05' X 12.57□' / 15" =	2.51	cfm
Run 3		0.05' X 12.57□' / 15" =	2.51	cfm
		Average Drawdown =	4.19	cfm

Filling Rate:

Run 1-2	Elev. X Area / Idle Time (min.)	= X =		cfm
Run 2-3		X =		cfm
		Average Filling =	0	cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 4.19 + 0 = 4.19 cfm

4.19 cfm X 7.48 gal / cf = 31.33 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 655 Date 12/21/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 12.57 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.6' \text{ X } 12.57 \square'}{15''}$ = 30.17 cfm

Run 2 $\frac{0.5' \text{ X } 12.57 \square'}{15''}$ = 25.14 cfm

Run 3 $\frac{0.55' \text{ X } 12.57 \square'}{15''}$ = 27.65 cfm

Average Drawdown = 27.65 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ___ X ___ = ___ cfm

Run 2-3 ___ X ___ = ___ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 27.65 + - 0 = 27.65 cfm

27.65 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 206.86 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 661 Date 11/9/89

Pump Tested No. 1

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 — Elev. X Area / Run Time (min.) = 0.36' X 28.27□' / 31.5" = 19.39 cfm

Run 2 ____ X ____ = ____ cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 19.39 cfm

Filling Rate: (NO FILLING OCCURRED)

Run 1-2 — Elev. X Area / Idle Time (min.) = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 19.39 + 0 = 19.39 cfm

19.39 cfm X 7.48 gal / cf = 145 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 661 Date 11/9/89

Pump Tested NO. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.36' \times 28.27^{\square'}}{30.5''}$ = 20.02 cfm

Run 2 ____ X ____ = ____ cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 20.02 cfm

Filling Rate: (NO FILLING OCCURRED)

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 20.02 + 0 = 20.02 cfm

20.02 cfm X $\frac{7.48\ \text{gal}}{\text{cf}}$ = 149.75 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 661 Date 11/17/89

Pump Tested NO. 1 & NO. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.41' \times 28.27 \square'}{0.5}$ = 23.18 cfm

Run 2 ____ X ____ = ____ cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 23.18 cfm

Filling Rate: (NO FILLING OCCURRED)

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 23.18 + -0 = 23.18 cfm

23.18 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 173.40 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG 247 Date 11/9/8[illegible]

Pump Tested NO. 1

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1	Elev. X Area / Run Time (min.) =	1.70' X 19.63 □' / 2.00 =	16.69 cfm
Run 2		0.75' X 19.63 □' / 1.00 =	14.72 cfm
Run 3		0.75' X 19.63 □' / 1.00 =	14.72 cfm
		Average Drawdown =	15.38 cfm

Filling Rate:

Run 1-2	Elev. X Area / Idle Time (min.) =	0 X 19.63 □' / 2.00 =	0 cfm
Run 2-3		0 X 19.63 □' / 2.00 =	0 cfm
		Average Filling =	0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 15.38 + 0 = 15.38 cfm

15.38 cfm X 7.48 gal/cf = 115 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 247 Date 4.79

Pump Tested NO. 2

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{0.13' \text{ X } 19.63^2}{42''}$ = 3.65 cfm

Run 2 $\frac{0.15' \text{ X } 19.63^2}{45''}$ = 3.93 cfm

Run 3 $\frac{0.14' \text{ X } 19.63^2}{45''}$ = 3.66 cfm

Average Drawdown = 3.75 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = 0 X 19.63 = 0 cfm

Run 2-3 0 X 19.63 = 0 cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 3.75 + 0 = 3.75 cfm

3.75 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 28.04 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BLDG. 247 Date 11/14/89

Pump Tested NO. 1 & NO. 2

X-Sectional Area, Wet Well 19.63 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}} = \frac{0.49' \times 19.63^{\square'}}{0.5} =$ 19.24 cfm

Run 2 $\frac{0.45 \times 19.63^{\square'}}{0.5} =$ 17.67 cfm

Run 3 $\frac{0.45' \times 19.63^{\square'}}{0.5} =$ 17.67 cfm

Average Drawdown = 18.19 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

Pumping Rate:

Avg. Drawdown + Avg. Filling = 18.19 + 0 = 18.19 cfm

18.19 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 136.08 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BALL FIELD Date 12/21/89

Pump Tested NO. 1

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.60' \times 28.27^{0'}}{20''}$ = 135.71 cfm

Run 2 $\frac{1.40' \times 28.27^{0'}}{20''}$ = 118.75 cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 127.23 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm
(LINE PLUGGED)

Pumping Rate:

Avg. Drawdown + Avg. Filling = 127.23 + 0 = 127.23 cfm

127.23 cfm X $\frac{7.48 \text{ gal}}{\text{cf}}$ = 951.66 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BALLFIELD Date 12/21/89

Pump Tested No. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{1.50' \times 28.27 \square'}{20''}$ = 127.23 cfm

Run 2 $\frac{1.75' \times 28.27 \square'}{20''}$ = 148.43 cfm

Run 3 ______ X ______ = ______ cfm

Average Drawdown = 137.83 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ______ X ______ = ______ cfm

Run 2-3 ______ X ______ = ______ cfm

Average Filling = 0 cfm

(LINE PLUGGED)

Pumping Rate:

Avg. Drawdown + Avg. Filling = 137.83 + 0 = 137.83 cfm

137.83 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1030.98 gpm

PUMP STATION CALCULATION SHEET

DAVIS & FLOYD, INC.

Pump Station BALLFIELD Date 12/21/89

Pump Tested No. 1 & No. 2

X-Sectional Area, Wet Well 28.27 sq. ft.

Drawdown Rate:

Run 1 $\frac{\text{Elev. X Area}}{\text{Run Time (min.)}}$ = $\frac{2.05' \times 28.27^{\square'}}{15''}$ = 231.81 cfm

Run 2 $\frac{1.95' \times 28.27^{\square'}}{15''}$ = 220.51 cfm

Run 3 ____ X ____ = ____ cfm

Average Drawdown = 226.16 cfm

Filling Rate:

Run 1-2 $\frac{\text{Elev. X Area}}{\text{Idle Time (min.)}}$ = ____ X ____ = ____ cfm

Run 2-3 ____ X ____ = ____ cfm

Average Filling = 0 cfm

(LINE PLUGGED)

Pumping Rate:

Avg. Drawdown + Avg. Filling = 226.16 + 0 = 226.16 cfm

226.16 cfm X $\frac{\text{7.48 gal}}{\text{cf}}$ = 1691.66 gpm

APPENDIX "E"
PUMP STATION PEAK FLOW CALCULATIONS

APPENDIX "E"

PUMP STATION PEAK FLOW CALCULATIONS

The following is a station-by-station listing of estimated pump station peak flows. The calculations are broken down into contributory flow from buildings and zones served by each pump station. All flows are presented as 1,000 gallons per day.

Pump Station		1990	1995	2000
No. 1				
Zone 27		62	66.5	69
+ Zone 28		119	124	172
+ Zone 29		34	34.5	35.5
+ Zone 30		54.5	55.5	56.5
+ Zone 31		83.5	88	91.5
+ Zone 32		52	58	60
+ Zone 33		44	51.5	53
+ Bldg. 84		1.14	1.2	1.25
+ Bldg. 646		8.2	8.6	9
+ Bldg. 644		2.9	3.0	3.1
+ Fire Training Area		27	28	30
	TOTAL:	488.2	519.2	581.25
	PEAK:	1464.6	1557.6	1743.75
No. 2				
Bldg. RTC-1		5.74	6.03	6.31
	PEAK:	17.22	18.09	18.93
No. 3				
CPO Pool (NS-639)		10.8	11.3	11.9
+ Brig (NS 648)		6	6.3	6.6
+ Bldg. NS-79		2	2.1	2.2
+ McDonald's		11.6	12.2	12.8
+ I/1		15	15	15
	TOTAL:	45.4	46.9	48.5
	PEAK:	136.2	140.7	145.5

Pump Station		1990	1995	2000
No. 4				
Zones 1-19		886	933.5	955
+ Mini-Mart (Bldg. 1346)		2.58	2.70	2.84
+ Bldg. 199		5	5.3	5.5
	TOTAL:	893.6	941.5	963.3
	PEAK:	2680.7	2824.5	2889.9
No. 5				
Zone 16		41.54	46	48
	PEAK:	124.5	138	144
No. 6				
Zone 15		45	46.5	48.0
- Bldg. 1178		.08	.08	.08
- Bldg. 25		.56	.59	.62
- Bldg. 1199		.68	.71	.74
	TOTAL:	43.7	45.1	46.6
	PEAK:	131.1	135.3	139.8
No. 7				
Zones 1-14		688.5	728.5	744
- Pier "F"		16.0	16.8	17.6
- Bldg. 247		0.18	0.19	0.20
	TOTAL:	672.3	711.5	726.2
	PEAK:	2016.9	2134.5	2178.6
No. 8				
Zone 2		35	35	35.5
- Res. "B" & "C"		0.46	0.48	0.51
	TOTAL:	34.5	34.5	35
	PEAK:	103.5	103.5	105
No. 9				
Zone 1		47.5	48	48
	PEAK:	142.5	144	144

Pump Station		1990	1995	2000
Pier "C-D"				
Bldgs. 46, 457, 1119		4.5	4.72	4.95
	PEAK:	13.5	14.2	14.9
Pier "F"		16.0	21.8	22.6
+ Bldg. 247		0.18	0.19	0.20
	TOTAL:	16.2	22	22.8
	PEAK:	48.6	66	68.4
Pier "K"		7.5	7.88	8.25
+ Pier "L"		4.5	12.7	13.36
+ Bldg. 185		0.5	0.53	0.55
	TOTAL:	12.5	21.1	22.2
	PEAK:	37.5	63.3	66.6
Pier "P"				
Zone 24		66.5	69	71.5
+ Zone 29		34	34.5	35.5
	TOTAL:	100.5	103.5	107
	PEAK:	301.5	310.5	321
Pier "S"				
Zone 29		34	34.5	35.5
- Pier "R"		1.3	1.35	1.4
	TOTAL:	32.7	33.15	34.1
	PEAK:	98.1	99.5	102.3
Building X-54		1.86	1.95	2.05
	PEAK:	5.58	5.85	6.15
Building 655		1.26	1.33	1.39
	PEAK:	3.78	4.0	4.11

Pump Station		1990	1995	2000
Building 661		1.14	1.2	1.25
	PEAK:	3.42	3.6	3.75
Building 247		0.2	0.21	0.22
	PEAK:	0.6	0.63	0.66
Ballfield Zone 18		31	31.5	32.5
	PEAK:	93	94.5	97.5

APPENDIX "F"
DEFINITIONS AND MISCELLANEOUS INFORMATION

DEFINITIONS

Sanitary Sewer: A sewer that carries liquid and waterborne wastes from residences, commercial buildings, industrial plants, and institutions, together with minor quantities of ground-, storm, and surface waters that are not admitted intentionally.

Gravity Line: A series of pipes which transport sewage on descending gradients from source to outlet, and which require no pumping.

Trunk Sewer: A sewer that receives many tributary branches and serves a large territory. (Example: Shipyard and Naval Station trunk lines.)

Manhole: A structure atop an opening in a gravity sewer to permit line access.

Surcharge: A condition existing in gravity lines in which the height of wastewater in a manhole is above the crown of the connecting sewer lines when the sewer is flowing completely full. (Example: Naval Supply Center gravity line upstream of Pump Station No. 9.)

Storm Sewer: A sewer that carries storm water, surface water, and street drainage, but excludes domestic wastewater and industrial wastes.

Peak Flow: The maximum instantaneous flow of wastewater.

Infiltration: The water entering a sewer system and service connections from the ground, through such means as pipe deficiencies, pipe joints, connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow.

Inflow: The water discharged into a sewer system and service connections from such source as roof leaders, yard and area drains, cross-connections from storm sewers, catch basins, surface runoff, or drainage. It does not include, and is distinguished from, inflow.

Infiltration/Inflow: The total quantity of water from both infiltration and inflow without distinguishing the source.

Pump Station: A structure containing pumps and other appurtenant piping, valves and other mechanical and electrical equipment for pumping wastewater.

Wet Well: A compartment in which sewage is collected. Wet wells are generally the storage structures for pump stations, which are set to pump liquid out of the wet well when it reaches a predetermined level.

Force Main: A pressure pipe that transports the pump discharge from a wastewater pumping station.

Wet Well-Dry Well: A sewage pump station that consists of a below grade compartment that houses all pumps, motors, electrical controls, etc., and a separate wet well. (Example: Pump Station Nos. 1-9.)

Submersible: A sewer pump station in which submersible pumps and other mechanical equipment is located within the wet well, with all electrical controls mounted aboveground. (Example: Ballfield Pump Station.)

"FORCE MAIN CLEANING"

Today the management and operators of waste water systems are becoming increasinly aware that the total efficiency and effectiveness of these systems are in large part dependent upon the collection system, connecting conduits and the varied functions of piping in their systems which constitute the largest dimensions and components of the entire system. After all, how effective can a multi-million dollar, perfectly designed waste water treatment facility be if the volume of effluent it is designed to receive, treat and dispose of can't be delivered to and discharged from it as per design because the piping systems servicing these facilities can't function as they were originally designed to do.

Engineers and designers of waste water piping systems have recognized that these piping systems are invariably subject to flow restricting and volume reducing characteristics due primarily to the physical and chemical nature of the effluent and related material that is transported through them.

That waste water piping systems can become "dirty" by any definition, is fairly indisputable, particularly by those who work in the field and must cope daily with waste water and effluent systems. The very nature of waste water effluent and the wide variety of unsavory elements that comprise this flow lends itself very readily to fallout, precipitation and sedimentation and subsequently to the development of dirty piping systems.

Consequently, the accepted and traditional design for gravity sewer piping systems generally has included the means to rehabilitate, correct or restore the flow or volume capacity in them. A typical piping configuration of a gravity system includes the operational sensible siteing of manholes for access into the system for cleaning, piping sized to accomodate low flow characteristics in a system and as much head differential for the piping system as the local topography will provide or allow.

Historically, these design features have proven to be necessary. This is again, due to the physical and chemical characteristics of the effluent passing through gravity piping systems, their propensity for picking up sand and other types of flow impeding material and the occasional "how did that get in there" surprise souvenir found in them, which warrants periodic cleaning of these systems. Consequently, the restoration of maximum flow capacity and required flow characteristics in a gravity sewer system is an accepted and routinely done procedure and is done to maintain the required efficiency of the system. Admittedly, the cleaning of many gravity systems is done primarily to relieve a localized problem in the piping itself, but the overall effect is the same, the maintenance or restoration of efficiency for the entire system.

In contrast, waste water force mains, which due to Florida's topography, are perhaps more commonly found here than in other areas, are not, as a rule, considered for any type of cleaning, both in their original design and as part of their normal operations.

In the past this reluctance to clean a force main despite the obvious benefits or doing so has been understandable. The apparent mechanical and logistical differences in the two systems would appear to present problems for force main cleaning that would make the costs of solving the flow problems in them exceed the benefits of cleaning them.

These problems include no strategically placed access points in a force main, the system is constantly flooded and under pressure, its routing, independent of gravity flow requirements and access points takes it through and many times under non-accessable areas and the length of the system can run for miles. These perceived difficulties have led to the concensus of opinion that when the cleaning of a force main is considered, it might be better to, "live with it, than mess with it."

However, force mains are subject to the same types of flow reducing and flow impeding problems that are found in gravity systems. In many force mains these problems are quickly compounded by the simple fact that when they develop within the system, they continue to grow and increasingly affect the operational ability of the system without any remedial action taken upon them.

When faced with a reducing flow and volume capacity in a force main, many operators of these systems will resort to many measures, including adding some form of chemical treatment to the lift station's holding tank to emulsify grease and similar deposits for example, or in a more resigned or desperate fashion, replacing the existing and likely still serviceable pumps with larger pumps in an earnest attempt to overcome the problem of restricting flow capacity in the system.

If the volume of flow to evacuate a lift station to the point where it will cycle to an off position is one thousand gallons and the force main it discharges into has a capacity of three thousand gallons, not an unusual ratio for many force main/lift stations, then the force main doesn't receive a full charge or opportunity to develop full bore flow through its entire configuration as the lift station pumps operate. This then creates inline conditions where the fallout of solids, sand that can only be kept in suspension if it is incorporated into a constant flow and other material of many descriptions can drop or settle out of the flow. Once this material has settled it can become very difficult to overcome its inert condition and reincorporate it into the flow when the system is flowing again. These deposits are also prone to find a "home" in piping deflections, fitting alignments, planned and installed low points in a system, going under or boxing out a canal or road for example, obstructional material left in the line from construction, and the material that previously was part of the discharging flow that has now been caught or trapped in the system. The end result of this can be a system that is unfortunately ideally set up for collecting more and more material, creating constantly growing "dams" of various sizes and at various locations and consequently seriously reducing both the volume and flow capacity of the system.

The other factor that makes force mains prime candidates for constantly reducing laminar flow characteristics in them is the physical and chemical aspects of the effluent transported through them. Usually, generically referred to as greasy or fatty deposits, it is this material which readily adheres to the interior pipe wall, regardless of the pipe's composition, and severely impairs the laminar or smoothness of the flow within the system. When this factor is combined with the physical depositing and collection of solids within the force main system, it is likely no longer capable of functioning as it was meant to do, resulting in restricted volume and impaired flow capacity.

Th major difference between the functioning of a gravity sewer system and its companion force mains, aside from the obvious mechanical difference, one is expensively pumped and the other obeys the free laws of gravity, is the matter of costs of operation.

In a gravity system, if the flow capacity of the system is restricted because of material accumulating in the piping, or adhering to the pipe walls, it may take more time to transfer the same volume of fluid through it. This may be acceptable as time in this situation is probably not a costly or operational consideration. Eventually, if the ultimate problem with a gravity system occurs, the system starts to back up and fill the manholes, then a solution to this problem is usually easily applied. In typical applications, the manholes are evacuated, the connecting piping is cleaned and the original design feature of providing access into the system proves its worth.

In a force main system, when its flow capacity is restricted due to deposited, adhering, accumulative or obstructional material, this easily applied solution is not available because you can't easily obtain access to the system. And besides, now we are talking about cleaning thousands of feet, if not miles of piping instead of a few hundred feet between manholes, so that even with an access point or two, traditional gravity sewer cleaning methods are no longer applicable.

When this problem in force mains happens, it usually results in:

a) pump run time way in excess of the designed or anticipated patterns,

b) "hot" pumps,

c) pump inline discharge pressures that can routinely exceed the pump manufacturere's warranty or guarantees,

d) stand-by or auxiliary pumps operating constantly,

e) increased dumping of expensive chemicals into the holding tank,

f) and a lot of swearing and holding of breath.

It can also result in the rapid or premature replacement of the pumps or its components because of the valid and genuine concerns of its operators. ("I'm not going to risk this station overflowing", "I can't live with this any longer", "I can't take the chance that the next time it will overflow", "You deal with the environmental people" - Pick one or more, or add your own.)

As for other problems, the biggest one by far is the wasteful expenditure for excess energy consumption by the pumps. For a lift station pump discharging into a dirty or restricted flow force main, this can easily be one hundred percent or more of what it should be or likely was when the system was operating with a "clean" force main.

There is a simple way to check whether a lift station pump is operating excessively. This is done by comparing current run time and kilowatt hour consumption for a particular lift station pump with the same operating figures of past years as illustrated in the following chart taken from the actual records of a system here in Florida. A review of this chart clearly shows that the costs of operation for this system have steadily risen every year. At seven cents ($ .07) a kilowatt hour it now costs approximately five hundred dollars ($500.00) a year more in 1988 to operate than it did in 1985. And this is a station that has been in operation for many years. What would the cost comparisons be if 1988 was compared to its first year of operation?

POWER USED FOR LIFT STATION #1

YEAR	RUNNING HOURS** MONTH	KWH DAY	KWH MONTH
1988*	273.00	54	1736
1987	273.13	48	1491
1986	251.93	46	1346
1985	238.25	39	1135

* Up to March 1988

** Average Value

Average monthly KWHRS used in 1988: 1736

Average monthly KWHRS used in 1985: 1135

Average monthly KWHRS increase: 601

601 KWHRS Per Month
x12 Months
7,212 - Annual Increase in Kilowatt Hour Usage.

7,212 Annual Increase
x .07 Assumed KWHR Cost
$504.84 - Annual Increase for Energy Consumption 1985 to 1988.

Up to now the operators and management of malfunctioning force main systems have had a very limited set of choices or alternatives to use in trying to resolve this problem. Most of these revolve around the gritting of teeth, the upgrading of pumps, the paying for excessive energy costs and maintenance, the diminishing hope that it won't get any worse and that they can, "live with it!"

The resolution of serious flow-related problems in a force main can be accomplished by eliminating and removing the causes of the flow restriction and volume reduction in the system. Although the procedure is different, the purpose is the same as done in a gravity system, rehabilitation of the system to restore design efficiency for the system as a whole. In other words, "Clean it so that it can work as it is supposed to do!"

The cleaning of a force main requires a procedure that can be easily applied, quickly completed and is economically sensible. This procedure should not required that the system be taken out of service for most force main systems have a very limited (or none) holding or back-up capacity and it must be able to clean the entire run of the system as one operation to eliminate the potential of by-passing any areas of inline blockage. It must be able to clean the system no matter how many fittings, low points or other interruptions of straight runs exist in it and at pressures that will not exert any strains or stresses upon the integrity of the system. Most important of all, it must be able to remove all of the adhering, deposited, accumulative or foreign material in the system so that original or design flow characteristics can be restored to the system and it can once again function properly. All of these criteria can be fully met by the poly pig piping system cleaning procedure.

In most applications, all that is required to set up the poly pig cleaning of a force main is one line-sized access point into the system. This can take the form of simply exchanging an elbow, ninety degree (90°) fitting, in the discharge piping of the lift station for a tee fitting which will then provide the required inlet port.

In situations where this is not feasible because of the lack of working room or other mechanical considerations, then the piping outside the lift station is exposed and a line-sized tee is installed in it. If the lift station has a valve on its downstream side, then the tee is inserted on the lift station side of this valve. (If a valve isn't available, this is also an excellent opportunity to install one.)

A poly pig launching device is then attached to this port. The only other requirement for cleaning is to then provide an auxiliary supply of water connected to the pig launcher to be used to pressurize or force the pigs into the system and to supplement the flows in the force main. Otherwise, the cleaning and movement of the poly pigs through the system will be completely and solely dependent upon the effluent collecting in the lift station. Although only using the collecting effluent can be utilized, it can extend the time of the procedure considerably. With these requirements completed, the first criteria for properly cleaning a force main, "It should be easily applied", can as well be easily met. The second criteria, "It should be quickly completed", is also an advantage of the poly pig procedure. At an average inline velocity of three feet a second, a poly pig can travel, navigate and clean through a mile of piping in approximately thirty minutes. The number, sizes and types of poly pigs to be used is obviously dependent upon the volume and type of material to be removed from the force main. This factor also dictates how many runs or passages of the poly pigs through the system will be required to clean it.

As the lift station is completely operational during the time its force main is being cleaned, except for the time required to install, change or remove any necessary access ports or piping, there is no, "We've got to be back on line and operational by a certain time", factor hanging over anyone's head. In normal operation, a mile of force main piping can readily be cleaned in eight hours. If it should take longer, the cleaning procedure can simply be continued until it is completed or it can be halted and completed the following day.

Can the poly pig pipe cleaning procedure be economically sensible? If you consider that a dirty or flow impaired force main is more than likely costing a lot of wasted funding in real dollars needlessly expended for electrical costs, treatment chemicals and excessive pump maintenance, repairs, and replacement charges, then eliminating this clear waste of money is certainly economically sensible. Once the system has been cleaned and an access point provided in it, you now have permanent control of its inline flow chracteristics and can then keep it operating at its maximum flow capacity all the time. What is it worth to know that if a system starts to show signs of reduced efficiency, inline pressures start going up, lift station takes longer to evacuate, etc., that all that is likely required to restore the system to its proper working is the hand inserted passing of a poly pig through it.

Further reason and evidence to support practical considerations for cleaning a force main is provided by the following record of pumping energy consumption and electrical costs for a small lift station with seventeen hundred feet of four inch (4") force main servicing it here in Florida.

Period End Date	Days	KWH Used	Current Average KWH/Day	Prior Yr. Average KWH/Day	Current KWH Demand	Prior Yr. Kwh Demand	Current Amount Billed	Prior Amount Billed
1/27/87	35	4837	138	148	20	20	362.53	
2/25/87	29	3554	123	135	20	20	314.19	327.84
3/26/87	29	2398	83	153	20	20	270.65	353.89
4/24/87	29	2166	75	151	20	20	258.15	373.59
5/26/87	32	2664	83	150	20	20	276.05	343.02
6/23/87	28	2086	75	155	20	20	255.28	360.68
7/23/87	30	2086	70	190	20	20	255.28	431.37
8/24/87	32	2271	71	222	20	20	261.93	430.06
9/22/87	29	3096	107	247	20	20	291.58	486.26
'/21/87	29	2333	80	255	20	20	259.98	458.43
11/20/87	30	2821	94	254	20	20	276.66	457.33
12/22/87	31	3313	104	143	20	20	293.00	358.23

In the ten months that this system has been operating since it was cleaned and restored to its maximum flow capacity, the daily average kilowatt hour consumption was reduced from 192.0 KWH per day to 84.2 KWH per day, a reduction of 56%. The monthly cost for operating this system was reduced from a monthly average cost of $405.30 to a cost of $240.55, a reduction of 41%, which resulted in an actual dollar savings of $1,647.50 for operating this system in a ten month period.

*This force main was cleaned by Professional Piping Services, Inc. on March 3, 1987.

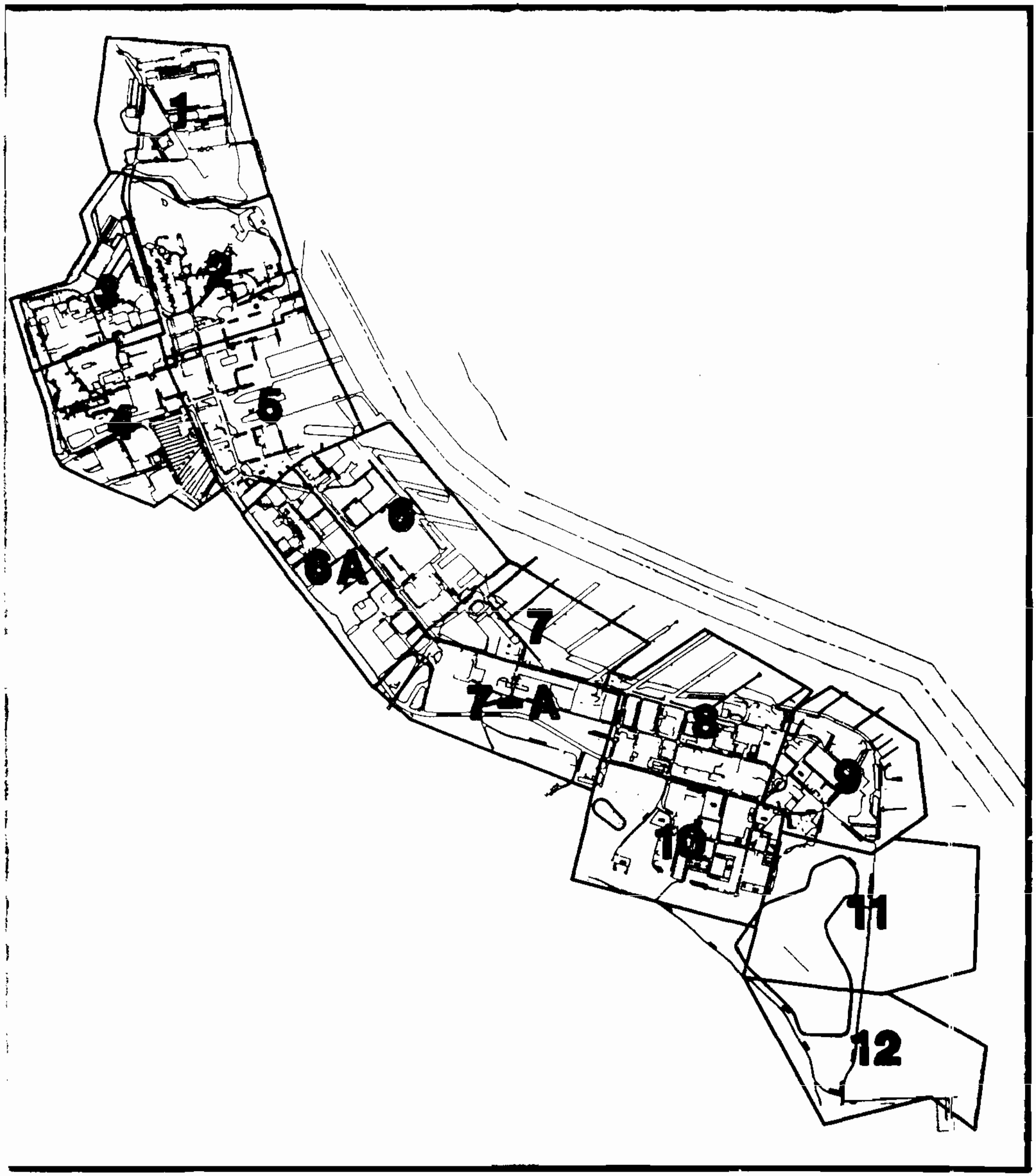
It should be noted that cleaning a force main and restoring it to its proper or designed operating condition does not alter the system in any way. Nothing is added to or subtracted from the system, no valves or piping are changed, the pumps are not modified or replaced. In fact, no changes with the system occur at all, except for one significant thing. With the force main cleaned and restored to its designed capability, the entire system can then function as it was designed to do, which is all anyone ever wants it to do anyway!

As the use of the poly pig pipe cleaning procedure is demonstrating its practical value in existing force main systems, designers and engineers are now routinely as they previously have for gravity systems, including in their design and specifications for force main systems, the means to clean them. These specifications also routinely require that the systems be cleaned before they are put into service to eliminate the possibility that a newly constructed force main doesn't have a head start on getting dirty because of debris or sand left in it.

The concerns of operators and the management of waste water systems about having to live with a dirty or flow restricted force main can now be alleviated. These systems can be easily cleaned and as readily maintained in a clean condition. Doing this can result in an excellent "pay back" period, where the real dollars saved for reducing energy, treatment or maintenance costs can be measured in money no longer expended or wasted needlessly. After all this is simply what everyone wants or needs, a system to work properly and to operate at a non-escalating cost rate.

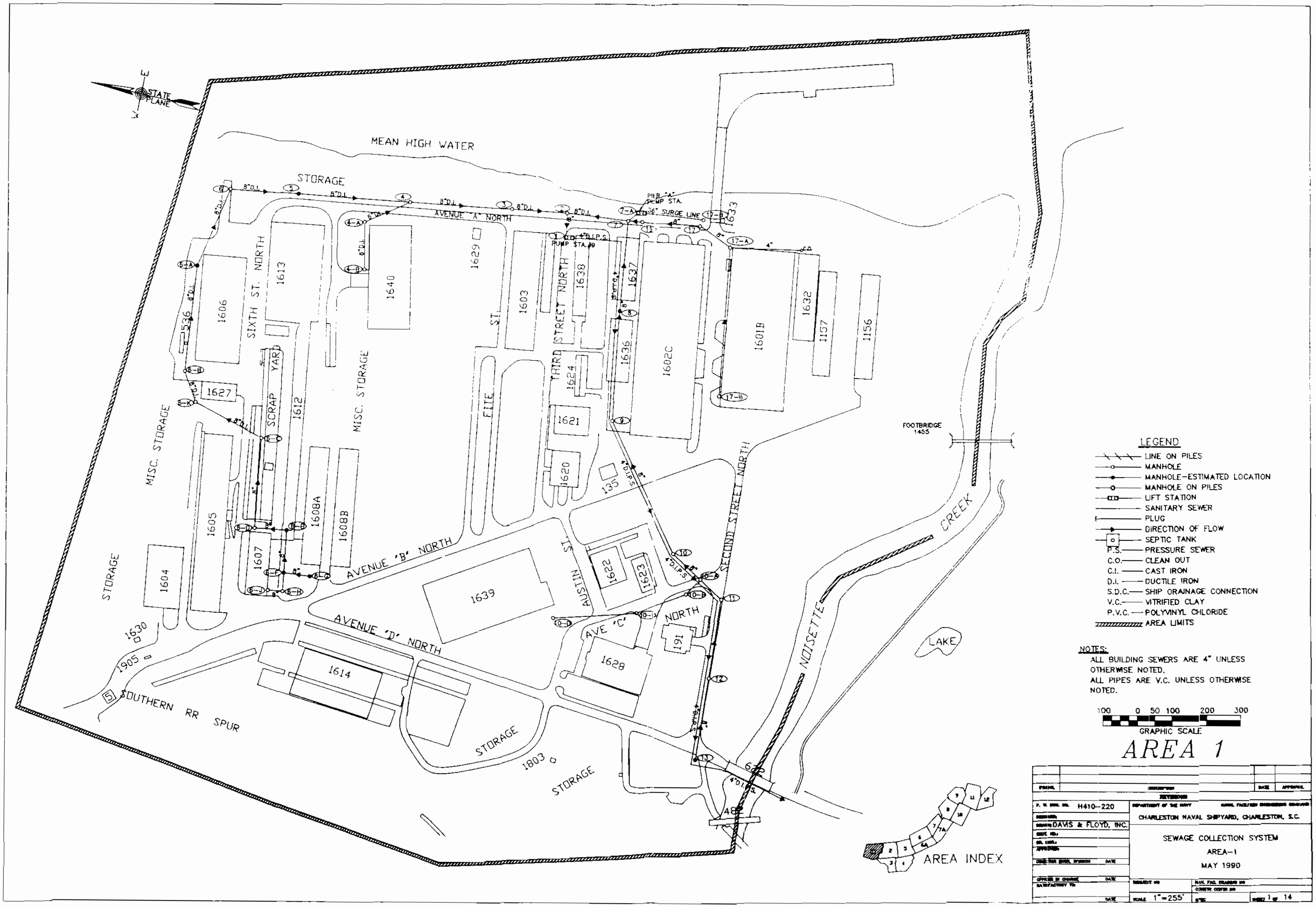
Cleaning a force main can provide exactly what is needed.

Roger M. Cimbora is the General Manager of Professional Piping Services, Inc. Land O' Lakes, Florida.

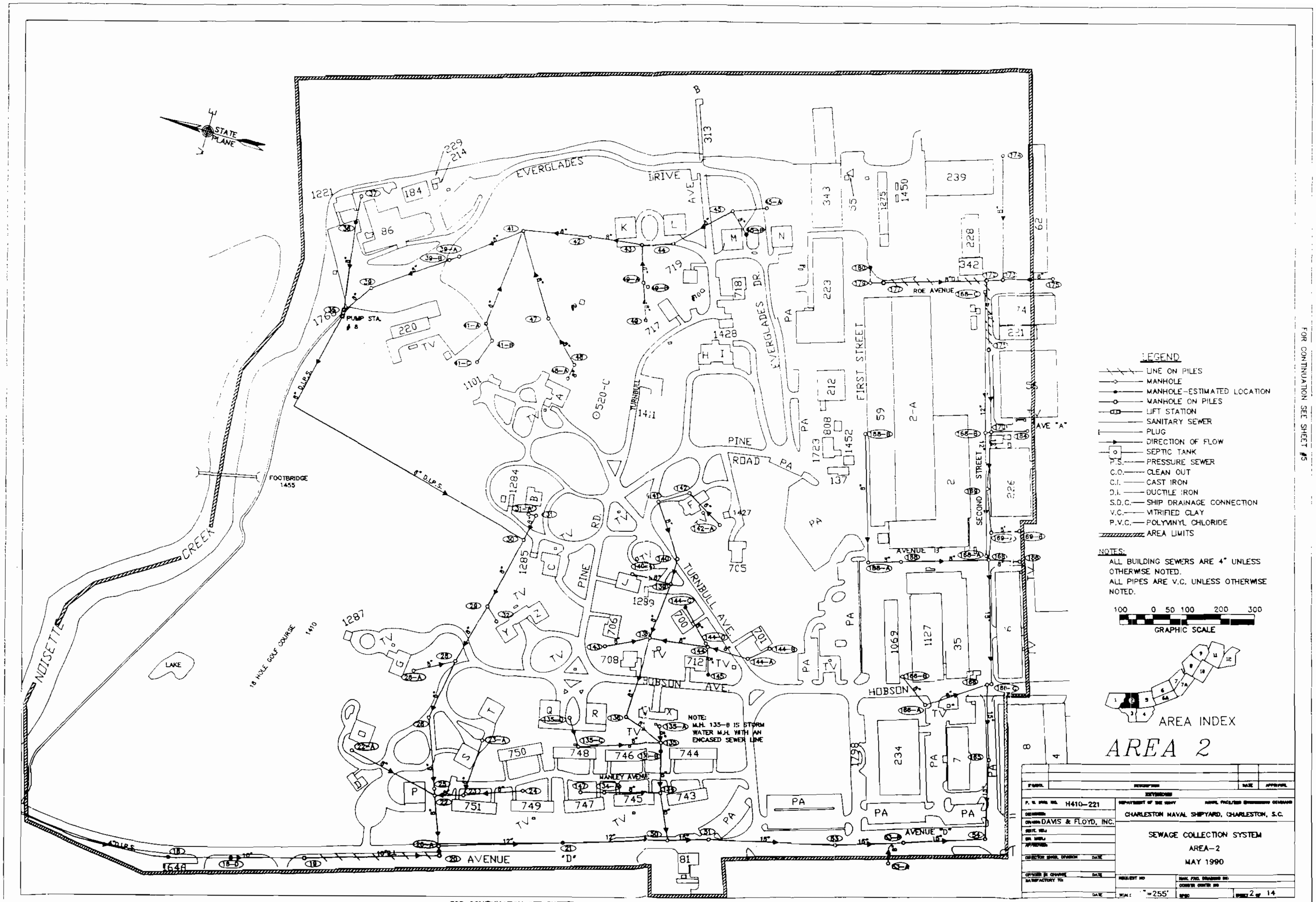


NAVAL BASE AREA INDEX

FOR CONTINUATION SEE SHEET #2

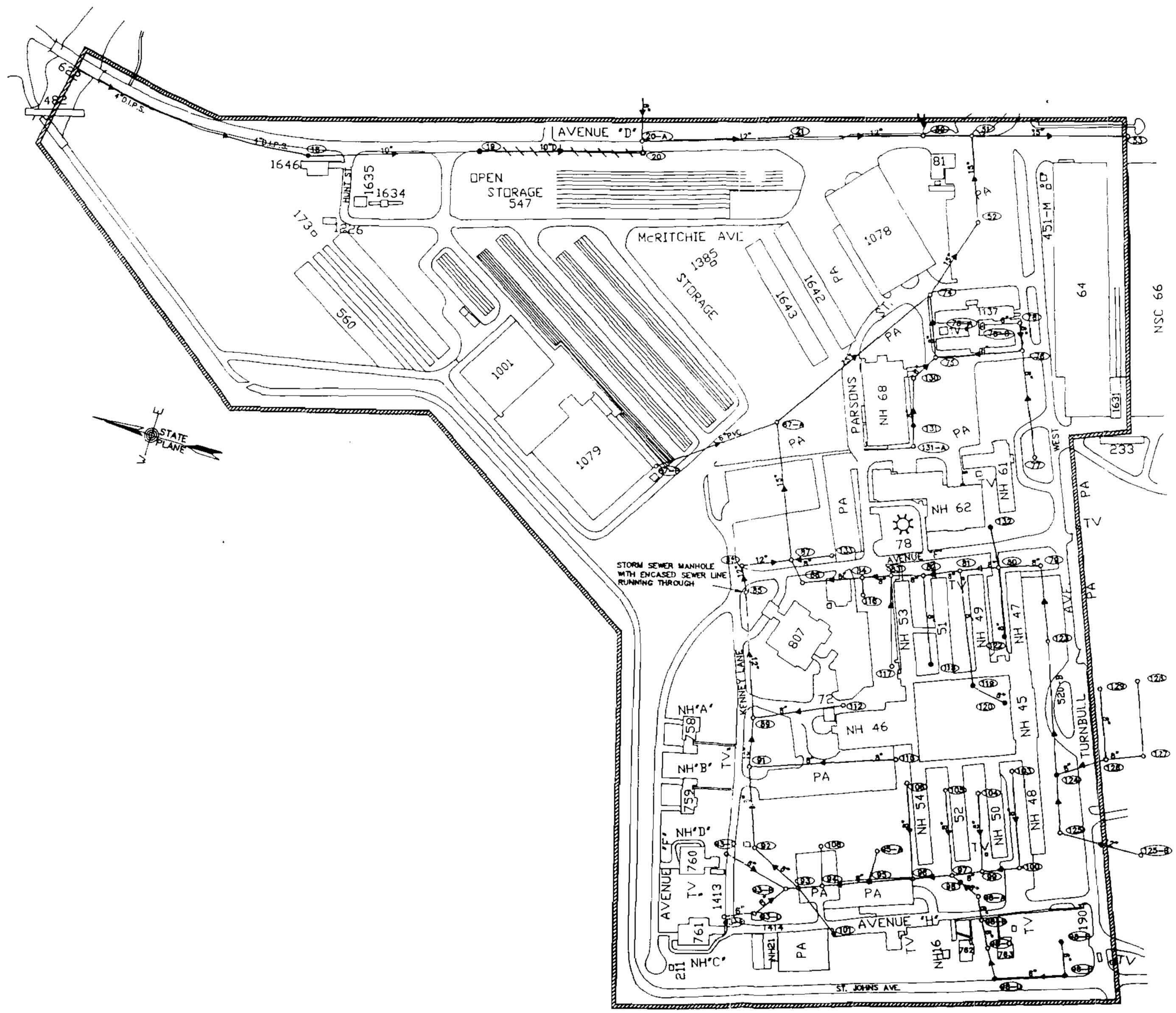


FOR CONTINUATION SEE SHEET #3



FOR CONTINUATION SEE SHEETS 3,4

FOR CONTINUATION SEE SHEET #2



FOR CONTINUATION SEE SHEET #4

LEGEND

- LINE ON PILES
- MANHOLE
- MANHOLE–ESTIMATED LOCATION
- MANHOLE ON PILES
- LIFT STATION
- SANITARY SEWER
- PLUG
- DIRECTION OF FLOW
- SEPTIC TANK
- P.S. — PRESSURE SEWER
- C.O. — CLEAN OUT
- C.I. — CAST IRON
- D.I. — DUCTILE IRON
- S.D.C. — SHIP DRAINAGE CONNECTION
- V.C. — VITRIFIED CLAY
- P.V.C. — POLYVINYL CHLORIDE
- AREA LIMITS

NOTES:

ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.

100 0 50 100 200 300
GRAPHIC SCALE

AREA INDEX

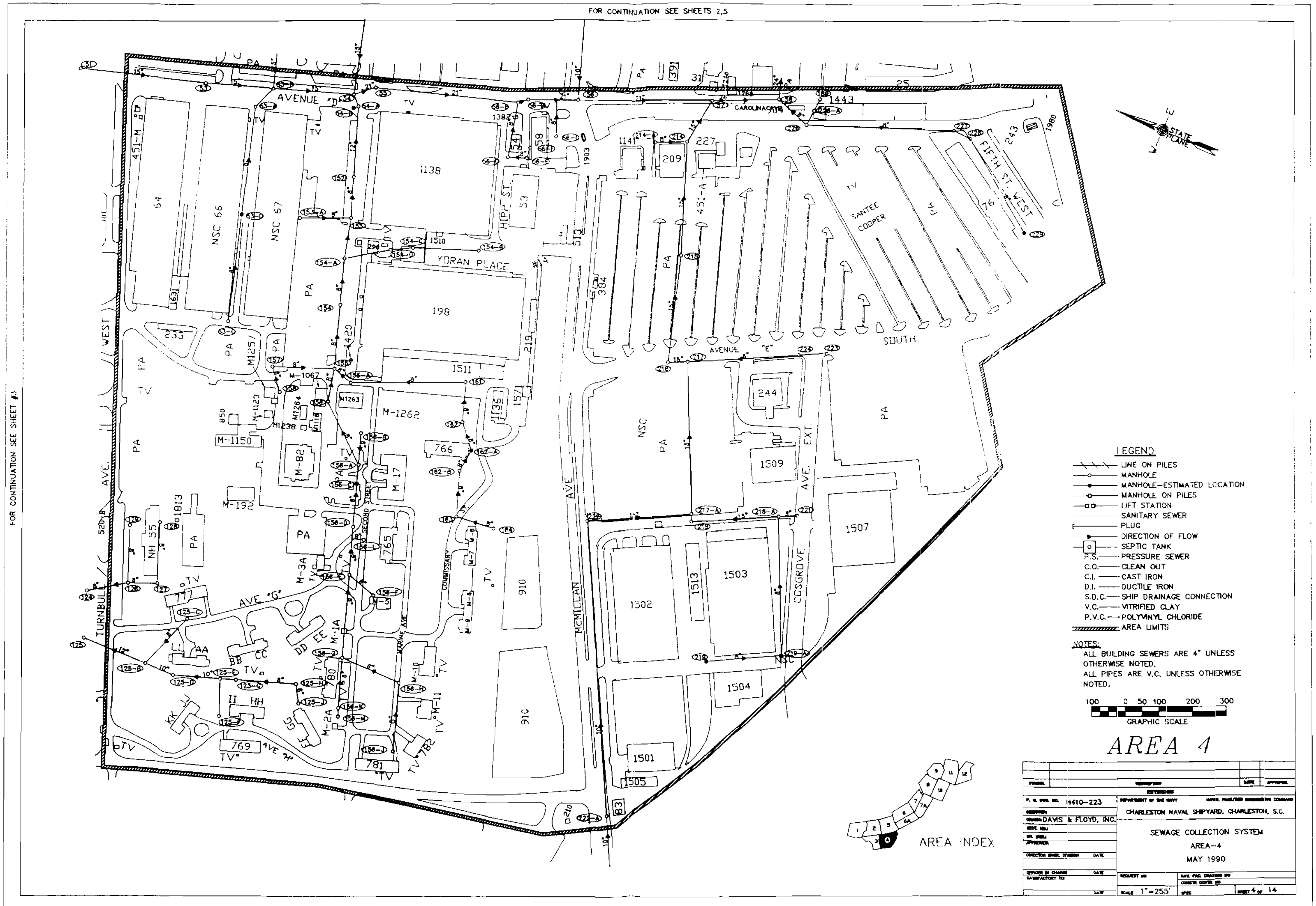
AREA 3

SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

P. W. DWG. NO. H410–222
DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
DRAWN: DAVIS & FLOYD, INC.

SEWAGE COLLECTION SYSTEM
AREA–3
MAY 1990

DIRECTOR ENGR. DIVISION — DATE
OFFICER IN CHARGE — DATE
SATISFACTORY TO: — DATE
REQUEST NO
NAV. FAC. DRAWING NO
SCALE 1"=255'
SHEET 3 OF 14



FOR CONTINUATION SEE SHEETS 2,5
FOR CONTINUATION SEE SHEET #3
AVENUE "D"
YORAN PLACE
AVENUE "E"
AVE "G"
SOUTH
TURNBULL AVE. WEST
MCMILLAN AVE.
COSGROVE AVE. EXT.
FIFTH ST. WEST
SECOND STREET
MARINE AVE
COMMISSARY
HIPP ST.
CAROLINA
SANTEE COOPER
STATE PLANE
LEGEND
LINE ON PILES
MANHOLE
MANHOLE-ESTIMATED LOCATION
MANHOLE ON PILES
LIFT STATION
SANITARY SEWER
PLUG
DIRECTION OF FLOW
SEPTIC TANK
P.S. PRESSURE SEWER
C.O. CLEAN OUT
C.I. CAST IRON
D.I. DUCTILE IRON
S.D.C. SHIP DRAINAGE CONNECTION
V.C. VITRIFIED CLAY
P.V.C. POLYVINYL CHLORIDE
AREA LIMITS
NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.
100 0 50 100 200 300
GRAPHIC SCALE
AREA 4
AREA INDEX
H410-223
DAVIS & FLOYD, INC.
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
SEWAGE COLLECTION SYSTEM
AREA-4
MAY 1990
SCALE 1"=255'
SHEET 4 OF 14

LEGEND

- LINE ON PILES
- MANHOLE
- MANHOLE--ESTIMATED LOCATION
- MANHOLE ON PILES
- LIFT STATION
- SANITARY SEWER
- PLUG
- DIRECTION OF FLOW
- SEPTIC TANK
- P.S. — PRESSURE SEWER
- C.O. — CLEAN OUT
- C.I. — CAST IRON
- D.I. — DUCTILE IRON
- S.D.C. — SHIP DRAINAGE CONNECTION
- V.C. — VITRIFIED CLAY
- P.V.C. — POLYVINYL CHLORIDE
- AREA LIMITS

NOTES:

ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.

100 0 50 100 200 300
GRAPHIC SCALE

AREA INDEX

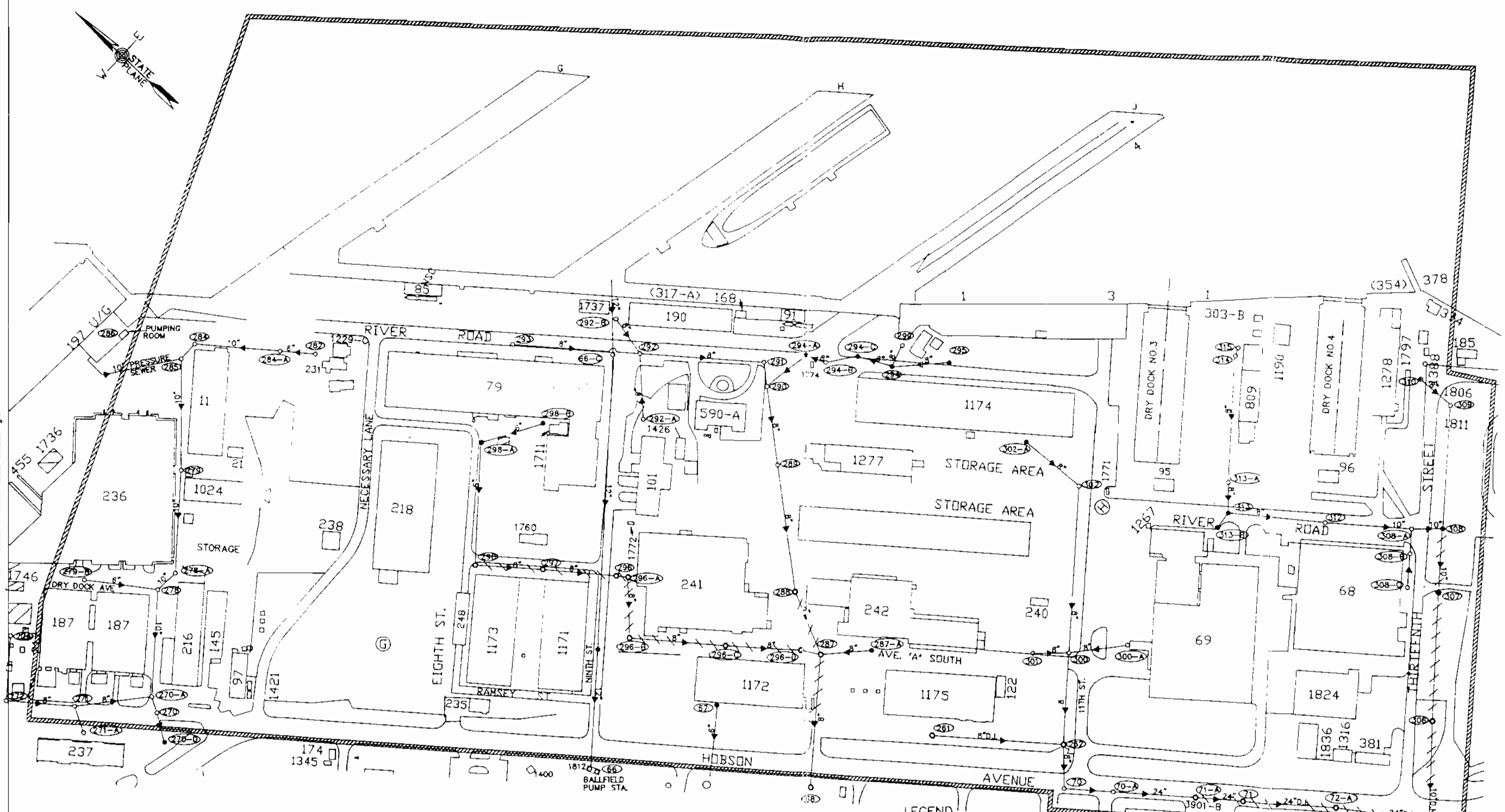
AREA 5

SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

P. W. DWG. NO. H410-224
DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
DESIGNED:
DRAWN: DAVIS & FLOYD, INC.
SEWAGE COLLECTION SYSTEM
AREA-5
MAY 1990
APPROVED:
DIRECTOR ENGR. DIVISION — DATE
OFFICER IN CHARGE — DATE
SATISFACTORY TO:
DATE
REQUEST NO
NAV. FAC. DRAWING NO
CONSTR. CONTR. NO
SCALE 1"=255'
SPEC
SHEET 5 OF 14

FOR CONTINUATION SEE SHEET #5

FOR CONTINUATION SEE SHEETS 8,9



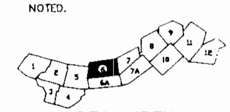
LEGEND

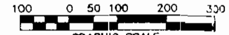
- LINE ON PILES
- MANHOLE
- MANHOLE-ESTIMATED LOCATION
- MANHOLE ON PILES
- LIFT STATION
- SANITARY SEWER
- PLUG
- DIRECTION OF FLOW
- SEPTIC TANK
- P.S. — PRESSURE SEWER
- C.O. — CLEAN OUT
- C.I. — CAST IRON
- D.I. — DUCTILE IRON
- S.D.C. — SHIP DRAINAGE CONNECTION
- V.C. — VITRIFIED CLAY
- P.V.C. — POLYVINYL CHLORIDE
- AREA LIMITS

NOTES:

ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.

ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.





AREA 6

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

F. N. DWG. NO. H410-225

DRAWN: DAVIS & FLOYD, INC.

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.

SEWAGE COLLECTION SYSTEM

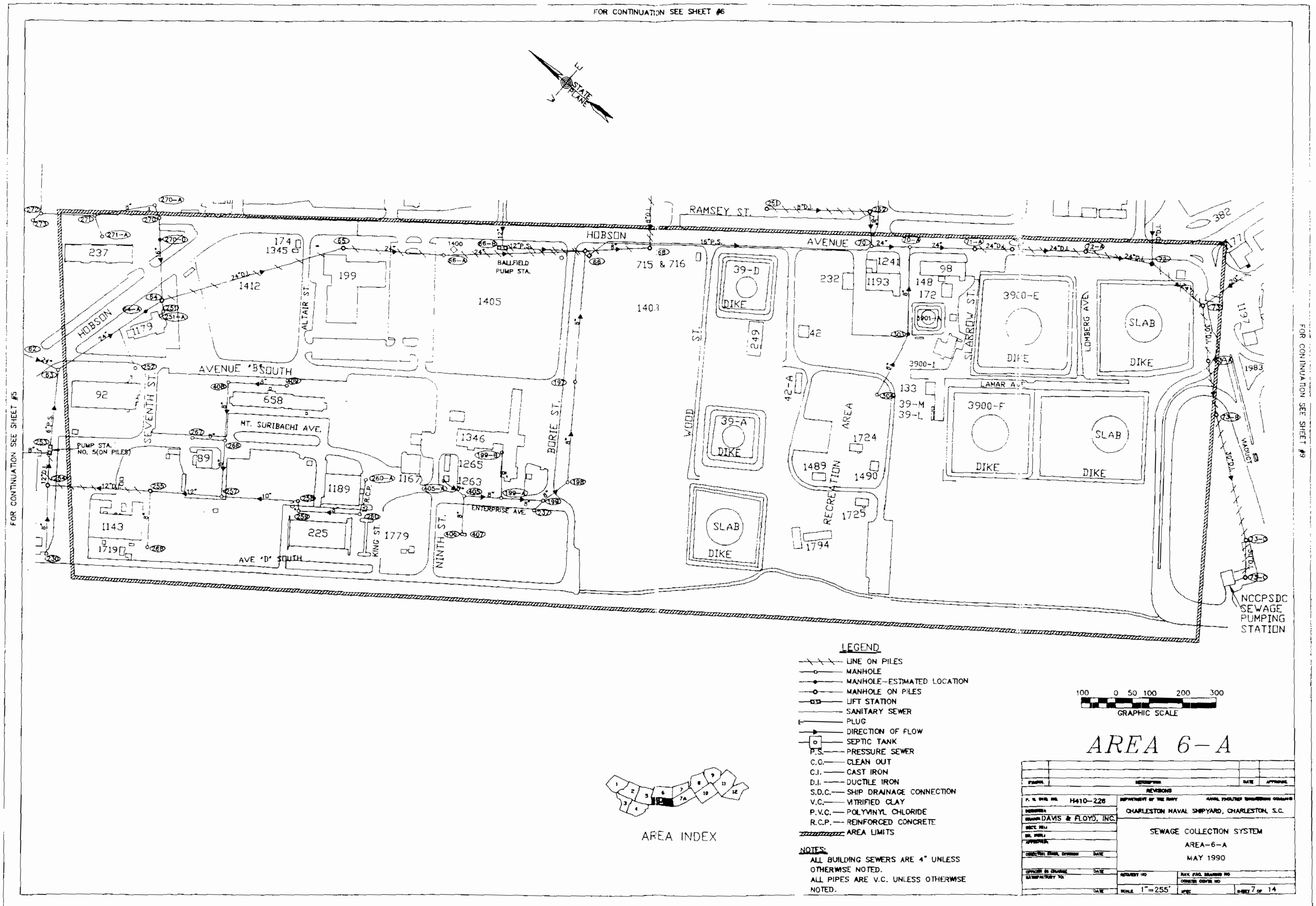
AREA-6

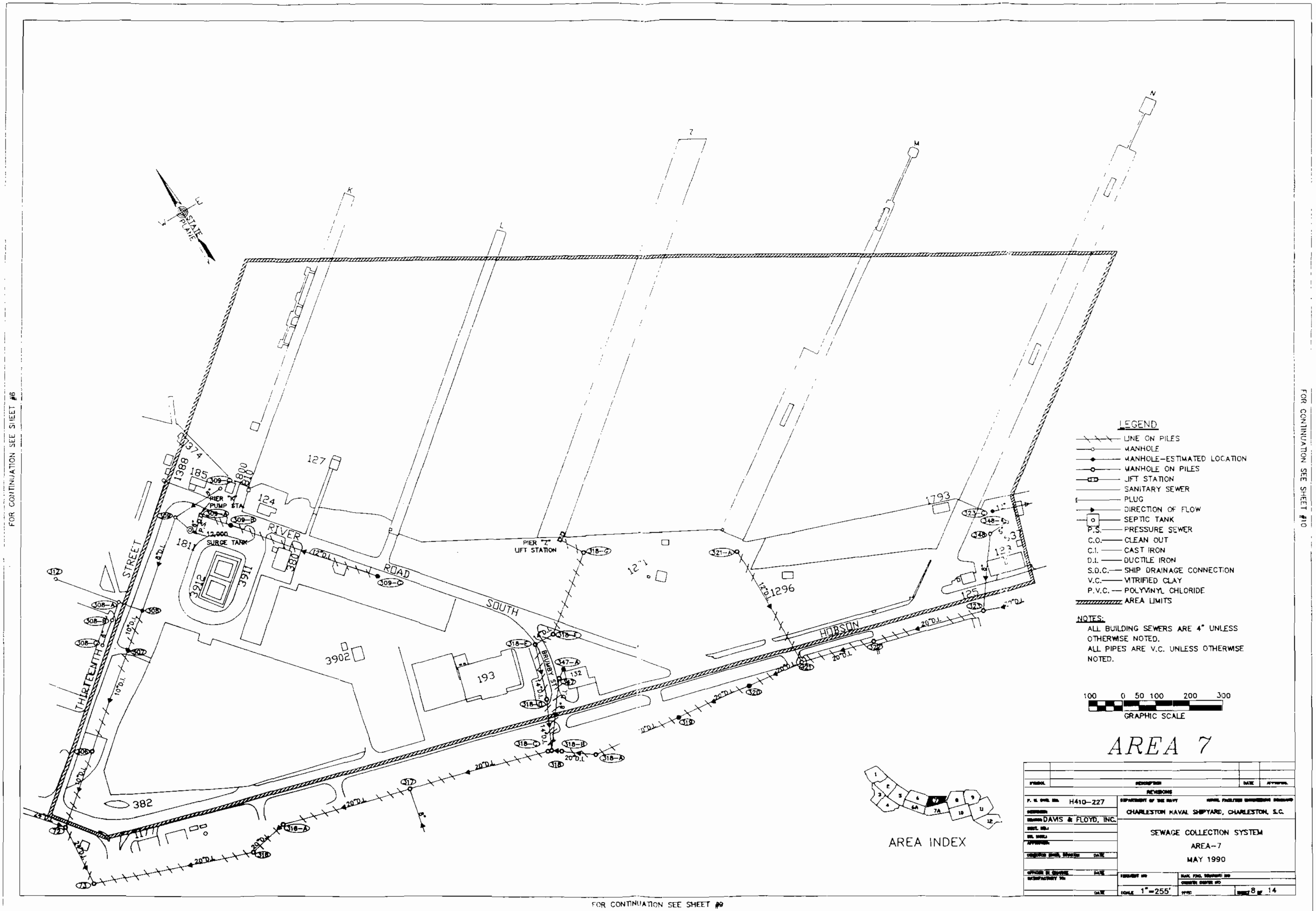
MAY 1990

SCALE 1"=255'

SHEET 6 of 14

FOR CONTINUATION SEE SHEET #7


FOR CONTINUATION SEE SHEET #6
FOR CONTINUATION SEE SHEET #5
FOR CONTINUATION SEE SHEET #9
STATE PLANE
RAMSEY ST.
HOBSON
AVENUE
AVENUE 'B' SOUTH
SEVENTH ST.
ALTAIR ST.
MT. SURIBACHI AVE.
BORIE ST.
WOOD ST.
ENTERPRISE AVE.
NINTH ST.
KING ST.
AVE 'D' SOUTH
RECREATION AREA
SLABROW ST.
LOMBERG AVE.
LAMAR AVE.
VIADUCT
BALLFIELD PUMP STA.
PUMP STA. NO. 5(ON PILES)
NCCPSDC SEWAGE PUMPING STATION
DIKE
SLAB
LEGEND
LINE ON PILES
MANHOLE
MANHOLE-ESTIMATED LOCATION
MANHOLE ON PILES
LIFT STATION
SANITARY SEWER
PLUG
DIRECTION OF FLOW
SEPTIC TANK
P.S.— PRESSURE SEWER
C.O.— CLEAN OUT
C.I.— CAST IRON
D.I.— DUCTILE IRON
S.D.C.— SHIP DRAINAGE CONNECTION
V.C.— VITRIFIED CLAY
P.V.C.— POLYVINYL CHLORIDE
R.C.P.— REINFORCED CONCRETE
AREA LIMITS
NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.
AREA INDEX
100 0 50 100 200 300
GRAPHIC SCALE
AREA 6-A
H410-226
DAVIS & FLOYD, INC.
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
SEWAGE COLLECTION SYSTEM
AREA-6-A
MAY 1990
1" = 255'
7 of 14

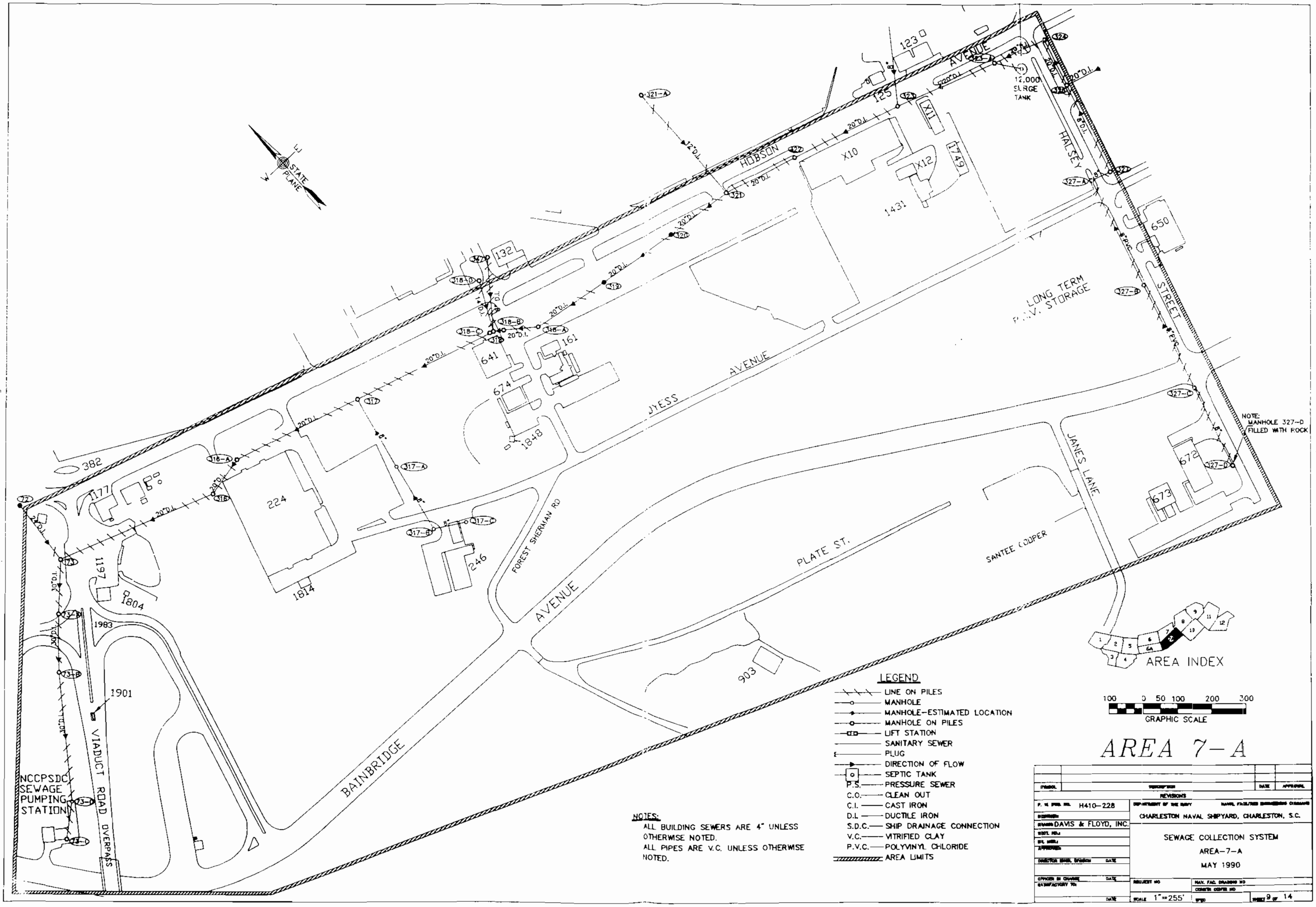


FOR CONTINUATION SEE SHEET #6
FOR CONTINUATION SEE SHEET #10
FOR CONTINUATION SEE SHEET #9
STATE PLANE
K
L
Z
M
N
127
1388
374
185
1800
1810
124
PIER "K" PUMP STA.
12,000 SURGE TANK
181
3912
3911
380
RIVER
ROAD
SOUTH
THIRTEENTH
STREET
PIER "Z" LIFT STATION
1296
1793
123
125
HOBSON
3902
193
132
BRUMBY ST.
382
LEGEND
LINE ON PILES
MANHOLE
MANHOLE-ESTIMATED LOCATION
MANHOLE ON PILES
LIFT STATION
SANITARY SEWER
PLUG
DIRECTION OF FLOW
SEPTIC TANK
P.S. PRESSURE SEWER
C.O. CLEAN OUT
C.I. CAST IRON
D.I. DUCTILE IRON
S.D.C. SHIP DRAINAGE CONNECTION
V.C. VITRIFIED CLAY
P.V.C. POLYVINYL CHLORIDE
AREA LIMITS
NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.
100 0 50 100 200 300
GRAPHIC SCALE
AREA 7
AREA INDEX
REVISIONS
H410-227
DAVIS & FLOYD, INC.
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
SEWAGE COLLECTION SYSTEM
AREA-7
MAY 1990
1"=255'
8 14

FOR CONTINUATION SEE SHEET #8

FOR CONTINUATION SEE SHEET #7

FOR CONTINUATION SEE SHEETS 10,11



LEGEND
- LINE ON PILES
- MANHOLE
- MANHOLE-ESTIMATED LOCATION
- MANHOLE ON PILES
- LIFT STATION
- SANITARY SEWER
- PLUG
- DIRECTION OF FLOW
- SEPTIC TANK
- P.S. — PRESSURE SEWER
- C.O. — CLEAN OUT
- C.I. — CAST IRON
- D.I. — DUCTILE IRON
- S.D.C. — SHIP DRAINAGE CONNECTION
- V.C. — VITRIFIED CLAY
- P.V.C. — POLYVINYL CHLORIDE
- AREA LIMITS

NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.

100 0 50 100 200 300
GRAPHIC SCALE

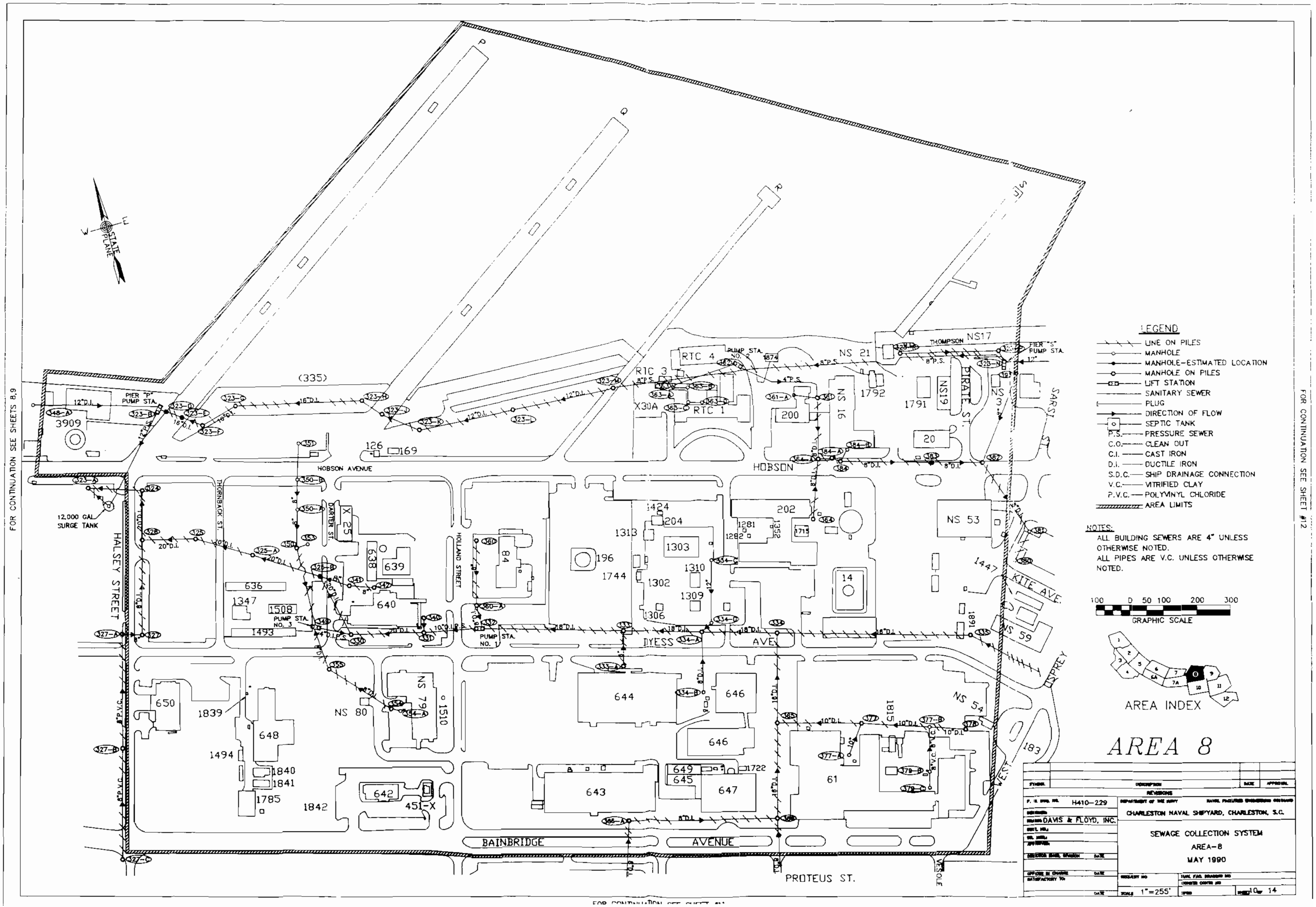
AREA 7-A

SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

H410-228
DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
DAVIS & FLOYD, INC.

SEWAGE COLLECTION SYSTEM
AREA-7-A
MAY 1990

SCALE 1"=255'
SHEET 9 OF 14


LEGEND
LINE ON PILES
MANHOLE
MANHOLE-ESTIMATED LOCATION
MANHOLE ON PILES
LIFT STATION
SANITARY SEWER
PLUG
DIRECTION OF FLOW
SEPTIC TANK
P.S. PRESSURE SEWER
C.O. CLEAN OUT
C.I. CAST IRON
D.I. DUCTILE IRON
S.D.C. SHIP DRAINAGE CONNECTION
V.C. VITRIFIED CLAY
P.V.C. POLYVINYL CHLORIDE
AREA LIMITS
NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.
GRAPHIC SCALE
AREA INDEX
AREA 8
FOR CONTINUATION SEE SHEETS 8,9
FOR CONTINUATION SEE SHEET #12
STATE PLANE
12,000 GAL SURGE TANK
PIER "P" PUMP STA.
PIER "S" PUMP STA.
PUMP STA. NO. 1
PUMP STA. NO. 3
HOBSON AVENUE
HALSEY STREET
THORNBACK ST.
DARTER ST.
HOLLAND STREET
DYESS AVE
BAINBRIDGE AVENUE
PROTEUS ST.
KITE AVE.
THOMPSON
PIRATE ST.
H410-229
DEPARTMENT OF THE NAVY
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
DAVIS & FLOYD, INC.
SEWAGE COLLECTION SYSTEM
AREA-8
MAY 1990
1"=255'
10 of 14

FOR CONTINUATION SEE SHEETS 10,12

LEGEND

- LINE ON PILES
- MANHOLE
- MANHOLE–ESTIMATED LOCATION
- MANHOLE ON PILES
- LIFT STATION
- SANITARY SEWER
- PLUG
- DIRECTION OF FLOW
- SEPTIC TANK
- P.S. — PRESSURE SEWER
- C.O. — CLEAN OUT
- C.I. — CAST IRON
- D.I. — DUCTILE IRON
- S.D.C. — SHIP DRAINAGE CONNECTION
- V.C. — VITRIFIED CLAY
- P.V.C. — POLYVINYL CHLORIDE
- AREA LIMITS

NOTES:

ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.

ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.

100 0 50 100 200 300

GRAPHIC SCALE

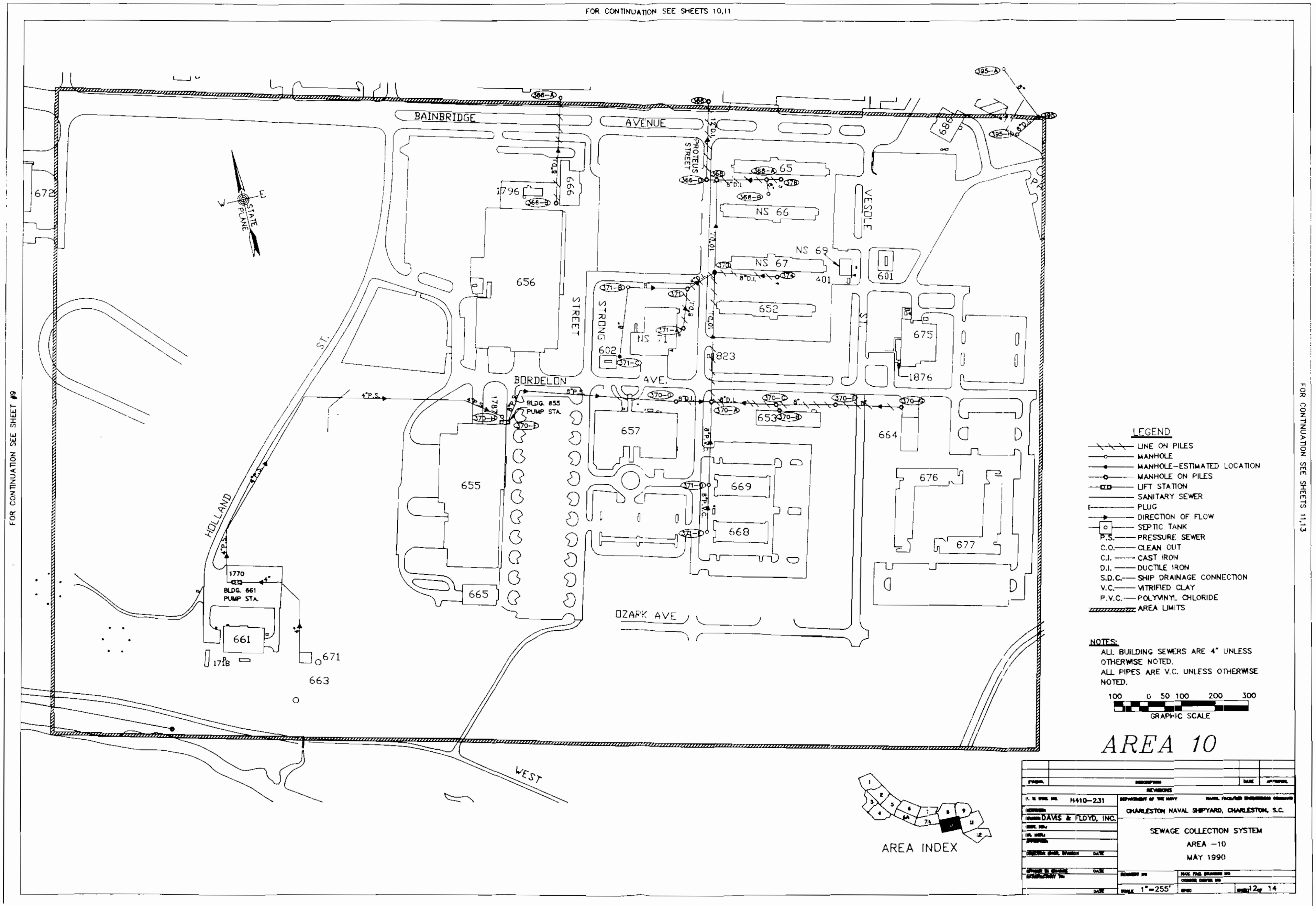
AREA 9

AREA INDEX

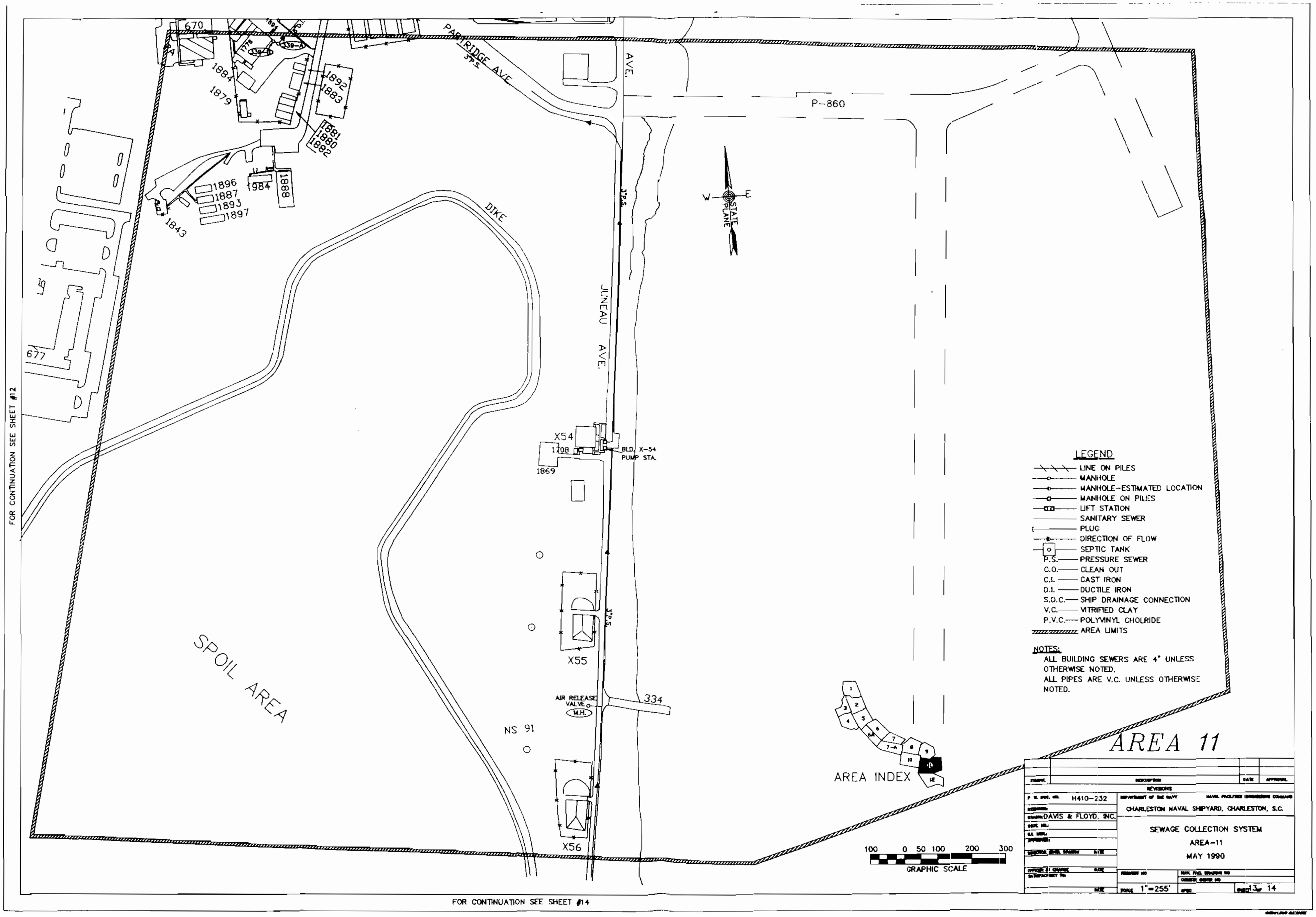
SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

H410-230	DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
DAVIS & FLOYD, INC.	CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
	SEWAGE COLLECTION SYSTEM AREA–9 MAY 1990
	SCALE 1"=255' — SHEET 11 OF 14

FOR CONTINUATION SEE SHEETS 12,13



FOR CONTINUATION SEE SHEETS 10,11
FOR CONTINUATION SEE SHEET #9
FOR CONTINUATION SEE SHEETS 11,13
BAINBRIDGE
AVENUE
PROTEUS STREET
VESOLE
STRONG
STREET
BORDELON
AVE.
HOLLAND
ST.
OZARK AVE
WEST
STATE PLANE
656
655
657
652
653
664
665
666
669
668
676
677
675
601
602
661
663
671
672
1796
1823
1876
1770
NS 66
NS 67
NS 69
NS 71
401
BLDG. 855 PUMP STA.
BLDG. 661 PUMP STA.
LEGEND
LINE ON PILES
MANHOLE
MANHOLE-ESTIMATED LOCATION
MANHOLE ON PILES
LIFT STATION
SANITARY SEWER
PLUG
DIRECTION OF FLOW
SEPTIC TANK
P.S. — PRESSURE SEWER
C.O. — CLEAN OUT
C.I. — CAST IRON
D.I. — DUCTILE IRON
S.D.C. — SHIP DRAINAGE CONNECTION
V.C. — VITRIFIED CLAY
P.V.C. — POLYVINYL CHLORIDE
AREA LIMITS
NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.
100 0 50 100 200 300
GRAPHIC SCALE
AREA 10
AREA INDEX
H410-231
DAVIS & FLOYD, INC.
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
SEWAGE COLLECTION SYSTEM
AREA -10
MAY 1990
1"=255'
12 of 14


FOR CONTINUATION SEE SHEET #12
670
PARTRIDGE AVE.
3"P.S.
AVE.
P-860
1884
1879
1892
1883
1881
1880
1882
1896
1887
1893
1897
1984
1888
1843
677
DIKE
JUNEAU AVE.
X54
1708
1869
BLD. X-54 PUMP STA.
X55
AIR RELEASE VALVE
M.H.
334
NS 91
X56
SPOIL AREA
W
E
STATE PLANE
LEGEND
LINE ON PILES
MANHOLE
MANHOLE-ESTIMATED LOCATION
MANHOLE ON PILES
LIFT STATION
SANITARY SEWER
PLUG
DIRECTION OF FLOW
SEPTIC TANK
P.S. PRESSURE SEWER
C.O. CLEAN OUT
C.I. CAST IRON
D.I. DUCTILE IRON
S.D.C. SHIP DRAINAGE CONNECTION
V.C. VITRIFIED CLAY
P.V.C. POLYVINYL CHOLRIDE
AREA LIMITS
NOTES:
ALL BUILDING SEWERS ARE 4" UNLESS OTHERWISE NOTED.
ALL PIPES ARE V.C. UNLESS OTHERWISE NOTED.
AREA INDEX
AREA 11
100 0 50 100 200 300
GRAPHIC SCALE
REVISIONS
H410-232
CHARLESTON NAVAL SHIPYARD, CHARLESTON, S.C.
DAVIS & FLOYD, INC.
SEWAGE COLLECTION SYSTEM
AREA-11
MAY 1990
1"=255'
13 of 14
FOR CONTINUATION SEE SHEET #14

FOR CONTINUATION SEE SHEET #13