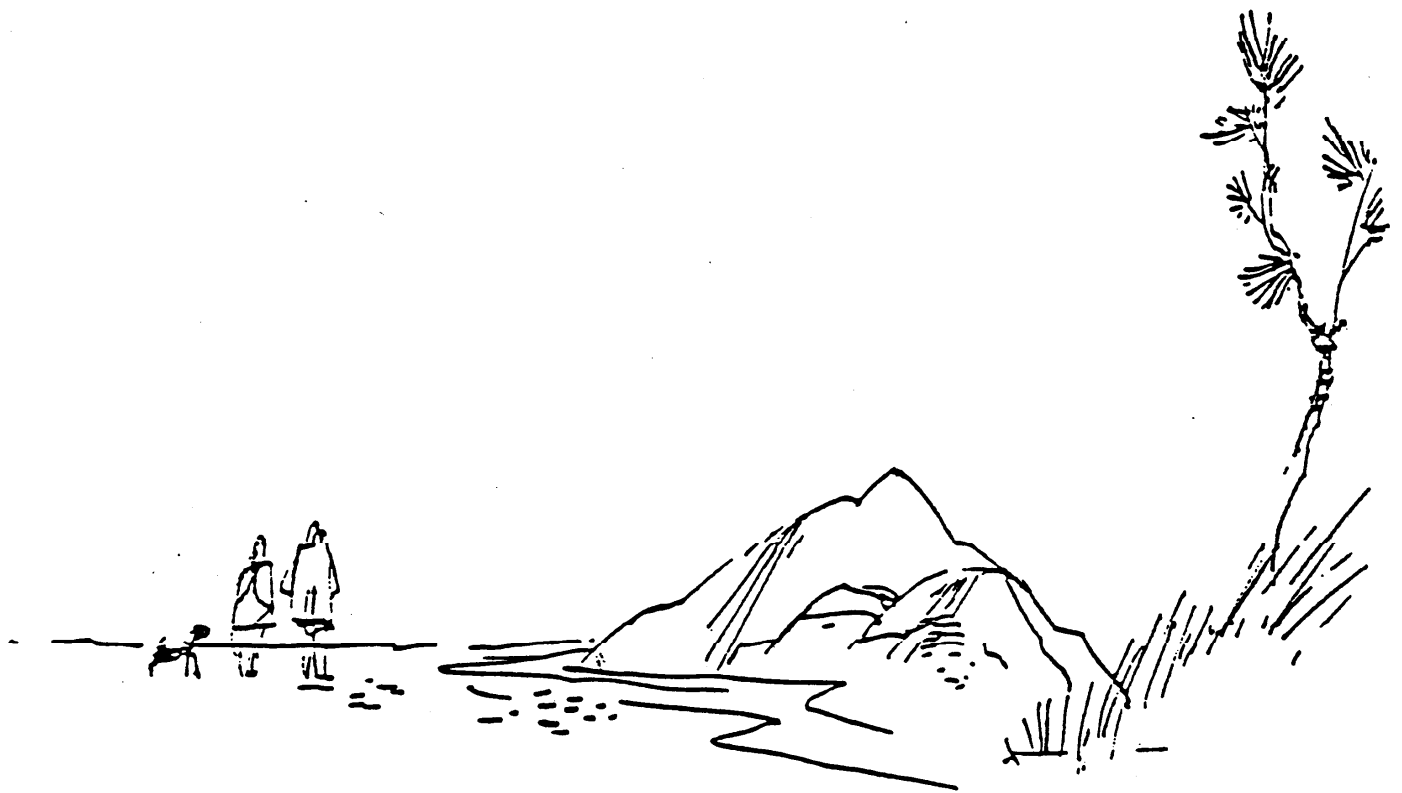
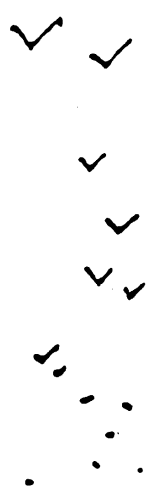


**ENGINEERING EVALUATION
AND FEASIBILITY STUDY**

MUIR BEACH WATER SYSTEM

PREPARED FOR THE

**MUIR BEACH
COMMUNITY SERVICES DISTRICT**



Hci

HARRIS CONSULTANTS, Inc.

IN ASSOCIATION WITH BURTON ENVIRONMENTAL ENGINEERING

ENGINEERING EVALUATION AND
FEASIBILITY STUDY
OF THE
MUIR BEACH WATER SYSTEM
PREPARED FOR THE
MUIR BEACH COMMUNITY SERVICES DISTRICT
FINAL REPORT
December, 1987



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December 9, 1987

Muir Beach Community Services District
Star Route 1304
Muir Beach, CA 94965

Gentlemen:

Harris Consultants, Inc., in association with Burton Environmental Engineering, is pleased to submit the final project report entitled "Engineering Evaluation and Feasibility Study of the Muir Beach Water System", in accordance with our agreement with the District dated August 19, 1987. The report summarizes results of our engineering investigation of the water system and is intended to provide a basis for implementing needed improvements.

Conclusions and recommendations are presented in Chapter II which is an executive summary of the report.

We appreciate the cooperation and interest shown by the Directors and staff of the District, by concerned residents of the community and by County and State health department staff in the preparation of the report.

Very truly yours,

HARRIS CONSULTANTS, INC.

Phillip G. Harris
PGH:jap

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CHAPTER I

CHAPTER I
INTRODUCTION

Background

The Muir Beach Community Services District Water System has provided reliable service to the community in the past, but deteriorating facilities may jeopardize service in the future. The sudden failure of a redwood tank last year dramatically emphasized the need to inspect all components of the existing system. A feasibility study was needed to investigate storage alternatives and other system components and develop a phased improvement program.

The system supply, obtained from two shallow wells adjacent to Redwood Creek, adequately meets community demands. Some contamination of this source by upstream users has been detected, however. The layout of pumping equipment and the interconnecting piping can be strengthened and simplified. Relatively minor modifications will improve reliability of the supply.

When one of the two 50,000 gallon low zone tanks failed, system storage capacity dropped to 200,000 gallons. This reduced the storage available for firefighting and emergency purposes. The tank failure underscores the need to replace, or at least plan for the replacement of, the remaining tanks.

The distribution system piping is in good condition. With a few exceptions, main sizes are adequate for a small residential community. Reliability and firefighting capability can be significantly improved by relatively minor modifications to the system.

The system is owned and operated by the Muir Beach Community Services District (CSD). The District acquired the lower service zone facilities in 1956 and later assumed ownership of the Seacape subdivision system. A five member Board of Directors governs the CSD.

Objectives

The principal objectives of the water system evaluation and feasibility study were to:

1. Establish water requirements for domestic use, fire protection and other emergencies.
2. Develop the best overall solution for storage considering the following factors:
 - a. Hydraulic requirements
 - b. Costs (i.e., both first costs and long term, or so called "life cycle" costs)

- c. Reliability
 - d. Siting limitations
 - e. Land availability
 - f. Aesthetics
 - g. Seismic safety
 - h. Soils and slope stability
3. Evaluate the physical condition and hydraulic adequacy of the distribution system. Recommend a phased program of improvements based on findings.
 4. Evaluate present and future treatment needs for the system.
 5. Determine the condition and adequacy of the well supply.
 6. Prepare a phased preliminary system improvement program including costs.
 7. Describe possible financing options available to Muir Beach. Express costs as annual costs per customer.
 8. Describe the benefits that will accrue to Muir Beach residents from improvements made to the water system. These will include improved reliability of service, improved fire protection, water quality protection and likely improvements in property values.

CHAPTER II

CHAPTER II

CONCLUSIONS AND RECOMMENDATIONS

Introduction

1. The Muir Beach Community Services District water system has provided reliable service to the community in the past, but deteriorating facilities may jeopardize service in the future. The sudden failure of a redwood tank last year dramatically emphasized the need to inspect all components of the existing system.
2. The system is owned and operated by the Muir Beach Community Services District. The District acquired the lower service zone facilities in 1956 and later assumed ownership of the Seacape subdivision system.
3. Principal objectives of the engineering investigation were (1) to establish water requirements for normal use and fire protection, (2) to develop the best overall solution for storage, (3) to evaluate the physical condition and hydraulic adequacy of the distribution system, (4) to determine the condition and adequacy of the supply components of the system, (5) to prepare a phased system improvement program including costs and (6) to investigate possible financing options available to Muir Beach.

Description of the Area

1. Muir Beach is included within the jurisdiction of the State Coastal Act and is surrounded by the Golden Gate National Recreation Area. Expansion beyond the present District boundaries is virtually impossible.
2. The area is steep and rocky with a shallow soil mantle. The topography and soils limit development within the area because of wastewater disposal constraints.
3. The District service area lies between State Highway 1 and the Pacific Ocean. Elevations in the service area range from sea level to an elevation of about 470 feet.

Existing Water Facilities

1. The Muir Beach water system includes the following major components.
 - a. Three shallow wells near Redwood Creek adjacent to Frank Valley Road.
 - b. Chlorination, booster pumping and metering facilities adjacent to the wells.

- c. A 4-inch transmission main.
 - d. A 150,000 gallon high zone redwood storage tank.
 - e. A 50,000 gallon low zone redwood storage tank.
 - f. Distribution system piping, including fire hydrants.
2. The pump in Well No. 1 delivers water directly to the high zone. This well is now used on a full time basis to meet District demands. Its production is 75 to 80 gallons per minute (gpm) - adequate to meet peak daily requirements. Well No. 2 was used as the District supply until Well No. 1 was drilled in 1982. Its pump delivers to the casing of Well No. 3, no longer used as a well, for booster pumping to the system. Well No. 2 lacks a feed line for applying chlorine down the well - a method the District has found effective in minimizing iron and manganese problems. Both Well No. 1 and Well No. 2 are shallow, 37 feet, and are sealed to a depth of only 10 feet. They are therefore subject to surface contamination.
 3. Water is piped to the system via a 4-inch cast iron main, 5,500 feet long, which runs along Frank Valley Road and State Highway No. 1. The condition of the main is unknown. It has shown no visible signs of leakage or deterioration, however. This pipe will be inspected in the near future when a new valve is installed in the line.
 4. The high zone distribution system is largely 6-inch diameter asbestos cement pipe. A section of 2-inch galvanized steel pipe near Starbuck Drive is the only size-deficient section of piping in the high zone.
 5. The 150,000 gallon high zone tank is of redwood construction. It is 37 feet in diameter and 20 feet high. The tank is approximately 20 years old. The condition of the wood in the tank is fair-to-good. The tank was rebanded last year to correct a serious band corrosion problem. The site is partially screened by berms and vegetation but is not fenced. The tank is visible from Seacape Drive and from adjacent residences.
 6. The low zone tank that is still in service and the recently-failed tank are located on the same parcel, southeast from the Starbuck Drive cul-de-sac. Nut-and-thread corrosion on the bands caused the failure of the northerly tank. The District has since taken the precaution of tack-welding the bolts to the bands on the remaining tank to prevent a recurrence. Both tanks were purchased used and are at least 30 to 35 years old. The condition of the wood in the remaining tank is poor.
 7. The original small diameter galvanized pipe in the low zone distribution system was replaced with 4-inch PVC pipe in the

Summary 5/74

early 1970's. The main is Schedule 40 pipe which provides adequate wall thickness for the pressures encountered in the low zone system. The depth of cover provided over the main is less than the recommended 30 to 36 inches. Nevertheless, there have been few problems with this piping. The low zone system is fed from the low zone tank. There are no other interconnections, or ties, between the high zone and the low zone. A much-needed pressure regulator station is under construction on Seacape Drive near the community center.

8. A computerized hydraulic model of the existing system was developed to test the system under various fire flow conditions. The results, and the improvements possible if system modifications are made, are discussed subsequently under "Distribution System Improvements".

Water Requirements

1. Water production records for 1985, 1986 and 1987 (through July) were analyzed. This was done to determine the patterns and trends in water use at Muir Beach and to forecast future demands. The average monthly production over the 31 month period was 1,076,600 gallons. Production has increased about 21 percent during this time. A significant part of the increase for 1987 is due to increased water use at the Pelican Inn for irrigation of recently-landscaped grounds. A drier-than-normal year is also contributing to the 1987 increase.
3. Based on 147 total services and an average household size of 2.43 persons, water production over the 31 month period averaged 100 gallons per capita per day (gpcd).
4. Water production and water sales data for May, June and July of 1957 were reviewed to estimate unaccounted-for water. Unaccounted-for water is the difference between water production and water sales. Metering inaccuracies and leakage are the usual causes of discrepancies. The unaccounted-for water component at Muir Beach is about 24 percent - somewhat higher than the 10 to 20 percent value deemed acceptable by the American Water Works Association. Tank leakage undoubtedly accounts for part of the water loss. It is recommended that the service meters and the production meter at the well be checked and recalibrated, or replaced, as needed. A leak detection program may also be worthwhile.
5. A table was prepared to summarize projected water requirements, based on 175 service equivalents and an institutional/commercial fire demand of 1,500 gallons per minute (gpm). The maximum projected daily demand is about 61 gpm. The total minimum storage requirement, including a one day emergency reserve allowance, is 280,000 gallons.

Design Criteria

1. The normal minimum pressure in a water system is 40 pounds per square inch (psi). Under fire flow conditions, a minimum pressure of 20 psi must be maintained at all points in the system as a safeguard against the entry of contaminated water and septic tank leachate into a main.
2. Water mains must be at least 4 inches in diameter when they are part of a looped system (i.e., when fed from both ends). Dead end water mains longer than 1,000 feet must be 6 inches in diameter, or larger.
3. Although analyses indicate that the District supply is of good quality overall, surface contamination is a possibility. Chlorination is the only type of treatment now provided. Backup chlorination equipment is needed. Additional treatment may be required in the future to remove turbidity that may harbor microbial contaminants (i.e., by filtration) and to remove organics (i.e., by activated carbon treatment). Increased monitoring of the supply will be required in the future to comply with increasingly stringent State and Federal requirements.

Supply and Treatment Requirements and Improvements

1. Well No. 1 has adequate capacity to supply the projected maximum day demand of 61 gpm.
2. It is recommended that Well No. 2, which is of similar construction to Well No. 1, be fitted with a pump similar to that in Well No. 1. Piping modifications are needed to allow direct delivery of the output from Well No. 2 into the distribution system.
3. It is recommended that chlorine feed piping be installed to allow chlorine solution to be fed directly into Well No. 2. The District should purchase a back-up chlorine solution metering pump.
4. The cost for making recommended improvements to supply, including piping modifications and the rehabilitation of Well No. 2, is about \$ 23,300.
5. County and State health authorities are concerned about possible contamination of the District's supply from both the Muir Woods National Monument (i.e., microbiological contamination) and from agricultural activities on the watershed (i.e., herbicides and pesticides). A plan for exporting Muir Woods' sewage out of the watershed is reportedly under investigation by the National Park Service. If this is accomplished, a major water quality concern would be eliminated. The creek and the District well will be sampled by the county in early 1988, as part of a State-sponsored program, and tested for organics including herbicides and

pesticides. If organics are found in the supply treatment will be required which may cost as much as \$260,000 for equipment alone.

Storage and Pumping Alternatives

1. Three storage and pumping alternatives were investigated, namely:
 - a. Alternative 1 - Pump to the high zone tank and backfeed the low zone from the high zone (i.e., with or without a low zone tank). This alternative is similar to the existing mode of operation.
 - b. Alternative 2 - Pump to the low zone tank and booster pump to the high zone tank from the low zone.
 - c. Alternative 3 - Pump to the low zone tank and booster pump to the high zone without a high zone tank.
2. To evaluate the storage and pumping alternatives, power costs were calculated. The annual power cost for Alternative 1, in which the entire supply is pumped to the high zone tank, is about \$5,150 per year. For Alternative 2 only that portion of the supply used in the high zone will be pumped to that zone, using a booster pump located at the low zone tank. The estimated annual cost for pumping is reduced to \$3,900 per year - about \$1,250 less than for Alternative 1. Under normal conditions the pumping costs for Alternative 3 will be same as Alternative 2. Electrical demand charges for the large fire pumps will reduce the power savings actually realized.
3. Both Alternative 2 and Alternative 3 require booster pump stations located at the low zone reservoir. The station needed for Alternative 2 is small, consisting of two, 50 gpm pumps. The high zone tank will continue to supply peak and fire demands. The estimated cost for the booster station is \$37,500.
4. Alternative 3, on the other hand, requires two, 1,500 gpm fire pumps in addition to the the smaller pumps used for normal service. This alternative also requires complex controls. A direct drive diesel engine, or a standby generator, is needed to maintain fire protection during power outages. This station will cost an estimated \$200,000.
5. A life cycle cost analysis showed that Alternative 1 was least costly on a "present worth" basis. Total annual costs were greater than for Alternative 2, however. The reason for this apparent disparity is that Alternative 2 requires an initial expenditure for a pump station but Alternative 1 does not. Alternative 3 is considerably more expensive than either of the two other alternatives.

6. Other factors considered in evaluating storage and pumping alternatives favor Alternative 1. It is the simplest scheme hydraulically and mechanically and maximizes reliance upon gravity storage. It is the mode of operation presently used by the District.
7. Redwood tanks, welded steel tanks or concrete reservoirs are all workable storage options at Muir Beach. Redwood tanks offer low maintenance and low initial cost but have the shortest service life. The resistance of redwood tanks to severe earthquakes is poor although these tanks often withstand minor-to-moderate shaking quite well owing to their inherent flexibility. Steel tanks, on the other hand, are designed for maximum seismic resistance. The first cost of steel tanks is moderate. However, the periodic painting needed is a demanding and expensive process requiring sand blasting and the use of special coatings. The service life of steel tanks is long (50 years or more) provided that they are kept properly coated. This is often a problem in coastal areas. Concrete reservoirs are seismically resistant and relatively maintenance free. Because they are custom-designed, they may be configured to the site and may be partially or completely hidden from view. The main drawback of concrete reservoirs is high first cost.
8. Based on condition, replacement of the low zone tank is the most critical item in the improvement program if this tank location is to be retained in the system. Although first costs and operating costs would be slightly lower if all the storage in the system were located at the high zone site, reliability would suffer in the event of a system malfunction or natural disaster. It is thus recommended that 100,000 gallons of system storage be located in the low zone. Because of its longevity and seismic resistance, a concrete reservoir is preferred although a redwood tank would also give satisfactory service. The estimated costs for a concrete reservoir and a redwood tank would be \$130,000 and \$70,000, respectively. In either case the piping and valving necessary for pumping to the high zone in an emergency would be provided.
9. The remaining service life of the existing 150,000 gallon tank is roughly 10 years, meaning that a new tank does not have to be built immediately. It is recommended that 200,000 gallons of storage be constructed at the high zone tank site when the existing tank is replaced.
10. The three alternatives investigated for high zone storage were two 100,000 gallon redwood tanks, two 100,000 welded steel tanks, and one compartmented 200,000 concrete reservoir. Regardless of which alternative is chosen, the existing 150,000 gallon tank should be removed before construction to make most efficient use of this site. Economic analysis showed the redwood tank alternative to be the least costly on a "present worth" basis but the most expensive

based on total capital and replacement costs, because these tanks must be replaced after about 30 years of service. The concrete reservoir, on the other hand, has the highest "present worth" cost, \$233,800, but the lowest total cost because major maintenance is not normally required over the 50 year service life of this type of structure.

11. If funds permit, construction of a concrete high zone reservoir is recommended. Advantages include low maintenance, siting flexibility, improved aesthetics and good seismic resistance.

Distribution System Improvements

1. An extensive main replacement program is not needed at Muir Beach because most of the distribution system is in good condition and is adequately sized. High zone piping should not require replacement for 30 years or more, if then. The low zone PVC piping should only be replaced if problems occur. It would be prudent, however, to encase any exposed sections of low zone piping in concrete for protection. If this pipe is replaced, it should be upsized to 6-inches and installed with a minimum of 30 inches of cover. The condition of the transmission main is not presently known but will be inspected in the near future.
2. A total of eight distribution system improvements are recommended (shown on Figure 9-1), namely:
 - a. D-1 - Complete the 4 inch tie and pressure regulator station now under construction on Seacape Drive near the community center.
 - b. D-2 - Construct 330 feet of 6 inch PVC main from the 4 inch transmission main at the intersection of Frank Valley Road and Highway 1 southeast along Highway 1 to the dead end 4 inch main. This tie will require a pressure regulator station. This improvement will increase fire flows to the Pelican Inn and to the adjacent residential area.
 - c. D-3 - Construct 190 feet of 6 inch PVC main from the 4 inch transmission main at the intersection of Highway 1 and Sunset Way to the end of the 4 inch, Sunset Way line. This tie will also require a pressure regulator.
 - d. D-4 - Construct 250 feet of 4 inch main between the 4 inch main on Sunset Way and the westerly end of the 4 inch main on Pacific Way. Because both mains are located in the low zone, this tie will not require a pressure regulator.
 - e. D-5 - Construct 500 feet of 4 inch main between the westerly end of the 4 inch Charlotte Way main and the westerly end of the 4 inch Sunset Way line. This tie

will require a pressure regulator station. This improvement is vital for providing adequate fire flows along Sunset Way.

- f. D-6 - Replace the 2 inch line serving Cove Lane with 300 feet of 4 inch PVC main.
 - g. D-7 - Replace 370 feet of 2 inch main along the private drive extending from Starbuck Drive with 4 inch PVC pipe. The replacement main will connect to the existing 6 inch ductile iron main. This improvement will allow the residential fire flow requirement to be met.
 - h. D-8 - Construct 470 feet of 8 inch PVC pipe parallel to the 6 inch high zone reservoir outlet pipe and 6 inch main on Seacape Drive (to Starbuck Drive). This improvement will prevent fire demands elsewhere in the system from reducing pressures at this location to dangerously low levels. The larger main will also improve local fire fighting capability.
3. The total cost for all recommended distribution system improvements is \$ 211,400.
 4. A table (Table 9-1) was prepared using the results from the computerized system model for both the existing system and for the improved system. It showed the improvement in fire flow at each location and the fire flow required for an optimal fire rating. While the recommended improvements significantly improve fire flows, they do not, in all cases, improve flows to the optimum. To provide optimum main capacity, an extensive (and expensive) main replacement program in the low zone would be needed. This, in our opinion, is not warranted until the condition of the pipe requires replacement.

Financing

1. Muir Beach will receive a grant from the State water system emergency fund to replace the low zone tank. The program will not, however, fund other system improvements.
2. Although the median household income level in Muir Beach is too high to qualify for either a grant or a low-interest loan from the federal Farmers Home Administration (FmHA), their so-called "market rate" terms may well be significantly better than conventional financing. It is recommended that the District contact FmHA to discuss possible financing under their program.

Recommended Program

1. A prioritized listing of all recommended improvements, including costs was prepared and is shown in Table 11-1.

The total cost for making all improvements to the system is \$ 618,500.

2. No timetable for completing the recommended improvements was established because funding is an unknown. Ideally, all the improvements should be completed within 10 years to be of maximum benefit to the present residents of the community.

CHAPTER III



CHAPTER III

DESCRIPTION OF THE AREA

Background and History

Muir Beach is an unincorporated community located along Highway 1 in southwestern Marin County. Its location is shown on Figure 3-1. The community is included within the jurisdiction of the State Coastal Act and is surrounded by the Golden Gate National Recreation Area (GGNRA). Expansion beyond the present Community Services District boundaries is virtually impossible.

The first inhabitants of Muir Beach were the Coast Miwok Indians. In 1838, an Englishman, William Richardson, received a Mexican land grant known as the Sausalito Rancho. Portuguese settlers bought ranches within the Sausalito Rancho, including what is now Muir Beach. In 1898, Constantino Bello bought three ranches called "K", "M" and "T", from the Tamalpais Land and Water Company and thus became the owner of Muir Beach.

In 1923 his heirs subdivided part of "T" ranch into the small lots of Bello Beach. Jacob Weil and Lewis Harris acquired ranches "K" and "T" in 1928, formed the Muir Beach Company and sold real estate at Muir Beach for more than 20 years. They developed the first community water supply.

The name of the community was changed to Muir Beach in 1940. During World War II, the overlook was used as a coast artillery installation.

In the 1950's, building activity increased. The Muir Beach Community Services District was formed in 1958, taking over the assets of the Muir Beach Water Company. Poor water quality from a coastal well was the principal system problem at that time.

In 1963, the Miwok Corporation was formed to develop Seacape, the name given to the remainder of Ranch "T". The Seacape Mutual Water Company was formed in 1966 to develop a water system that today includes the major components of the present system. The quality of water from the Seacape well, located inland on Frank Valley Road, was far superior to that of the Muir Beach CSD well. The District purchased the Seacape system in 1970. The boundaries have remained the same since that time.

Community concern about the influx of visitors to the beaches which caused traffic, parking and sanitation problems, led to the purchase of the surrounding area by the Golden Gate National Recreation Area in 1972. In 1977, Big Beach was added to the GGNRA.

In the last few years community development has been limited to the infilling of the few remaining developable properties within the District.

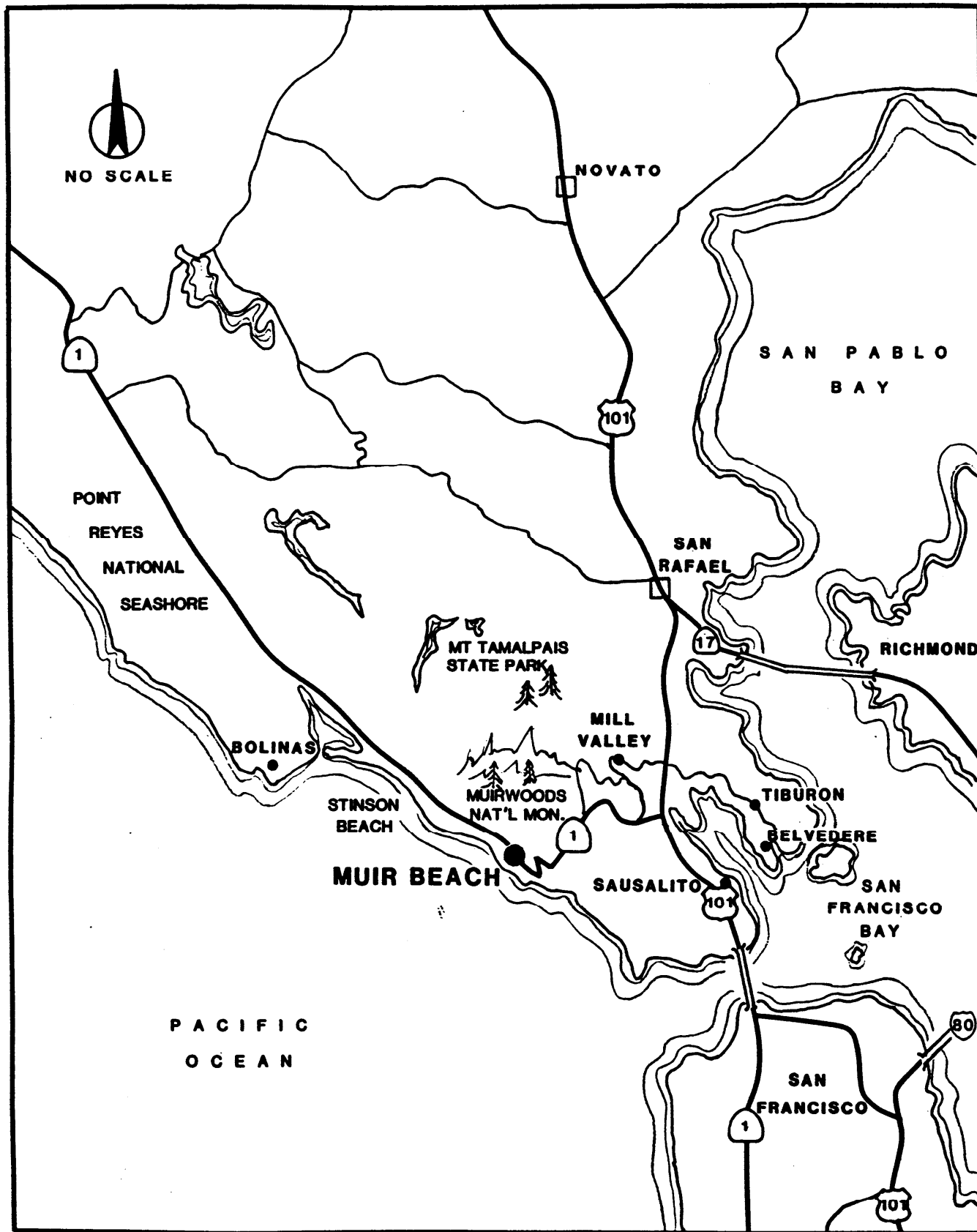


FIGURE 3-1
LOCATION MAP

Topography

The topographic features of Muir Beach and the surrounding area are shown on Figure 3-2. The District provides water service to the area located between Highway 1, Shoreline Highway, and Muir Beach (i.e., "Big Beach"), and to properties located along Highway 1 east of the main service area. The District serves properties located at elevations ranging from sea level to 470 feet. Service is provided in two "pressure zones". The "high zone" includes all customers located along Seacape Drive, Starbuck Drive, Ahab Drive and Charlotte's Way. The elevations of properties served range from 160 feet to 470 feet. The "low zone" includes properties located along Sunset Way, Pacific Way, Lagoon Drive and Highway 1. Low zone elevations range from sea level to about 150 feet.

The District's wells and chlorination building are located about one mile north of Muir Beach along Redwood Creek near Frank Valley Road. The elevation of these facilities is about 40 feet.

Soils and Geology

The Muir Beach area is steep and rocky with a shallow soil mantle. The soil is generally clayey with a high winter water table caused by the proximity of bedrock. This typical coastal soils situation places practical limits on development because of the difficulty in locating and constructing workable septic systems.

Muir Beach, like most of California, must be considered seismically active. Any water system-related improvements must be designed to resist damage from earthquakes.

Climate

The climate in Muir Beach is maritime, characterized by frequent fog and cool temperatures. The average annual precipitation at Muir Woods, the closest location having official records, is 40.37 inches per year. Muir Woods, however, receives more rainfall than Muir Beach. Inspection of available coastal precipitation records in Sonoma County (Fort Ross) and in San Mateo County (Half Moon Bay) indicates that the precipitation at Muir Beach is probably in the 30 to 35 inch per year range.

The average annual temperature at Muir Beach is in 51 to 53 degree F. range.

Flooding Potential

Because of generally steep topography, most of Muir Beach is not subject to flooding. Low-lying roadways below 20 to 30 feet in elevation along Pacific Way, Lagoon Drive and Highway 1 do flood periodically, particularly when high tides and heavy runoff from Redwood Creek coincide.

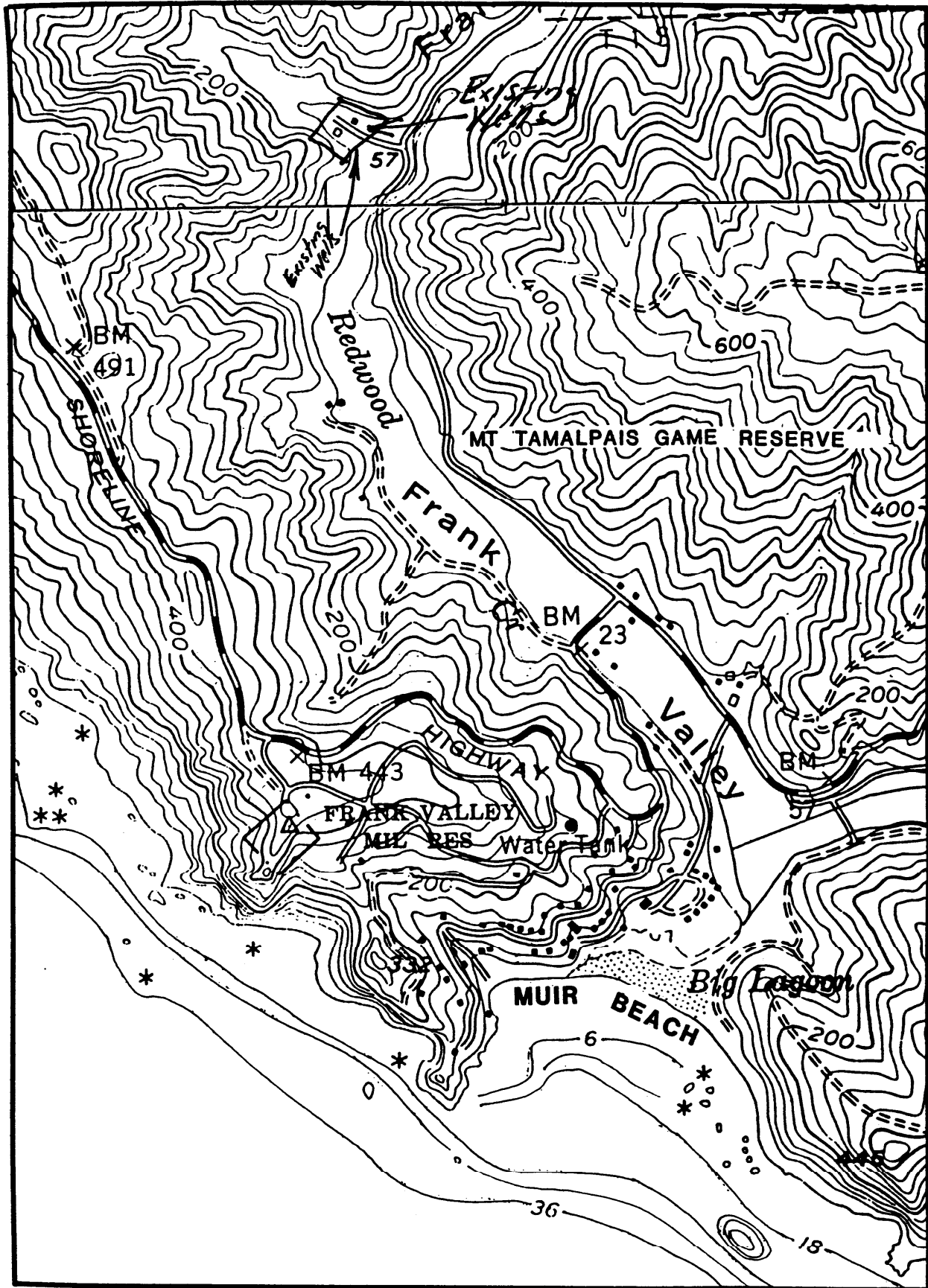


FIGURE 3-2
TOPOGRAPHY

Zoning and Land Use

Muir Beach is included within Marin County's "R-A District" (i.e., residential-agricultural zoning). The Muir Beach Community Plan states that "the size of lots in Muir Beach ranges from 3,000 sq.ft. to about 10 acres. The present county zoning requires lots of a minimum size of 10,000 sq.ft. in old Muir Beach and one acre in Seacape. Some parcels adjoining Seacape require a minimum of two acres per lot. Many undersized lots in both areas are legal but non-conforming building sites".

The Muir Beach Community Plan states that "commercial zoning and commercial use is neither needed nor wanted by the people living at Muir Beach. Neither is it in the best interest of the recreational use of the surrounding Golden Gate National Recreation Area, since it would diminish the unique beauty of our coast line".

The only commercially zoned property at Muir Beach is the Pelican Inn.

Roads

All roads in Muir Beach except Seacape, Starbuck and Ahab Drives are maintained by the Community Services District. The latter roads are owned and maintained by Marin County.

Fire Protection

The Muir Beach Community Services District provides funding to the Muir Beach Volunteer Fire Department. The fire department receives additional funding from the federal government for assisting with fire protection in the surrounding public lands. The fire department elects a fire chief who is responsible for membership, operation and training of this all-volunteer organization.

CHAPTER IV

CHAPTER IV
EXISTING WATER FACILITIES

Description of the System

The Muir Beach water system is comprised of the following major components:

1. Three shallow wells located in the alluvium of Redwood Creek adjacent to Frank Valley Road.
2. Chlorination, booster pumping and metering facilities. These are located in a small building adjacent to the wells that also serves as a District office.
3. A four inch transmission main running from the wells to the service area.
4. A 150,000 gallon redwood storage tank serving the high zone of the system. The high zone tank is located on Seacape Drive adjacent to the Golden Gate National Recreation Area overlook.
5. A 50,000 gallon redwood storage tank serving the low zone of the system. The low zone tank is located adjacent to a private road extending from the cul-de-sac at the end of Starbuck Drive. The recently-failed low zone tank is located on the same site.
6. Distribution system piping, including fire hydrants.

Figure 4-1 shows the location of principal components of the existing system and also shows the District boundary.

Supply

There are three wells located on property owned by the District on Frank Valley Road. Figure 4-2 is a schematic site plan of the various facilities at this location. Well No. 3, located in the small service building, is now used only as a standby booster pump. The well itself failed several years ago.

Well No. 1 is now used on a full time basis. It is the only well that can be chlorinated at the wellhead using the existing chlorine feed arrangement. The 15 horsepower submersible pump in Well No. 1 provides the pumping head needed to deliver water directly to the high zone tank. Weeks Drilling and Pump Company drilled the well in 1982 and has serviced it from time-to-time since. Well (i.e., pump) production is 75 to 80 gallons per minute (gpm) - adequate to meet the peak daily demands of the system. The well is 37 feet deep. The casing is perforated from a depth of 15 feet to 35 feet. Weeks Drilling bailed, swabbed and pumped the well in 1986 to clean it and restore capacity.

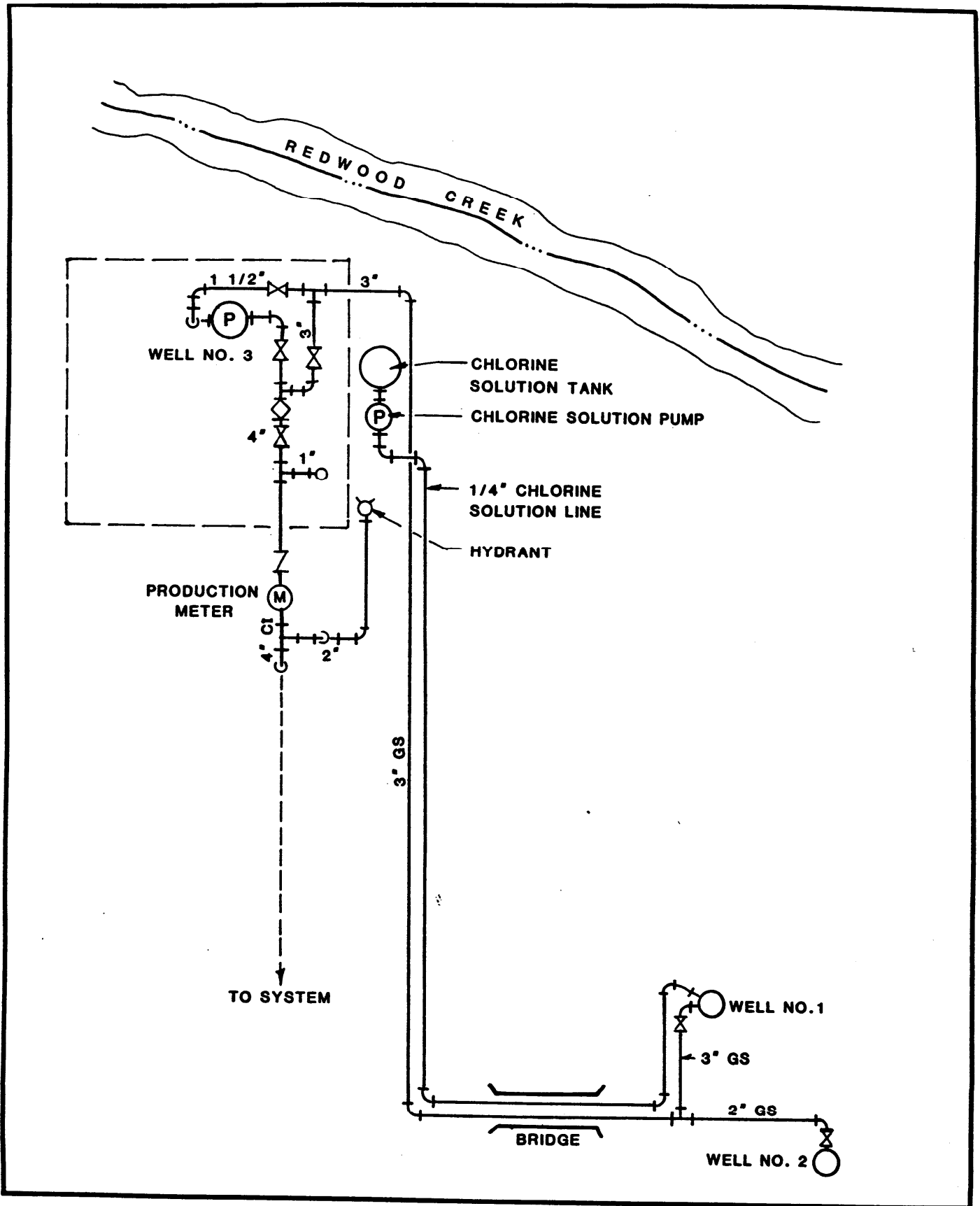
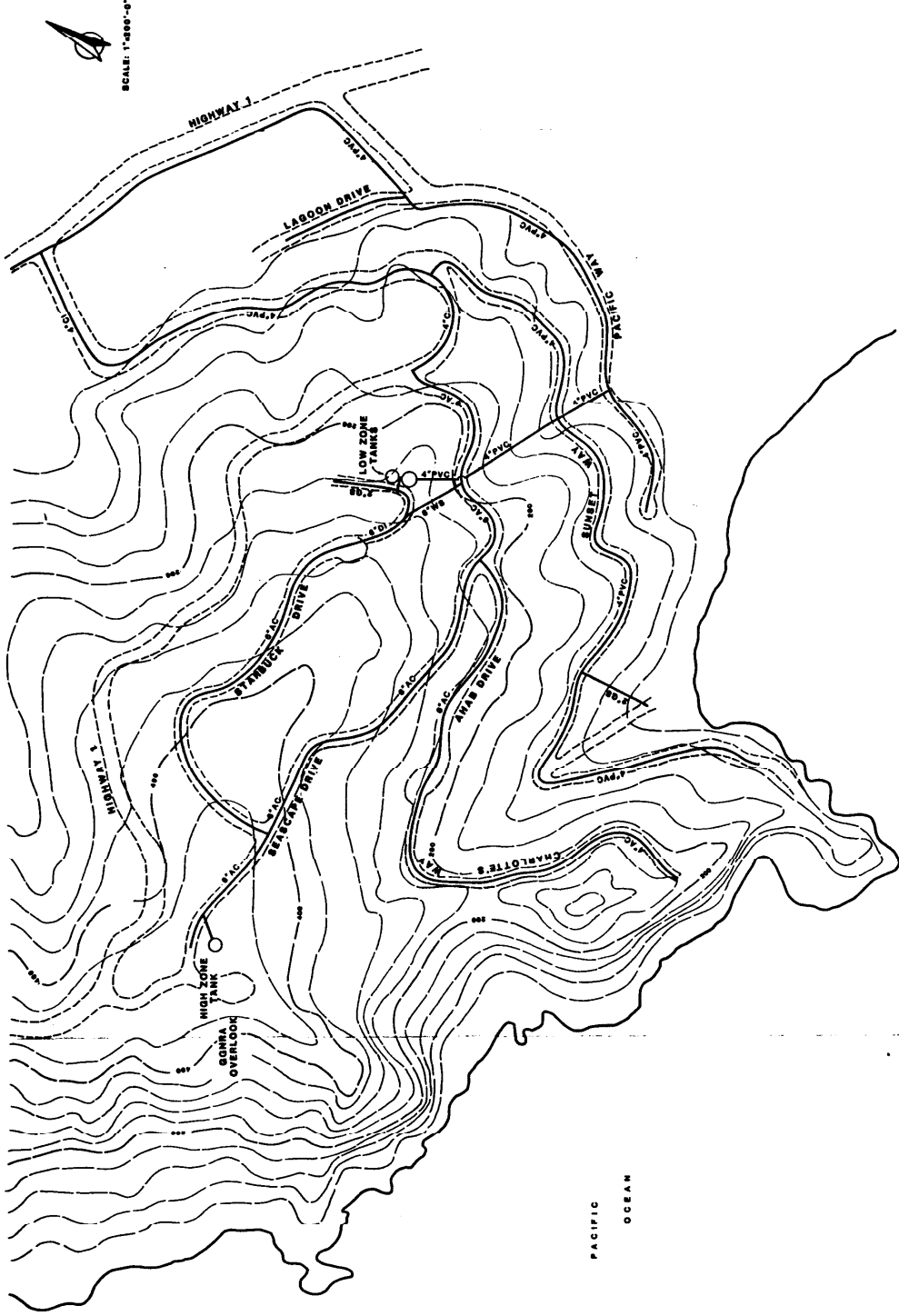


FIGURE 4-2
EXISTING SUPPLY FACILITIES



SCALE: 1"=500'-0"

FIGURE 4-1
EXISTING WATER SYSTEM

The well log, pump curve and service history for Well No. 1, obtained from Weeks, are included in Appendix A.

Well No. 2, drilled in 1970, is located about 100 feet east of Well No. 1. It is of the same depth and of similar construction as Well No. 1. The pump installed in Well No. 2 is a 2 horsepower submersible type that pumps directly to Well No. 3 from which it is booster-pumped into the system. Well No. 2 lacks a feed line for applying chlorine down the well - a method the District has found effective in minimizing iron and manganese problems. As a result, the well is not used on a regular basis. Weeks' records show that Well No. 2 was acid-treated, bailed and swabbed in 1982 to restore capacity.

Sodium hypochlorite is fed to oxidize iron and manganese and for disinfection using a Wallace and Tiernan Model A747 diaphragm metering pump. Backup chlorination equipment is not available. Total water production is read daily from a propeller meter installed in the discharge piping. The number of hours the well pump operates each day is indicated by a clock that runs only when the "pump run" signal is received from the high zone tank.

Figure 4-3 shows photographs of the wells and supporting facilities.

Transmission Main

Water is piped to the system via a four inch cast iron (CI) main about 5,500 feet long. This main runs along Frank Valley Road to its intersection with State Highway No. 1 and then follows the highway to Seacape Drive. It was installed in the mid-sixties as part of the Seacape subdivision. The condition of the main is unknown. Normally the service life of cast iron pipe, in a favorable environment, is 50 years or more. Corrosive soils can, however, reduce service life. Nevertheless, this pipe is only 20 years old. It has not, to date, shown visible signs of leakage or deterioration. It is recommended that the main be dug up in several locations and checked to determine its condition. The District plans to install a gate valve in this piping near the chlorine building. The condition of the section of pipe removed when the valve is installed will be checked at that time.

1
5500

High Zone Distribution System

The mains in the upper zone are, with one exception, six inch asbestos cement (AC) pipe. These mains were also installed during the mid-sixties. Although this pipe is no longer being actively marketed due to a forthcoming EPA ban on its manufacture, it does not ordinarily present a health hazard to water users unless the water is highly corrosive (i.e., not the case at Muir Beach). The reason for its prohibition by EPA is the exposure of workers during the manufacturing process to airborne asbestos fibers. This pipe is not subject to normal soil-related corrosion. When properly installed, asbestos-cement pipe will provide

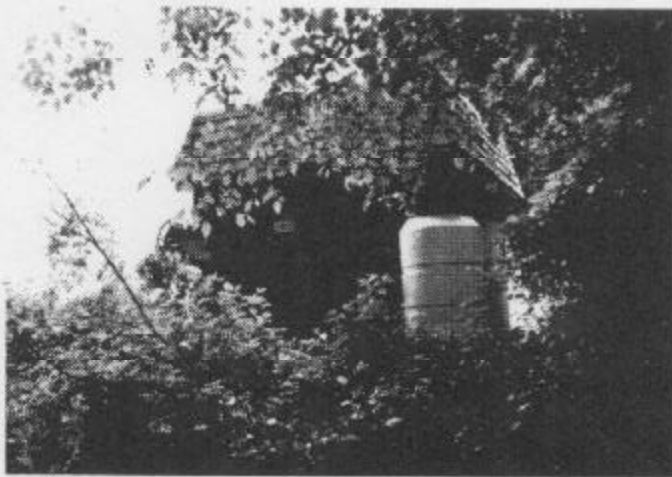
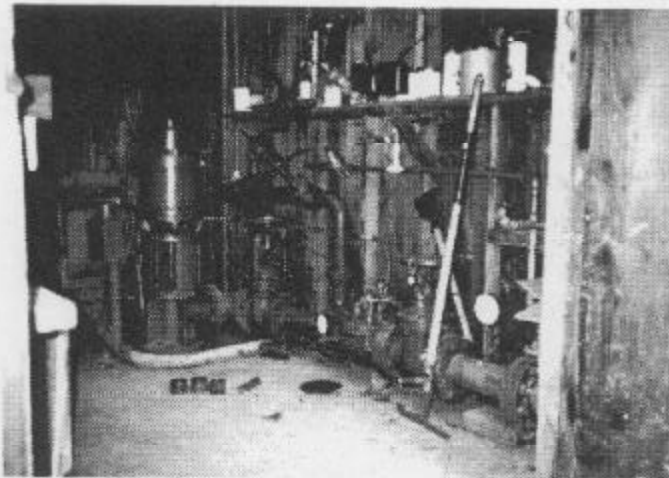


FIGURE 4-3

EXISTING SUPPLY FACILITIES

a 50 year, or greater, service life. The upper zone of the system includes about 6,500 feet of this pipe.

6500'
340'
370'

Other piping materials were used in the upper system near the lower tanks. A 340 foot section of six inch ductile iron (DI) pipe was installed from the end of the Starbuck Drive cul-de-sac south along a private road. A section of six inch welded steel pipe connects the ductile iron pipe to a six inch asbestos cement pipe on Seacape Drive below the tanks. A 370 foot length of two inch galvanized steel (GS) piping feeds those residences located along the private road north of the tanks. This pipe is the only size-deficient section of piping in the high zone.

High Zone Tank

The high zone tank, located at the westerly end of Seacape Drive, serves as the hydraulic control for the system. Level in this tank controls the well pumps. The tank is of redwood construction. It is 37 feet in diameter and 20 feet high providing a capacity of about 150,000 gallons when full. The pad elevation of this tank is about 475 feet, which provides a working water surface elevation in the tank in the 490 to 495 foot range. This tank was constructed when the Seacape system was built - in the mid-to-late-sixties. The condition of the wood in the tank appears satisfactory. The original bands are extensively corroded. Rebanding the tank has corrected this problem. It is estimated that the District can expect another 10 years of service from this tank before replacement. Figure 4-4 shows photographs of the tank and tank site.

Separate inlet and outlet tank piping promotes circulation. The outlet piping includes a check valve so that incoming water is diverted to the upper pipe. The tank is also equipped with a bottom drain and overflow. The site is not fenced. The tank is, however, partially screened by berms and vegetation. Figure 4-5 is a site plan of the existing high zone tank.

Low Zone Tank(s)

The remaining low zone tank and the recently failed low zone tank are both located on the same site. This site is adjacent to the private roadway, southeast of the Starbuck Drive cul-de-sac. The pad elevation of these tanks is about 260 feet, sufficient to provide adequate service pressures to the low zone of the system. This zone includes properties located along Sunset Way, Lagoon Drive and Pacific Way. Figure 4-6 is a site plan showing the low zone tanks. Figure 4-7 shows photographs of both tanks and the tank site.

Both tanks are of redwood construction. Band nut and thread failure was the direct cause of failure of the northerly tank. The District has taken the precaution of tack-welding the bolts to the bands on the remaining tank to prevent such a failure from occurring to the remaining tank. When the top bands broke on the failed tank, several staves broke at the approximate midpoint of

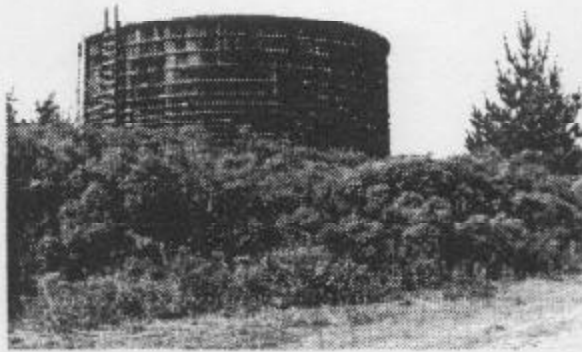


FIGURE 4-4

EXISTING HIGH ZONE TANK

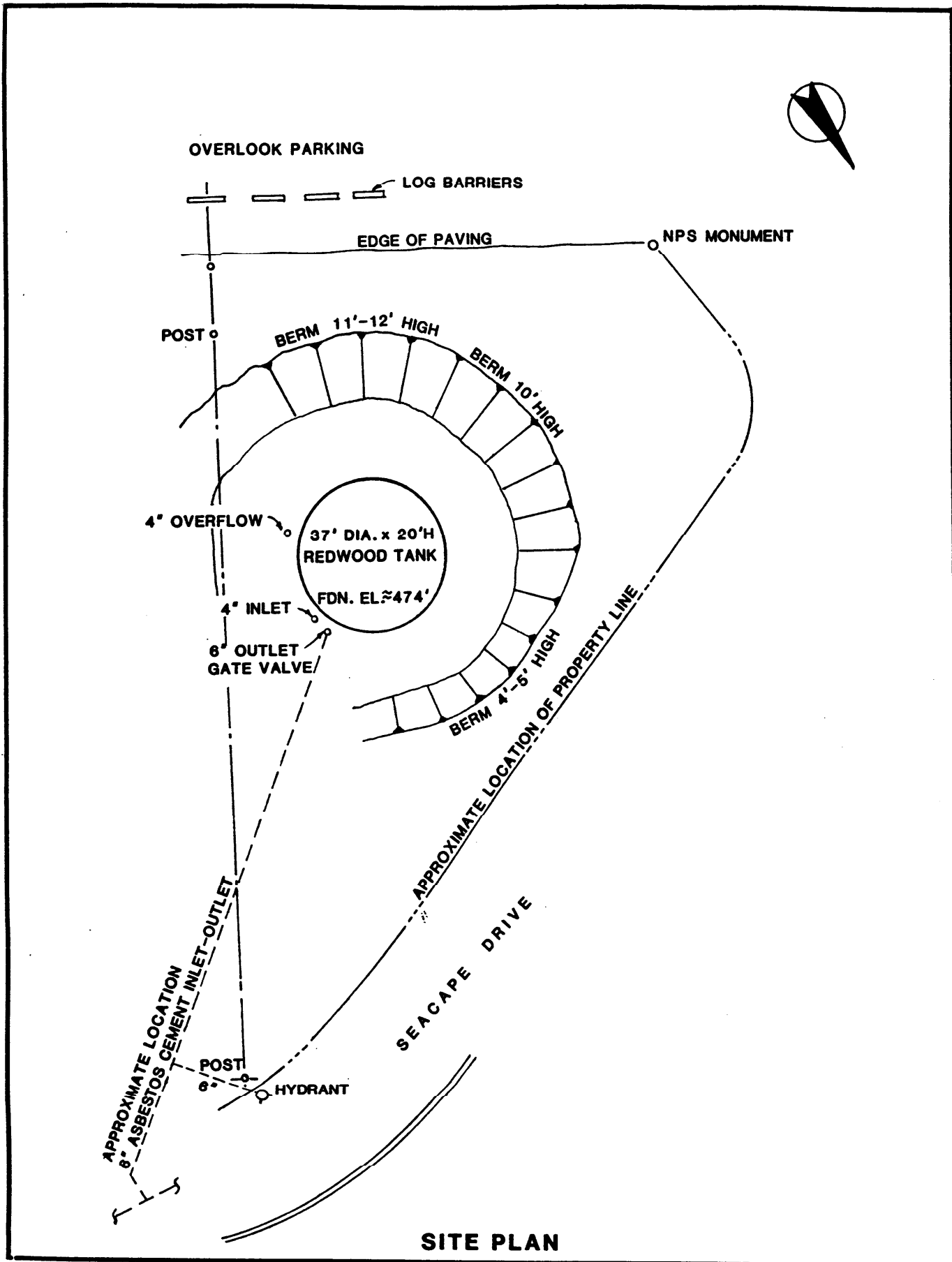
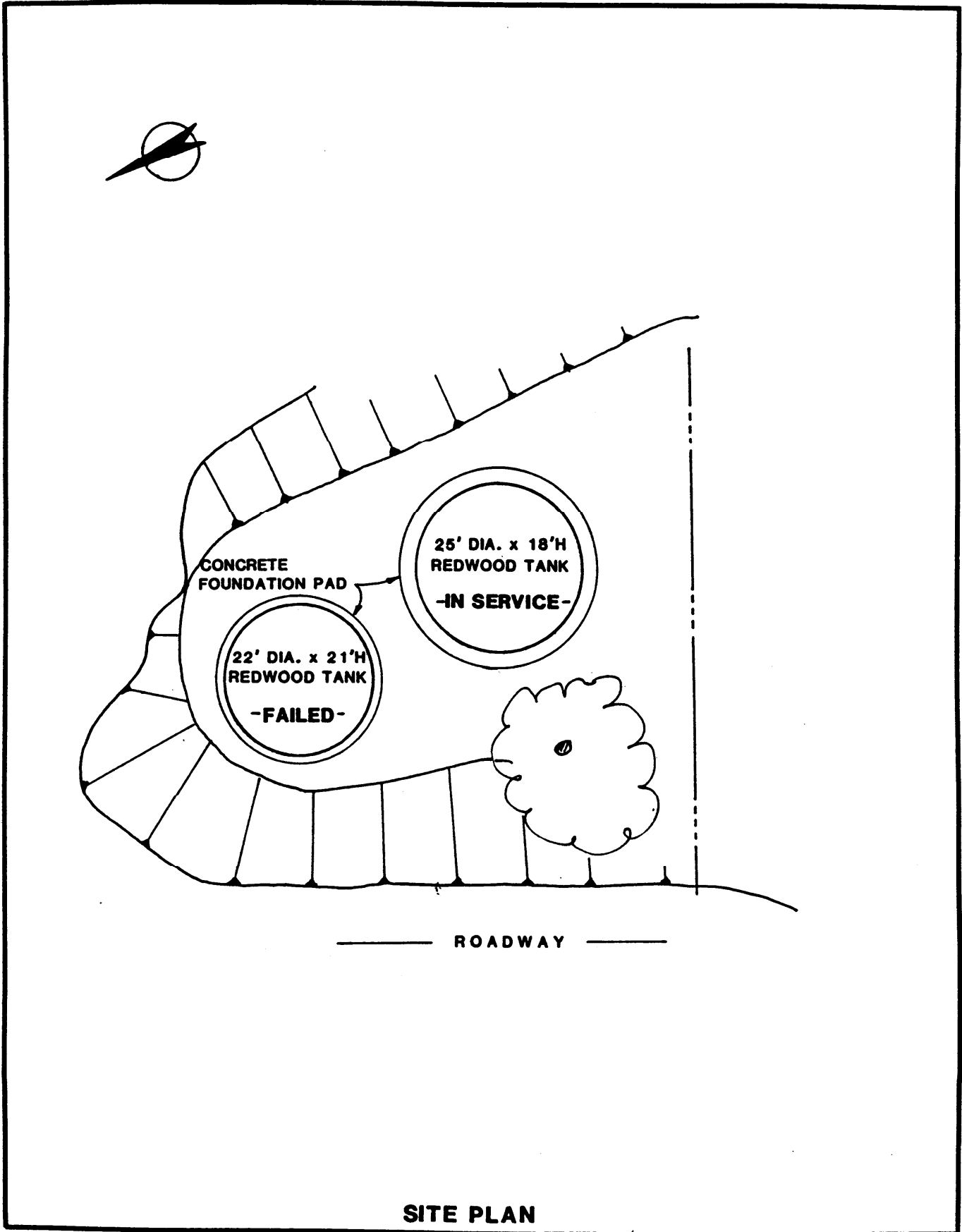


FIGURE 4-5
EXISTING HIGH ZONE TANK



SITE PLAN

FIGURE 4-6

EXISTING LOW ZONE TANK(S)

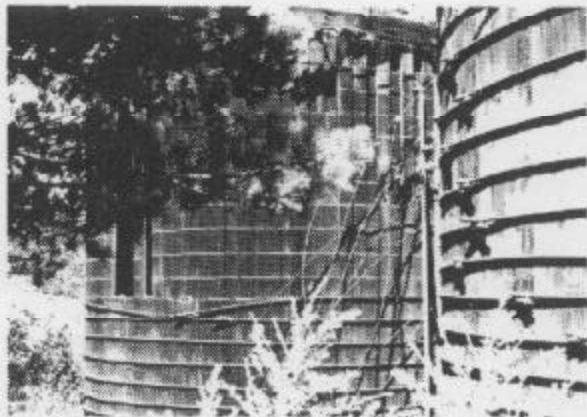
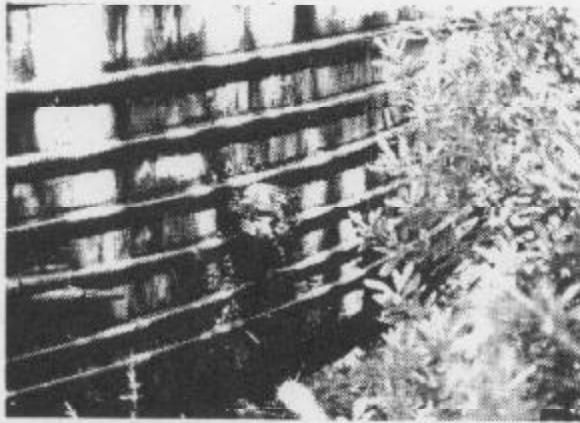
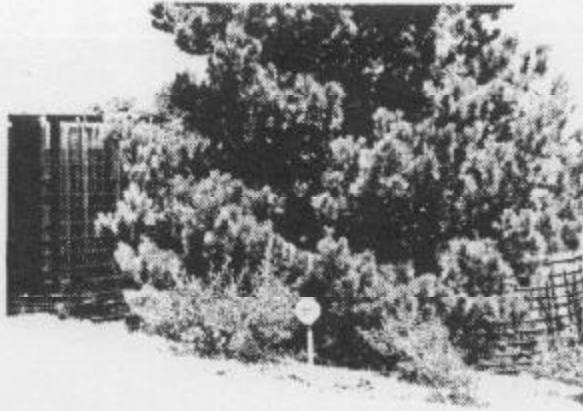


FIGURE 4-7

EXISTING LOW ZONE TANKS

the tank. Examination of the broken staves showed that they were in poor condition. These tanks were reportedly purchased used and have likely exceeded the normal life expectancy of 30 to 35 years for redwood tanks. The tank that is still in service is leaking. Wood shingles have been used to plug holes in the tank in an attempt to minimize leakage. The condition of the wood staves in this tank is poor.

The combined capacity of the two low zone tanks was about 100,000 gallons. The remaining tank has a diameter of 25 feet and is 18 feet high. Full to a normal working level, the capacity of this tank is about 50,000 gallons. The concrete foundation under the tank is 30 feet in diameter which may permit the erection of a larger diameter tank on the existing pad.

Low Zone Distribution System

The original low zone distribution system was installed in the 1920's. It consisted of small diameter galvanized steel pipe. All of this pipe was replaced with four inch polyvinyl chloride (PVC) pipe in the early seventies except for a section of 2 inch galvanized steel (GS) pipe on Cove Lane. A total of about 7,400 feet of PVC pipe was installed. The PVC pipe used was Schedule 40 which, considering the lack of an American Water Works Association (AWWA) standard for such pipe at that time, was a prudent choice. This pipe has a sufficiently thick wall to withstand pressures greater than 100 pounds per square inch (psi) over an extended period of time. Had a thinner-walled PVC pipe been used, the pipe may have failed prematurely. The installed depth of this pipe, however, is less than the normally-recommended 30 to 36 inches. The District manager has repaired sections of this pipe located in ditches that were damaged by vehicles because of shallow cover in ditches.

The low zone tank feeds the low zone system. There are no other interconnections between the high zone and the low zone. The District is now constructing a pressure regulator station on Seacape near the community center. This facility will improve the reliability of the low zone system and will allow service to be maintained in the low zone if the remaining low zone tank fails.

Fire Flow Capability

A computerized hydraulic model of the existing system was developed to test its adequacy under various assumed fire flow conditions. Appendix B lists the data used in preparing the model and includes printouts of typical computer "runs". The fire flow conditions modeled were chosen to simulate "worst case" fire flow situations. These included high fire flow locations or locations

at the extremities of the high zone or low zone systems. The specific locations at which the fire flow capability of the existing system was tested were as follows:

1. Pelican Inn (low zone).
2. Community Center (high zone).
3. Southwest end of Charlotte's Way (high zone).
4. Southwest end of Sunset Way (low zone).
5. Northeast end of private driveway - extension of Starbuck Drive (high zone).
6. Intersection of Seacape and Starbuck Drives (high zone).

The Pelican Inn location was chosen because of its relatively high fire demand (a commercial structure) and because it is located near the end of the 4 inch main at Pacific Way and Highway 1. The sustainable fire flow is now only about 300 gallons per minute (gpm). This is considerably less than the recommended fire flow of about 1,500 gpm for a structure of this type and size. These results show that the fire flow deliverable to residences near the end of Pacific Way or on Lagoon Drive is also roughly 300 gpm. This flow is also less than the minimum acceptable residential fire flow of 500 gpm.

The central location of the community center in the high zone and its size and construction also make it a valuable indicator of the hydraulic strength of the system. The model showed that a flow as high as 1,500 gpm can be sustained at this location. A flow of 1,500 gpm will, however, cause a vacuum condition in the 6-inch main at the intersection of Seacape and Starbuck Drives. This is an unacceptable condition, health-wise, because of possible contamination by septic tank leachate entering the main. A positive pressure can be maintained in this main if the fire flow is reduced to 1,000 gpm. Therefore, 1,000 gpm is the maximum allowable fire flow at the community center unless improvements are made to the system.

The end of the 4-inch main on Charlotte's Way is the "worse case" residential fire in the southwest area of the high zone. A flow of 400 gpm can be sustained at this location, slightly less than the 500 gpm residential minimum.

The southwest end of the Sunset Way main is the "worse case" residential fire for the low zone. The sustainable fire flow is only 250 gpm.

A fire at the northeast end of the private driveway off of Starbuck Drive (i.e., the "Moldenhour" property) was modeled to show the flow-restricting effects of the 2 inch line serving this area. The fire flow was only 125 gpm.

The intersection of Seacape and Starbuck Drives is a critical location because of its relatively high elevation compared to the water surface elevation of the high zone tank. The water level in the tank is only 75 feet higher than the elevation of the intersection, providing a maximum of 32 psi pressure under "no flow" or "low flow" conditions. Forty (40) psi is usually the minimum acceptable pressure for residential service. Pressures are lower at times of heavy demand.

The sustainable fire flow at this intersection, maintaining the desired 20 psi residual, is about 800 gpm, adequate for residential purposes. Although the main sizes in this area are 6 inch, pressure problems will occur at this location from high flows elsewhere in the system.

The pressure problem worsens west of this intersection as Seacape rises to the elevation of the tank. Residents adjacent to the tank use individual pressure tank systems to boost pressures to acceptable levels.

CHAPTER V

CHAPTER V

WATER REQUIREMENTS

Historical Water Production

Daily water production records have been maintained by the District since January 1985. The records include the total volume of water pumped, the hours of pumping and the total energy (power) used. These records were analyzed to determine the patterns and trends in water use to forecast future demands.

The results of this evaluation are summarized in Table 5-1 below. Appendix C includes a tabulation of monthly water production data.

Table 5-1

Summary of Water Production Data

	<u>1985</u>	<u>1986</u>	<u>1987*</u>
Total Annual Use, gallons	12,197,000	12,634,000	8,544,000
Avg. monthly use, gal/mo.	1,016,400	1,052,800	1,205,700
Peak monthly use, gal/mo.	1,168,800	1,297,500	1,421,000
Avg. daily use, gal/day	33,400	34,600	40,100
Ratio, max mo./avg. mo.	1.13	1.21	1.18
Average pumping, hr/day	8.0	8.2	9.6
Increase, % (1985 base)	-	3.6	18.6

*Through July 31

The following can be concluded from Table 5-1 and the data included in Appendix C:

1. The average monthly production has been 1,076,600 gallons during the past 31 months.
2. Production during that period has increased. Using 1985 as a base year, the 1986 demand increased by 3.6 percent. The 1987 demand, through July 31, has increased by 18.6 percent. The increase for 1987 is due, in part, to increased water use by the Pelican Inn for irrigation of recently landscaped grounds. For May, June and July, for example, water sales to the Pelican Inn were equivalent to over 2,500 gal/day - double to triple water sales to this establishment the previous year. Lower-than-normal rainfall is also responsible for increased use this year.
3. Peak water use occurs during the summer months. Water use increases from 13 to 21 percent, based on monthly data.

4. Based on 147 total services and an average household size of 2.43 persons, the following average unit water production rates were calculated:

<u>Year</u>	<u>Gal/Service/Day (gpsd)</u>	<u>Gal/Capita/Day (gpcd)</u>
1985	227	93.5
1986	235	96.9
1987	273	112.3

5. Well No. 1 pumps at a rate of 70 to 75 gallons per minute for 8 to 10 hours per day to meet demands.

Water Production Versus Sales

Water production and sales data for May, June and July of 1987 were reviewed to estimate unaccounted-for water. Unaccounted-for water is the difference between water production and water sales. The two main components of unaccounted-for water are usually metering inaccuracies and leakage (i.e., assuming that all water uses are metered). Table 5-2 summarizes these data:

Table 5-2

	<u>Production</u>	<u>Sales</u>	<u>Unaccounted- for Water</u>
May 1987 (gal)	1,414,100	1,033,600	380,500
June 1987 (gal)	1,421,000	1,104,300	316,700
July 1987 (gal)	<u>1,407,600</u>	<u>1,086,300</u>	<u>321,300</u>
Total (gal)	4,242,700	3,224,200	1,018,500
Average Day (gpd)	46,116	35,045	11,071
% of Production	100.0	76.0	24.0

The unaccounted-for water component, 24.0 percent at Muir Beach, is somewhat higher than the 10 to 20 percent value deemed acceptable by the American Water Works Association. The reason(s) for this are not known. The following approach is recommended for determining the sources of unaccounted-for water:

1. Check the calibration of all service meters. When water meters become old and worn they tend to under-register, particularly at low flows.
2. Check the calibration of the propeller-type meter at the well house.
3. Inspect (i.e., dig up) sections of the 4-inch transmission main to check its condition (i.e., potential leakage).

4. Spot-check service saddles and customer service lines ahead of meters.
5. Estimate leakage from tank(s). The remaining low zone tank is leaking an undetermined amount. Each 1 gallon per minute (gpm) leak is equivalent to 1,440 gpd, or 13 percent of the total unaccounted-for water component.

Projected Water Requirements

A water demand of about 75 gallons per capita per day (gpcd) is often used to estimate the in-house component of water use. This value does not, however, provide for irrigation, commercial usage or peak demands nor for unaccounted-for water. Based on the historical water production data for Muir Beach, 100 gpcd is a better estimate of average use in Muir Beach that includes allowances for other uses and unaccounted-for water.

Table 5-3 is a summary of projected water requirements for Muir Beach that was used for sizing recommended improvements. This table summarizes water requirements for 147 service connections (i.e., the present level of development) and for 175 "service equivalents."

The average daily demand for the system was calculated using 100 gallons per capita per day (gpcd), assuming 2.5 persons per service connection. Maximum monthly, daily and hourly demands were derived using Muir Beach data and data from similar small coastal communities. Note that the projected maximum day demand for 175 service equivalents is roughly 60 gpm. This demand has been used to evaluate the adequacy of supply and treatment facilities.

The storage required in the system is the sum of three components, namely:

1. Equalizing Storage - This is storage needed to provide for the peak usage periods during the day. For small systems a volume equivalent to about 25 percent of the maximum daily demand is usually adequate. The storage allotted to equalizing storage may be reduced if source capacity (i.e., well pumping capacity) is greater than the maximum daily demand.
2. Emergency Reserve - This is storage needed to maintain service in the event of a power outage, pump failure or natural disaster. A volume commonly used to meet this need is the maximum daily demand.
3. Fire Protection Storage - The minimum residential fire flow is 500 gpm, sustained for a 2 hour period. The equivalent volume is 60,000 gallons. Fire flow estimates were made for the two largest structures in Muir Beach, the community center and the Pelican Inn. These estimates were prepared using the Fire Suppression Rate

TABLE 5-3

WATER REQUIREMENTS
=====

Item -----	Ratio -----	Number of Service Equivalents	
		147 -----	175 -----
Demands/Flow Requirements =====			
Per Capita Water Use (gpcd)		100	100
Persons per Service		2.43	2.50
Average Daily Demand (gpd)	1.00	35,721	43,750
" " " (gpm)		24.8	30.4
Max. Monthly Demand (gpd)	1.25	44,651	54,688
" " " (gpm)		31.0	38.0
Max. Daily Demand (gpd)	2.00	71,442	87,500
" " " (gpm)		49.6	60.8
Max. Hourly Demand (gpm)	5.00	124.0	151.9
Residential Fire Demand (gpm)		500	500
Inst./Comm'l Fire Demand (gpm)		1,500	1,500
Storage Requirements - Residential =====			
Equalizing Storage (gallons) (1)		7,061	11,075
Emergency Reserve (gallons) (2)		71,442	87,500
Residential Fire Protection (gallons) (3)		60,000	60,000
Total Storage (gallons)		138,503	158,575
Storage Requirements - Inst./Comm'l =====			
Equalizing Storage (gallons) (1)		7,061	11,075
Emergency Reserve (gallons) (2)		71,442	87,500
Inst./Comm'l Fire Protection (gallons) (4)		180,000	180,000
Total Storage (gallons)		258,503	278,575

(1) Calculated as 25 percent of the maximum daily demand adjusted to consider well pumping capacity.

(2) Equal to the maximum daily demand.

(3) Calculated as a 500 gpm fire flow maintained for 2 hours.

(4) Calculated as a 1,500 gpm fire flow maintained for 2 hours.

Schedule published by the Insurance Services Office (ISO). Fire flows so calculated ranged from 1,500 to 2,000 gpm. A flow of 1,500 gpm for a 2 hour duration was used to calculate the required fire protection storage shown on Table 5-2. The equivalent volume is 180,000 gallons.

Table 5-3 also shows that total system storage should be about 280,000 gallons. The location(s) of storage facilities is discussed in Chapter 7.

CHAPTER VI

CHAPTER VI

DESIGN CRITERIA

Overview

The purpose of this chapter is to discuss and summarize design standards. These will be used as a basis for evaluating the existing water system and for developing alternatives and, ultimately, a recommended improvement program.

A number of standards exist that are applicable to the Muir Beach water system. Minimum water requirement criteria were discussed in Chapter 5, including storage needs. The "California Waterworks Standards", administered by the State Department of Health Services, (Title 22, Division 4, Chapter 16, of the California Administrative Code) specify minimum pipe sizes, construction materials and construction standards for water system components. State and Federal standards for potable water quality generally dictate treatment requirements. Finally, many standards and guidelines not carrying the force of legal requirements are used in designing water system improvements (i.e., "best practice" standards). Many of these recommendations are contained in standards and manuals published by the American Water Works Association (AWWA).

System Pressures

Pressures within a distribution system are often highly variable depending upon such factors as sizes of pipelines, the location of the source(s) and storage facilities and the topography of the service area. It is good practice to design service pressures greater than 40 psi throughout the distribution system during the peak hourly demand conditions.

The Insurance Services Office (ISO), is the rating bureau for the fire insurance industry. This organization requires that a minimum pressure of 20 psi be maintained at all locations within a system under fire flow conditions to receive a favorable rating. The State has a similar requirement. This precaution is taken to avoid creating a vacuum in the system with possible back siphonage of contaminated water under a high-demand condition.

Water Mains

Insofar as minimum water main diameter is concerned, the "California Waterworks Standards" require the following:

- "(a) Water mains shall have a nominal inside diameter of at least 4 inches (i.e., when such mains are part of a looped system or in instances where total length is less than 1000 feet.)

- (b) Dead-end water mains exceeding 1,000 feet in length shall be constructed of pipe with a nominal inside diameter of at least 6 inches.
- (c) Dead-end water mains exceeding 2,000 feet in length shall be constructed of pipe with a nominal inside diameter of at least 8 inches."

Portions of these requirements may be waived, providing analysis by a registered engineer demonstrates that the design meets flow and pressure requirements without meeting the criteria specified.

State requirements dealing with the layout of water mains are as follows:

- "(a) Water mains should be laid out only in segmented grids and loops and should be located within streets. Dead-end water mains shall be installed only if:
 - (1) Looping or gridding is impractical due to topography, geology, pressure zone boundaries, unavailability of easements or locations of users; or
 - (2) The main is to be extended in the near future and the planned extension will eliminate the dead-end conditions.

Federal and State Water Quality Standards and Treatment Requirements

Both Federal and State water quality standards and treatment requirements are currently undergoing revision as a result of the 1986 Amendments to the Safe Drinking Water Act. During the next three years the Environmental Protection Agency has been directed to establish maximum contaminant levels (MCL's) for 83 contaminants. These include inorganics, organics, microbiological organisms, and radionuclides. Standards now exist for many of these constituents under the 1975 Federal Safe Drinking Water Act (SWDA) and the 1977 California SDWA. In some instances the California standards are more stringent than the Federal standards.

Results of available past analyses of the Muir Beach supply are described in Chapter 7 along with current and proposed standards for the various constituents. Of particular concern at Muir Beach are various herbicides because these chemicals are used for agricultural purposes on the Redwood Creek watershed. They have not been detected in the Muir supply as of this date, however. If the District's supply were contaminated with herbicides, activated carbon treatment would be needed to remove them.

The second provision of the 1986 Amendments to the SDWA with possible significant impact on Muir Beach is that dealing with mandatory filtration of surface waters. The District wells, because they are shallow and not sealed to 50 feet, are not true

groundwater sources and may be subject to surface contamination. The wells may, at some time in the future, be classified as surface sources requiring filtration. This will probably not occur for several years, if then. Increased monitoring of the water quality of both Redwood Creek and the District's wells will undoubtedly be a forthcoming requirement, however.

CHAPTER VII

CHAPTER VII

SUPPLY AND TREATMENT IMPROVEMENTS

Overview

Supply and treatment-related improvements fall into two categories - "short term" and "long term". Short term improvements for Muir Beach are those needed immediately to improve the reliability of the supply and to remedy known problems. Long term improvements, if required, relate to any future treatment requirements arising from increased upstream contamination of the source and/or increasingly stringent water quality standards.

Short Term Improvement Requirements

There are three operational deficiencies in the systems supply that require correction to provide reliability. These are:

1. Replace the pump in Well No. 2 with a unit capable of pumping directly to the high zone of the system.
2. Provide a chlorine solution feed line to Well No. 2 to allow in-the-well chlorination.
3. Provide a backup chlorine solution feed pump.

Figure 7-1 shows these improvements schematically. The new well pump should be of similar capacity to that in Well No. 1 rated at approximately 75 gallons per minute (gpm). This will insure that the maximum daily demand of 61 gpm can be met with either pump in operation. Electrical switchgear is needed that will automatically alternate the operation of the two well pumps and switch the point of chlorine application. Because Well No. 2 has not been used frequently in recent years, it should be rehabilitated before it is put in service.

The total estimated cost for the improvements shown on Figure 7-1 and described in this chapter will be about \$23,300. This estimate is based in part on costs the District incurred in 1982 when installing the pump in Well No. 1.

Water Quality

Both Well No. 1 and Well No. 2 are considered shallow wells because they are only 37 feet deep. They cannot be sealed to a 50 depth - the minimum required for protection from surface contamination. These wells are not true wells because they draw their supply from the underflow of Redwood Creek rather than from a true ground water aquifer. There is no known aquifer in the area that will provide water in the quantities needed by the District.

The Muir Beach water source is thus subject to upstream contamination. Careful attention to chlorination of the supply has, to

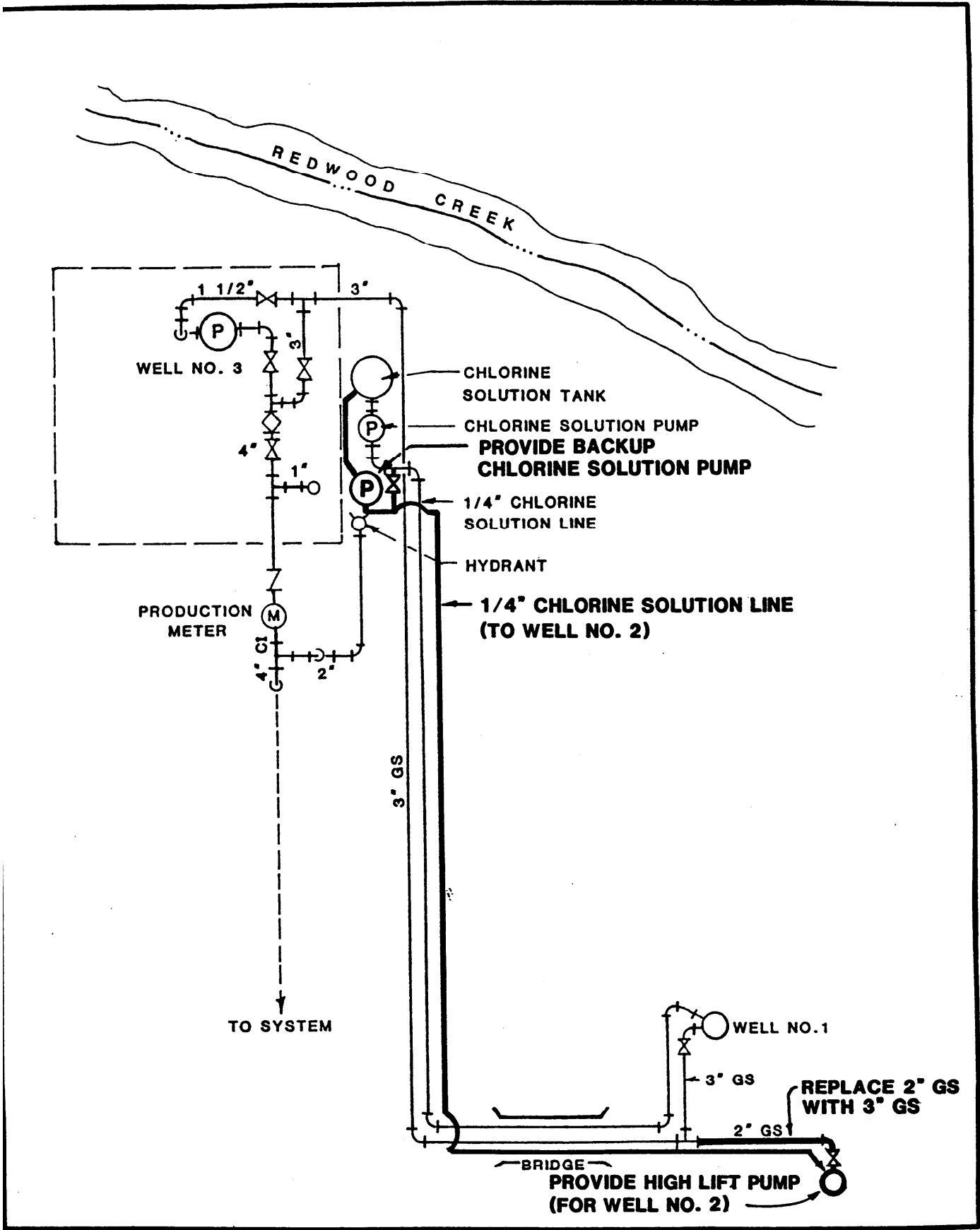


FIGURE 7-1
 PROPOSED SUPPLY IMPROVEMENTS

date, maintained the microbiological safety of the supply delivered to the community. The Muir Woods National Monument, however, serves an ever-increasing visitor load upstream. Muir Woods has in the past used a septic tank and leach field. Recent problems with this system led to the installation of chemical toilets and the abandonment of the septic system. It is our understanding that a study is now underway investigating the feasibility of pumping Muir Woods sewage out of the watershed for treatment and disposal. If an export scheme is implemented, the major potential source of contamination of the District's supply will have been eliminated.

As discussed in Chapter 6, the other known possible sources of contaminants of the District's supply are local agriculture and recreational activities. Herbicides and possibly pesticides are the most likely contaminants although animal wastes could also pose a threat.

Table 7-1 shows the results of various analyses run on Muir Beach water.

A sample was taken from District Well No. 1 (i.e., raw unchlorinated water) as part of this investigation. The results are included in Table 7-1. They indicate that only two constituents, iron and manganese, exceed maximum contaminant levels (MCL). These constituents have no known health-related effects at the concentrations indicated. In any event, these substances are oxidized by chlorination at the wellhead and thus generally reach consumers in lower concentrations.

Marin County will sample and analyze the District's supply for trace organics, including herbicides and pesticides, early in 1988. This is being done as part of a State-sponsored program. These results may help establish a water quality baseline for the District's supply and may also provide some indication of what future treatment needs will be.

If filtration is required, a 75 gpm plant constructed on District property near the wells would cost about \$185,000 (1988 basis). If activated carbon treatment is necessary to remove organics, such as herbicides, the cost of treatment will increase by about \$75,000 to \$260,000.

TABLE 7-1

WATER QUALITY DATA

Parameter	Date Sampled						Maximum Contaminant Level	
	2/8/82	9/21/82	9/24/84	2/4/85	6/10/86	8/21/86		11/24/86
Arsenic	<0.002		<0.10	<0.003			<0.002	0.05
Barium	<0.2		<0.10	<0.2			<0.3	1.0
Cadmium	<0.001		<0.005	<0.001			<0.002	0.01
Chromium	<0.002		<0.030	0.003			<0.004	0.05
Mercury	<0.0005		<0.001	<0.0005			<0.0002	0.002
Zinc	0.02						0.051	(5.0)
Nitrate	<0.05	<0.05	0.60				<1.0	10
Selenium	<0.005		<0.005	<0.003			<0.002	0.01
Silver	<0.001		<0.030	<0.001			<0.002	0.05
Fluoride	0.18	0.12	0.15				<0.1	2.0
Chloride	32	24	20.0				30	(250)
Iron	0.02	0.34	<0.10				0.71	(0.3)
Manganese	0.14	0.10	0.09				0.06	(0.05)
Sodium	21	19	20				18.0	
Hardness			109				100	
Aluminum			0.232					
Lead	<0.005		<0.010	0.008			<0.01	0.02
Copper	<0.01	<0.01	0.064			24.4	0.007	(1.0)
Calcium	20.0	19.2	<20					
Magnesium	14.4	11.2	12.2					
Sulfate	16	13	13					
Alkalinity	94.5	87	18					
Total Dissolved Solids	209	160	167					
pH (2)	7.22	7.02	8.1					
Total THMs		0.10						
Endrin	<0.00003							
Lindane	<0.0001							
Methoxychlor	<0.0001							
Toxaphene	<0.0001							
2,4 -D	<0.0007							
2,4,5 -TP Silvex	<0.0001							
Turbidity (3)	0.73	1.2						
Color (4)	5	10						
Total Coliforms (5)			<1				0	0

(1) All results in mg/l except as noted.
 (2) pH units
 (3) Turbidity units
 (4) Color units
 (5) Coliform count
 (6) Values in () are secondary standards.

CHAPTER VIII

CHAPTER VIII

STORAGE AND PUMPING ALTERNATIVES

Overview

Because of the recent tank failure and the concern of several residents in the vicinity of the high zone tank about the visual impacts of that structure, an analysis of storage and pumping alternatives is timely. The need to implement a storage and pumping scheme that is both reliable and economical is equally important.

The following three storage and pumping alternatives are described and compared in this chapter:

1. **Alternative 1 - Pump to High Zone Tank/Backfeed Low Zone** - This is the way the system now operates. The well pump is controlled by level in the high zone tank. The low zone tank is now kept full by backfeeding it from the upper zone. With pressure regulators to feed the low zone this alternative is workable with or without a low zone tank.
2. **Alternative 2 - Pump to Low Zone Tank/Booster Pump to High Zone Tank** - For this alternative, well pump operation is controlled by level in the low zone tank. A small booster pump station, located next to the low zone tank, would pump to the high zone tank.
3. **Alternative 3 - Pump to Low Zone Tank/Booster Pump to High Zone (No Tank)** - This scheme is similar to Alternative 2 except that the booster pumps must be sized to deliver the full range of water demands in the high zone, including fire flows.

Figure 8-1 shows schematic diagrams for each alternative.

A total storage requirement of 280,000 gallons and a fire flow requirement of 1,500 gpm were used in developing all three alternatives. This approach is consistent with the flow and storage recommendations previously shown on Table 5-3. The evaluation of alternatives was based on both economic and non-economic criteria.

The second topic investigated in this chapter is the types of tanks and reservoirs suitable for Muir Beach. The advantages and disadvantages of, and costs for, redwood tanks, steel tanks and concrete reservoirs are listed and discussed. Preliminary sketches are included showing the visual impacts of each storage alternative at the high zone site.

The chapter concludes by recommending a storage and pumping scheme.

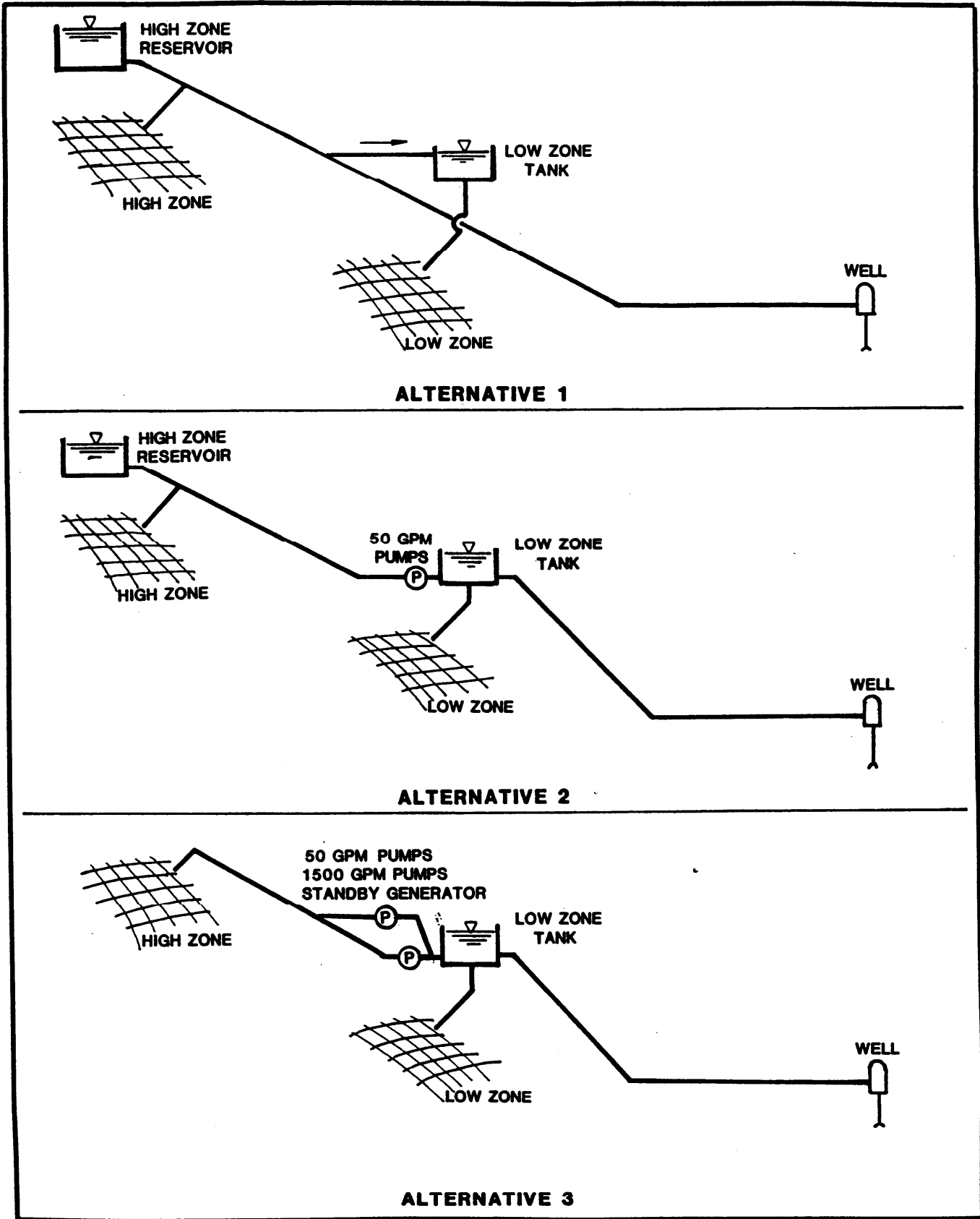


FIGURE 8-1

STORAGE AND PUMPING ALTERNATIVES

Economic Evaluation of Storage and Pumping Alternatives

In order to estimate power costs for the alternatives, District pumping and production data were reviewed again to determine the average water demands of the high zone and low zone systems. Assuming an average daily demand for the entire system of 40,000 gpd, the high zone and low zone demands are 17,250 gpd (43.2%) and 22,750 gpd (56.8%), respectively. Power costs for operating the well pump are about \$0.10 per kilowatt hour (kwhr).

Alternative 1 assumes that the entire supply is pumped to the high zone. Therefore, the total pumping cost is that cost incurred through operating the 15 horsepower, 75 gpm well pump. The annual power cost will be about \$5,150 per year.

Alternative 2 assumes that the entire supply is pumped to the low zone. Approximately 43 percent of the supply would then be booster-pumped to the high zone. The booster pump station would include two (one standby) 7-1/2 horsepower, 50 gpm pumps, controls and interconnecting piping. The estimated cost for these improvements, including engineering, is about \$37,500. The combined annual power cost for operating the well pump and a booster pump will be about \$3,900 per year. Therefore, the annual power savings as compared to Alternative 1 is about \$1,250. Maintenance costs for operating the booster pump station will be about \$500 per year.

Alternative 3 also assumes that the entire supply is pumped to the low zone and that demands in the high zone are met by booster pumping. The booster pump station, however, will be more complex than that required for Alternative 2 because it must satisfy variations in normal water demands and also pump a 1,500 gpm fire demand. Two, 7-1/2 horsepower, 50 gpm pumps will meet normal demands. These pumps, must be controlled by either a hydropneumatic tank or by constant pressure controls. To meet fire flows, two (one standby unit) 200 horsepower, 1,500 gpm pumps are needed. A direct drive diesel engine or a diesel-electric standby generator is also needed to ensure that fire protection is maintained during power outages. Extensive modifications to the piping near the low zone tank are also needed to accommodate 1,500 gpm flows. The estimated cost for the booster pump station, standby power and associated improvements would be \$200,000. Annual operation and maintenance costs be about \$4,000. The power savings, on a power consumed basis, would be the same as for Alternative 2 - \$1,250 per year. Demand charges for power for operating the large fire pumps will eliminate some of the savings, however. For this analysis it was assumed that net power savings will be 50 percent of the apparent savings or, \$625 per year (i.e., an total cost of \$4,525 per year).

A present worth analysis of the three alternatives was made to determine which alternative is cheapest over a 40 year period. The results of the analysis are shown on Tables 8-1, 8-2 and 8-3 for Alternatives 1, 2 and 3, respectively. These tables show first costs and major replacement costs for additional pumping

facilities in the column entitled "Capital or Replacement Cost". These costs have been escalated at a rate of 3.5 percent per year. The additional annual operation and maintenance costs for operating a pump station at the low zone tank site for Alternatives 2 and 3 are shown in the "Annual O&M Cost for Pumping" column. A 3.5 percent rate of escalation was also used for operation and maintenance costs. Total annual power costs for all the alternatives are shown in the column entitled "Annual Power Cost". The escalation factor used for power costs is 5 percent per year. The "Total Annual Cost" column is the sum of the preceding three columns. Values shown in the "Present Worth Cost" column are those values in the "Total Annual Cost" column reduced to a "year zero" equivalent. The assumed discount, or interest, rate was 8 per cent for present worth calculations. Referring to Table 8-1, for example, the present-worth cost of an expenditure of \$10,593 in the 15th year is \$3,606. This means that \$3,606 invested at 8 percent per year would grow to \$10,593 after 15 years.

Examination of Tables 8-1, 8-2 and 8-3 shows that Alternative 1 is the least costly over a 40 year period on a present worth basis. Alternative 2, on the other hand, is least costly based on projected total annual costs. The reason for this apparent disparity is the timing of expenditures. Alternative 2 requires that a new pump station be built initially at a cost of \$37,500 (i.e., the "present worth" is also \$37,500). For Alternative 1, on the other hand, the higher annual power costs are spread over the full 40 year period. A comparison of the three alternatives shows the following:

<u>Alternative No.</u>	<u>Total Annual Cost</u>	<u>Total Present Worth Cost</u>
1	\$683,943	\$131,920
2	\$610,330	\$146,636
3	\$1,372,513	\$415,339

It bears mentioning that tank, or reservoir costs will be roughly the same regardless of the storage and pumping alternative chosen because a total of 280,000 gallons of storage is needed regardless of where the tank, or tanks are located.

Other Factors - Evaluation of Storage and Pumping Alternatives

Alternative 1 is somewhat more reliable than Alternative 2, and much more reliable than Alternative 3, because of its simplicity and reliance upon gravity storage. Alternative 2 retains gravity storage in the high zone thereby providing emergency storage in the event of a power outage but adds a pumping station, increasing the mechanical complexity of the system. Even with a standby generator, the high zone booster pumping scheme of Alternative 3 is not as reliable as the gravity storage afforded by either Alternative 1 or Alternative 2.

Noise is another disadvantage of Alternative 3. Housing the large pumps and the standby generator will reduce, but not completely eliminate, noise from this equipment. The pump station would be located in a residential area adjacent to the low zone tank.

The operational simplicity of Alternative 1 is a decided advantage, over-and-above that shown by the economic analysis.

Alternative Materials for Tank and Reservoir Construction

The storage options available at Muir Beach in the 50,000 to 280,00 gallon capacity range include:

1. Redwood tanks.
2. Welded steel tanks.
3. Concrete reservoir.

Owing to Muir Beach's proximity to the ocean, the redwood tank or concrete reservoir is preferable to a steel tank from a corrosion standpoint. Steel tanks with modern coatings can, however, provide satisfactory service in coastal environments providing the tanks are regularly recoated.

Quotations were obtained from tank manufacturers for redwood and steel tanks. Cost estimates were prepared for concrete reservoirs of several sizes. Concrete reservoirs are cast-in-place, not site-erected prefabricated structures like redwood and steel tanks.

Redwood tanks are practically maintenance free, requiring only occasional cleaning and band-tightening. As the residents of Muir Beach are acutely aware, the service life of redwood tanks is about 30 years - usually less than the other storage alternatives.

Welded steel tanks are built to American Water Works Association (AWWA) specifications that guarantee that these tanks meet certain strength and performance criteria. Properly designed and installed, these tanks are more earthquake-resistant than redwood tanks. If coated regularly, the economic life of steel tanks may exceed 50 years.

A welded steel tank is constructed of curved steel plates that are field welded. Once the structure is complete, the tank is sandblasted inside and out and coated. Welded steel tanks are perhaps the most common tanks used in California for water storage because of their excellent seismic resistance and overall economy.

A concrete reservoir offers obvious advantages in terms of maintenance and longevity but is usually somewhat more expensive than the other alternatives in terms of first cost. It offers the

best opportunity to blend storage into a site inasmuch as its dimensions are not fixed. It can be partially, or completely, buried providing health requirements are met to ensure that contamination from groundwater does not occur.

Evaluation of Tank and Reservoir Alternatives

The existing remaining low zone tank is in poor condition and must be replaced immediately if a low zone tank is to be retained in the system. The high zone tank, on the other hand, will serve for another 10 years, perhaps longer now that it has been reband-ed.

The total storage requirement for Muir Beach, based on meeting a fire demand of 1,500 gpm and the other criteria described earlier in this report, is approximately 280,000 gallons. Assuming that Alternative 1 is implemented, storage may be provided at both the high zone and the low zone tank sites or only at the high zone location. Although both first costs and operation and maintenance costs would be somewhat less if the entire 280,000 gallons is located at the high zone site, it is not recommended. Reliability is improved by locating storage facilities at different locations within a system. With different tank sites a main break or other system malfunction or an earthquake or natural disaster is less likely to totally disrupt service.

A rationale for allocating the 280,000 gallons of storage between the high zone and low zone may be developed as follows:

1. Equalizing Storage - If storage is allocated based on the 11,000 gallons needed for equalization under average daily demand conditions, high zone storage will be approximately 5,000 gallons and low zone storage, 6,000 gallons.
2. Emergency Reserve - Since the low zone can be served from the high zone tank, the entire emergency reserve, 87,500 gallons, can be stored in the high zone tank. This is one approach. It is also reasonable to allocate the emergency reserve between zones in proportion to average demands. For this assumption high zone storage would be approximately 37,500 gallons and low zone storage would be 50,000 gallons.
3. Fire Protection - Based only on hydraulic considerations the entire 180,000 gallon fire reserve may be stored in the high zone tank. Reliability considerations dictate otherwise. A reasonable approach would be to provide sufficient storage, 60,000 gallons, in the low zone tank to fight a 500 gpm residential fire in the low zone and to provide the remainder, 120,000 gallons, in the high zone tank.

Using the foregoing assumptions, storage in the low zone tank could range from as little as 6,000 gallons to as much as 116,000 gallons.

Other factors bearing consideration in selecting a capacity for the low zone tank include:

1. Phasing of Tank Construction - Because the low zone tank requires immediate replacement and the high zone tank may remain in service for 10 years or more, constructing a low zone tank smaller than the existing 50,000 gallon tank will create a system storage deficiency until the new high zone tank is built.
2. Economies of Scale - Since many costs associated with constructing tanks are fixed or decrease at a much lower rate than tank capacity, a larger tank is more economical on a per-gallon-stored basis. The costs for three sizes of redwood tanks illustrate the economies of scale concept:

<u>Tank Capacity</u>	<u>Total Cost</u>	<u>Cost/Gallon Stored</u>
25,000 gal	\$31,800	\$1.27
50,000 gal	\$46,600	\$0.93
100,000 gal	\$69,900	\$0.70

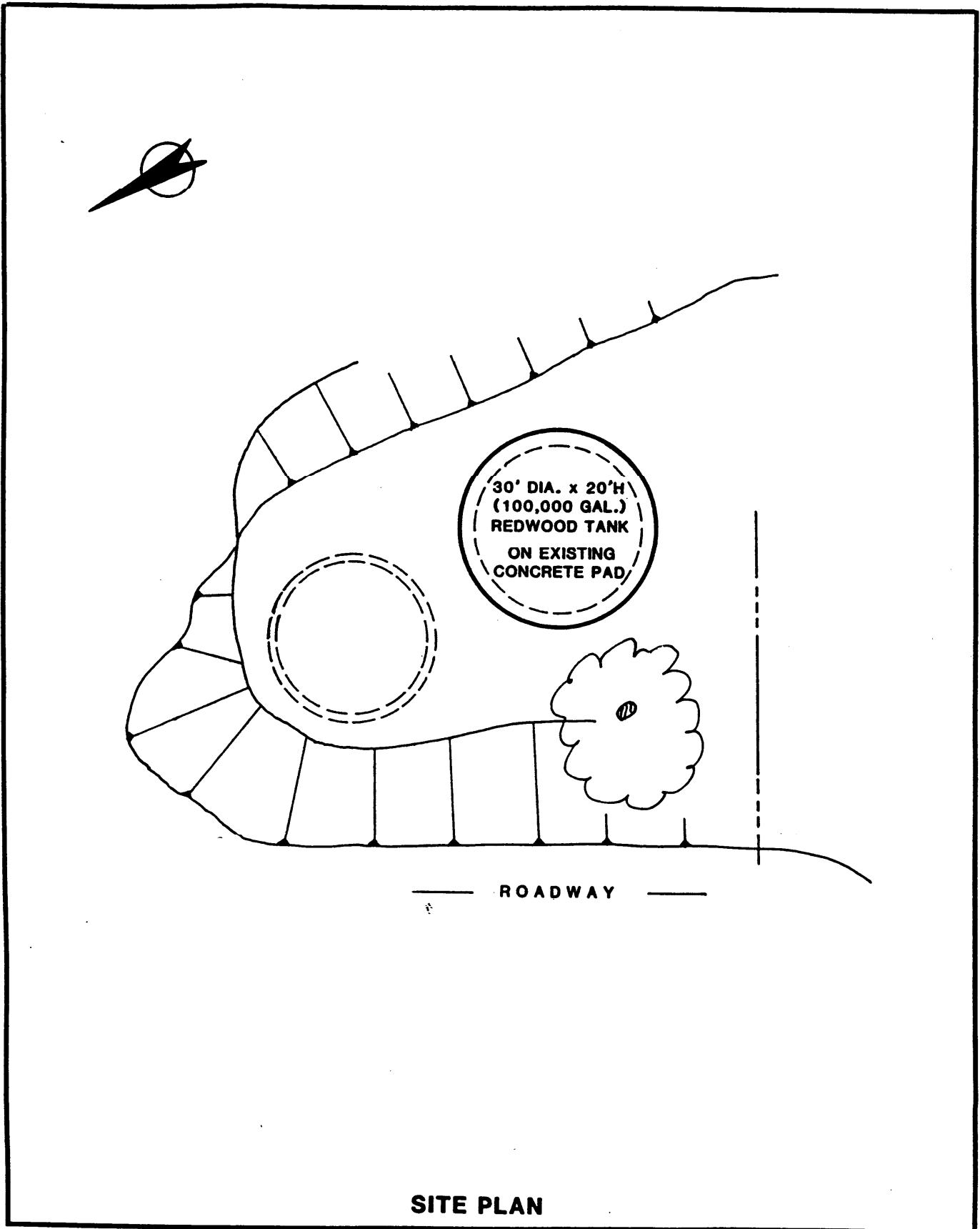
Similar relationships exist for concrete reservoirs and steel tanks.

3. Existing Site Conditions - The remaining 50,000 gallon tank is constructed on a concrete pad 5 feet larger in diameter than the tank itself. If a redwood tank is constructed on this pad, a capacity of 80,000 to 100,000 gallons can be provided without constructing a new tank foundation.

It is recommended that 100,000 gallons of storage be constructed at the low zone tank site. Because of its longevity and seismic resistance, a concrete reservoir is preferred although a redwood tank would also be satisfactory. The estimated costs for a concrete reservoir and a redwood tank are \$130,000 and \$70,000, respectively. Both estimates allow for piping and valving necessary to permit rapid hookup of a portable pump to serve the high zone from the low zone tank under emergency conditions.

Figure 8-2 shows a low zone tank site plan for a 30 foot diameter by 20 foot high redwood tank. The dimensions for a concrete reservoir of equivalent capacity would be 31 feet square by 16 feet high.

A workable high zone storage scheme may be developed using redwood tanks, welded steel tanks or a concrete reservoir. Nominal storage provided at the high zone site must be approximately 200,000 gallons. For maximum flexibility, two tanks or a compart-



SITE PLAN

FIGURE 8-2

**PROPOSED LOW ZONE STORAGE IMPROVEMENTS
REDWOOD TANK**

mented reservoir, should be constructed to allow one tank/compartments to be drained, cleaned and inspected while maintaining service in the upper zone.

Because aesthetics are of concern at the high zone site, tank or reservoir height must be limited to no more than 20 feet, the height of the existing tank. A height reduction to approximately 16 feet appears feasible. Further height reductions would jeopardize service, especially in the area adjacent to the tank itself.

Figure 8-3 is a plan showing two 30 foot diameter by 20 feet high tanks located on the existing high zone tank site. Note that the existing tank must first be removed to make efficient use of the site (i.e., this is true with all viable options). This arrangement is workable for either redwood or welded steel tanks. An alternative layout, not shown but essentially the same in plan, would use two, 33 foot diameter by 16 foot high tanks thereby lowering the overall profile by 4 feet.

Figure 8-4 is a plan showing a two-compartment concrete reservoir approximately 60 feet long by 30 feet wide and 16 feet high. An earth berm would be built around and abutting the reservoir so that it could not be seen from Seacape Drive or from adjacent residences. The roof would be constructed using precast concrete panels that may be tinted brown, if the community so desires.

A "life cycle" economic analysis of the three high zone tank/reservoir alternatives is summarized on Table 8-4. Capital and replacement costs and present worth costs are shown for each tank system. It was assumed for the analysis that redwood tanks would be replaced after 30 years and that the welded steel tanks would require complete interior and exterior recoating at 10 year intervals. All tanks and reservoirs require occasional cleaning (i.e., costs will be about the same) so this item has not been included in the economic analysis.

Table 8-4 shows that the redwood tank alternative is the least costly on a present worth basis, \$169,842, but is the most expensive, \$505,542, based on capital and replacement costs. The need to replace both tanks after 30 years of service at costs prevailing at that time accounts for this finding. The concrete reservoir, on the other hand, has the highest present worth cost, \$233,800, but the lowest capital and replacement cost of the three alternatives.

If the community can afford the higher first cost of a concrete reservoir at the high zone site, it is recommended. Advantages include low maintenance, siting flexibility (i.e., aesthetics) and good seismic resistance.

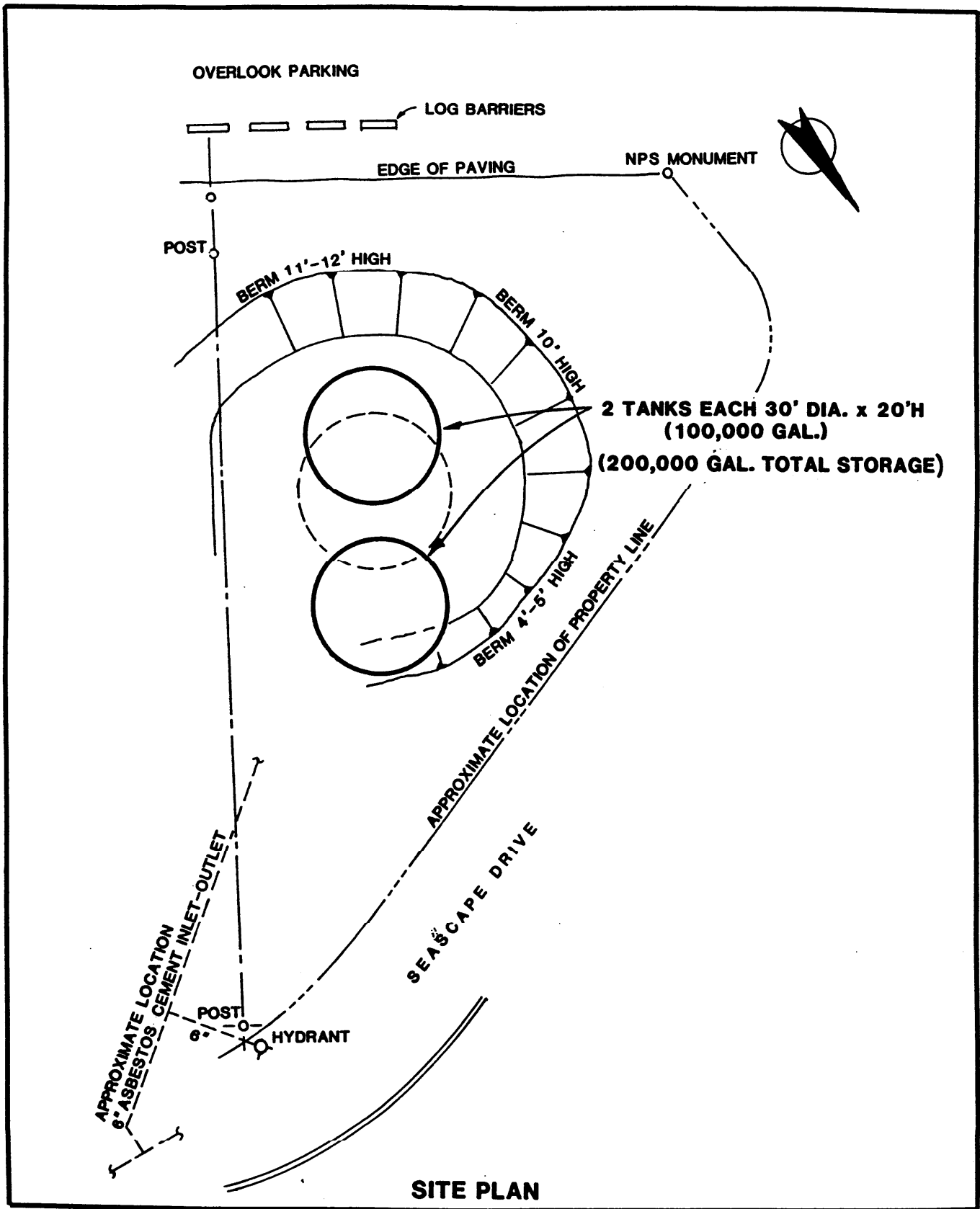


FIGURE 8-3

PROPOSED HIGH ZONE STORAGE IMPROVEMENTS
REDWOOD OR WELDED STEEL TANKS

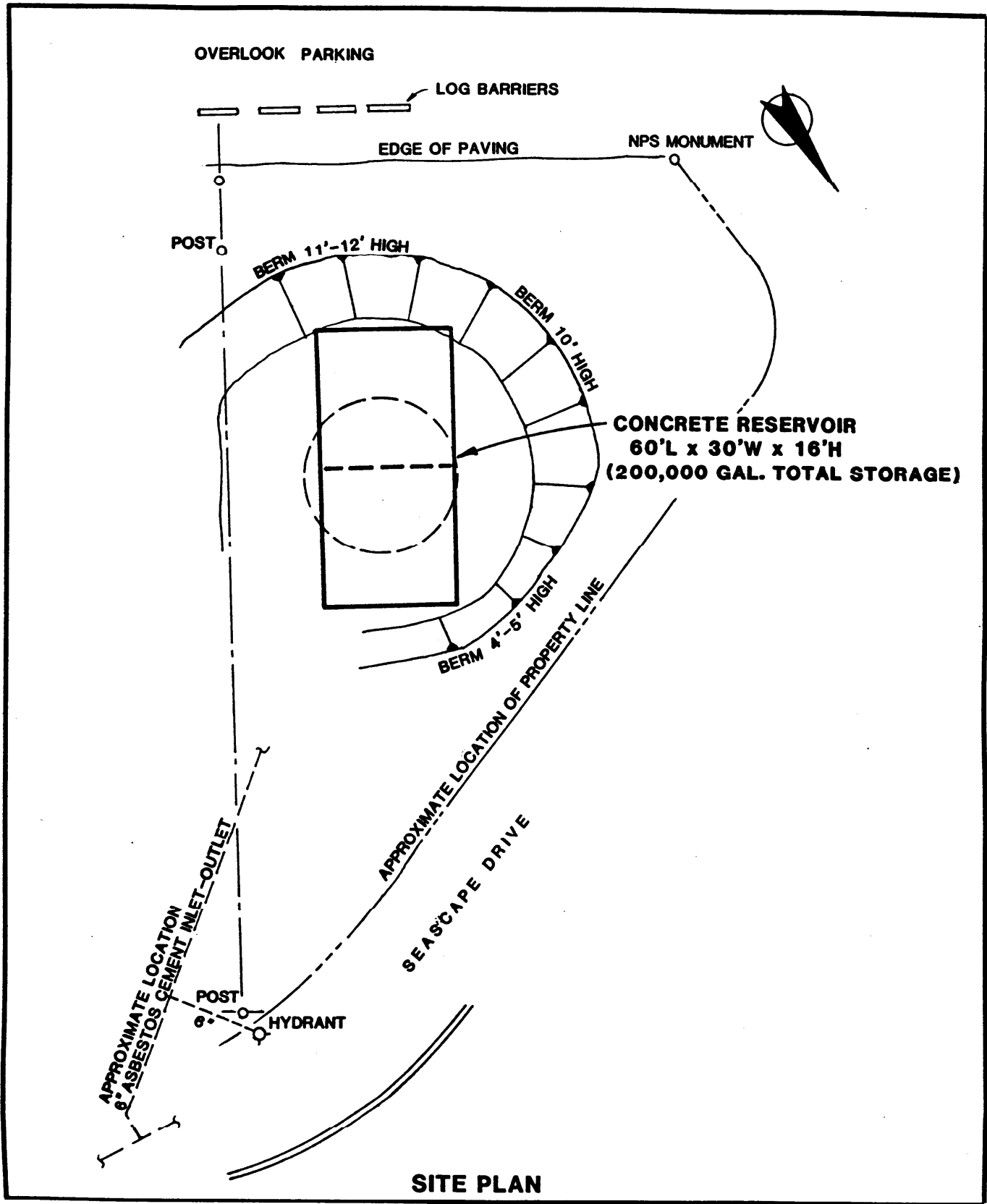


FIGURE 8-4
 PROPOSED HIGH ZONE STORAGE IMPROVEMENTS
 CONCRETE RESERVOIR

TABLE 8-4

ECONOMIC ANALYSIS OF TANK AND RESERVOIR ALTERNATIVES

Cost Escalation Factor 1.035
 Present Worth Factor 1.080

Year	Redwood Tanks		Welded Steel Tanks		Concrete Reservoir	
	Capital/ Replacement Cost	Present Worth Cost	Capital/ Replacement Cost	Present Worth Cost	Capital/ Replacement Cost	Present Worth Cost
0	\$132,800	\$132,800		\$157,000	\$233,800	\$233,800
1						
2						
3						
4						
5						
6						
7						
8						
9						
10			\$42,318	\$19,601		
11						
12						
13						
14						
15						
16						
17						
18						
19						
20			\$59,694	\$12,807		
21						
22						
23						
24						
25						
26						
27						
28						
29						
30		\$372,742	\$84,204	\$8,368		
31						
32						
33						
34						
35						
36						
37						
38						
39						
40			\$118,778	\$5,467		
Totals	\$505,542	\$169,842	\$461,993	\$203,244	\$233,800	\$233,800

CHAPTER IX



CHAPTER IX
DISTRIBUTION SYSTEM IMPROVEMENTS

Approach

The distribution system improvements recommended in this chapter assume continued use of a well supply pumped directly to the high zone of the system. This is Alternative 1 as described in Chapter 8. If low zone delivery scheme (i.e., Alternative 2) is implemented in the future, the required system modifications will be minor. Required modifications would include construction of a booster pump station and relocation of one pressure regulator.

Because the distribution system is generally in good condition and is adequately sized to deliver minimum fire flows to most areas, an extensive main replacement program is not needed. This conclusion assumes that the improvements described in this chapter are constructed. High zone piping should not require replacement for 30 years or more, if then. The low zone PVC piping, installed with insufficient cover, should only be replaced if problems occur. When replacing sections of pipe the District should use only PVC pipe meeting the current AWWA C-900 specifications. The pipe should be bedded in sand, and installed to a depth of at least 30 to 36 inches. As mentioned previously, the condition of the cast iron transmission main is unknown. It is recommended that this main be dug up in several locations to check its condition.

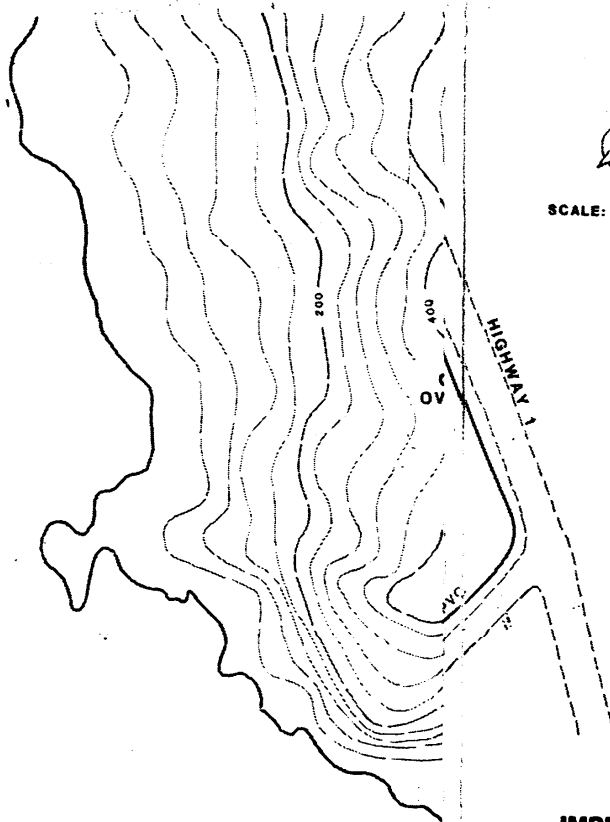
Recommended Improvements

Figure 9-1 shows recommended distribution system improvements. Many of the recommended improvements are interconnections between dead end mains, some including pressure regulator stations. The latter are needed whenever an interconnection, or tie, is made between a high zone and a low zone main. These ties will improve fire flows and system reliability, particularly in the low zone. The capacity of a main is effectively doubled if fed from both ends in a fire-fighting situation. The reliability of the low zone system, in particular, will be improved by providing five points of entry from the high zone into the low zone system. Now there is only one source - the low zone tank.

The other improvements shown on Figure 9-1 are replacements of undersized mains.

It is recommended that the following distribution system improvements be made:

1. Complete the 4 inch tie and pressure regulator station now under construction on Seacape Drive near the community center.



SCALE: 1"=200'-0"

PACIFIC
OCEAN

IMPROVEMENTS

- D-1 100'-4" PVC W/PRV
- D-2 330'-6" PVC W/PRV
- D-3 190'-6" PVC W/PRV
- D-4 250'-4" PVC
- D-5 500'-4" PVC W/PRV
- D-6 300'-4" PVC
- D-7 370'-4" PVC
- D-8 470'-8" PVC

LEGEND


- PRV PRESSURE REGULATOR VALVE STATION
-  PRESSURE REGULATOR VALVE
- PVC POLYVINYL CHLORIDE PIPE
- CI CAST IRON PIPE
- DI DUCTILE IRON PIPE
- AC ASBESTOS CEMENT PIPE
- WS WELDED STEEL PIPE
- GS GALVANIZED STEEL PIPE

FIGURE 9-1
OPOSED DISTRIBUTION SYSTEM IMPROVEMENTS

2. Construct 330 feet of 6 inch PVC main from the 4 inch transmission main at the intersection of Frank Valley Road and Highway 1 southeast along Highway 1 to the dead end 4 inch main. This tie will require a pressure regulator station. This improvement will increase fire flows to the Pelican Inn and to the adjacent residential area.
3. Construct 190 feet of 6 inch PVC main from the 4 inch transmission main at the intersection of Highway 1 and Sunset Way to the end of the 4 inch, Sunset Way line. This tie will also require a pressure regulator.
4. Construct 250 feet of 4 inch main between the 4 inch main on Sunset Way and the westerly end of the 4 inch main on Pacific Way. Because both mains are located in the low zone, this tie will not require a pressure regulator.
5. Construct 500 feet of 4 inch main between the westerly end of the 4 inch Charlotte Way main and the westerly end of the 4 inch Sunset Way line. This tie will require a pressure regulator. This improvement is vital to provide adequate fire flows along Sunset Way.
6. Replace the 2 inch line serving Cove Lane with 300 feet of 4 inch PVC main.
7. Replace 370 feet of 2 inch main along the private drive extending from Starbuck Drive with 4 inch PVC pipe. The replacement main will connect to the existing 6 inch ductile iron main. This improvement will allow the residential fire flow requirement to be met in this area.
8. Construct 470 feet of 8 inch PVC pipe parallel to the 6 inch high zone reservoir outlet pipe and 6 inch main on Seacape Drive (to Starbuck Drive). This improvement will prevent fire demands elsewhere in the system from reducing pressures at this location to dangerously low levels. The larger main will also improve local fire fighting capability.

Fire Flows

The hydraulic model of the existing system, described previously, was modified to include all recommended improvements. The fire flows modeled for the existing system were rerun. Improvements to fire flows were substantial but did not, in all cases, improve them to recommended levels. Further improvements, however, will require construction of additional mains in the system - a costly program that may not be cost-effective. The recommended approach is for the District to adopt a policy of replacing any section of 4 inch PVC main that needs to be replaced with 6 inch, or larger, pipe.

Table 9-1 summarizes the fire flow results obtained from the system model for both the existing system and for the improved system. The table also shows the improvement in fire flow at each location, and the fire flow required for an optimal fire rating.

TABLE 9-1

FIRE FLOWS - IMPROVED DISTRIBUTION SYSTEM

<u>Location</u>	<u>Fire Flows (gpm)</u>			
	<u>Exist- ing System</u>	<u>Im- proved System</u>	<u>In- crease</u>	<u>Re- quire- ment</u>
1. Pelican Inn (low zone)	300	800	500	1,500 (1)
2. Community Center (high zone)	1,000	1,500	500	1,500 (1)
3. SW End of Charlotte's Way (high zone)	400	425	25	500 (2)
4. SW End of Sunset Way (low zone)	250	600	350	500 (2)
5. NE End of Private Drive near Starbuck Drive (high zone)	125	850	725	500 (2)
6. Intersection of Seacape and Starbuck Drive (high zone)	800	1,500	700	1,500 (3)

(1) Minimum commercial or institutional fire flow - range 1,500 to 2,000 gpm.

(2) Minimum residential fire flow - range 500 to 1,000 gpm.

(3) Based on a 1,500 gpm fire flow at the community center (i.e., Location No. 2).

CHAPTER X

CHAPTER VIII

FINANCING

Overview

The financial feasibility of any water system improvement project is determined by the interrelationship of two factors, namely 1) the annual costs of improvements and operation and maintenance and 2) the means by which payment of these costs can be made. The costs for improvements and their equivalent annual costs are presented in Chapter 11. Possible sources of funding is the subject of this chapter.

Funding Sources

Muir Beach will receive a grant to replace the low zone tank from a State water system emergency fund that is administered by the Department of Health Services. This program will not, however, fund other needed system improvements.

Other than conventional financing, which is usually prohibitively expensive and often unobtainable for small communities, funding sources for rural water system improvements are usually limited to the State Drinking Water Bond Law, the Federal Farmer's Home Administration Community Facilities Loan and Grant Program and the State Community Development Block Grant Program. Funding under the State's Safe Drinking Bond Law program is unlikely unless a serious health-related water quality problem arises necessitating treatment. Muir Beach is not eligible for State-administered CDBG funding because Marin County is considered an urban area. This program may only fund projects in counties designated as rural.

Farmer's Home Administration guidelines provide grants to the most financially needy communities to reduce user costs to what they consider to be reasonable levels. Financial need is assessed on a sliding scale. FmHA's regulations state the following:

"Ordinarily an applicant will be considered for grant assistance only when the service portion of the average annual user cost for either water or waste service, for only those users in the applicant service area, exceeds the following percentages: (i) 0.5% when the median household income of the service area is below the poverty line. The poverty line will be that income prescribed by the Office of Management and Budget for a non-farm family of four, as adjusted under Section 624 of the Economic Opportunity Act of 1964, (ii) 1.0% when the median household income of the service area is not more than 85% of the non-metropolitan median household income of the state. (iii) No FmHA grant funds will be used in any project when the median household income of a service area is more than 85% of non-metropolitan median household income of the state."

For loans, FmHA also establishes interest rates based on financial need. For the "poverty line" an interest rate of 5 percent is charged (i.e., generally the poverty level is approximately 70 percent of the non-metropolitan median household income). For household incomes between the poverty line and 85 percent of the non-metropolitan median household income range, the interest rate charged is the poverty line rate, currently 5 percent, plus one-half of the difference between the poverty line rate and the market rate. For incomes greater than 85 percent of the median, full market rate is charged.

Because of the relatively high median household income in the community, Muir Beach is only eligible for a loan from FmHA at the so-called "market rate". This may, nevertheless, be the best source of funding. The current "market rate" used by FmHA is 7.875 percent, a rate the community is unlikely to obtain under conventional financing. This rate is adjusted quarterly for new applicants but remains fixed for the term of the loan at the rate in effect at the time the application is accepted. The loan term allowed with FmHA financing is 30 to 40 years - another advantage.

It is recommended that the District contact FmHA and submit a preapplication for funding. Taking these steps will not obligate the District but will establish the District's eligibility (or ineligibility) under this program.

CHAPTER XI

CHAPTER XI

RECOMMENDED PROJECT

Project Description

The recommended project consists of the following components that have been described in detail in Chapters 7, 8 and 9:

1. Supply Improvements - Rehabilitate Well No. 2 and install a pump able to deliver water directly to the high zone. Provide a backup chlorination system.
2. Low Zone Reservoir - Construct a 100,000 gallon concrete reservoir on the site of the existing low zone tank. If State funding will not support the higher first cost of the concrete reservoir, construct a 100,000 gallon redwood tank at that location. Provide piping and valving to permit pumping of water to the high zone in emergencies.
3. High Zone Reservoir - Construct a 200,000 gallon, two-compartment concrete reservoir on the existing high zone tank site.
4. Distribution System Improvements
 - a. Complete the 4 inch tie and pressure regulator station now under construction on Seacape Drive near the community center.
 - b. Construct 330 feet of 6 inch PVC main from the 4 inch transmission main at the intersection of Frank Valley Road and Highway 1 southeast along Highway 1 to the dead end 4 inch main. This tie will require a pressure regulator.
 - c. Construct 190 feet of 6 inch PVC main from the 4 inch transmission main at the intersection of Highway 1 and Sunset Way to the end of the 4 inch, Sunset Way line. This tie will also require a pressure regulator.
 - d. Construct 250 feet of 4 inch main between the 4 inch main on Sunset Way and the westerly end of the 4 inch main on Pacific Way. Because both mains are located in the low zone, this tie will not require a pressure regulator.
 - e. Construct 500 feet of 4 inch main between the westerly end of the 4 inch Charlotte Way main and the westerly end of the 4 inch Sunset Way line. This tie will require a pressure regulator.

- f. Replace the 2 inch line serving Cove Lane with 300 feet of 4 inch PVC main.
 - g. Replace 370 feet of 2 inch main along the private drive extending from Starbuck Drive with 4 inch PVC pipe. The replacement main will connect to the existing 6 inch ductile iron main.
 - h. Construct 470 feet of 8 inch PVC pipe parallel to the 6 inch high zone reservoir outlet pipe and 6 inch main on Seacape Drive (to Starbuck Drive).
5. Telemetry System - Provide tank level indication and recording equipment and an alarm system with a telephone dialer that will indicate high or low tank levels and malfunctioning pumps or chlorination equipment.
 6. Treatment - If filtration is required, construct a 75 gpm pressure filter plant adjacent to the wells. If organics such as herbicides are detected in the supply, provide activated carbon treatment.

Prioritized Project Improvements

Table 11-1 lists the project components described in the previous section and the costs for constructing them. This table also shows a priority ranking, or number for each recommended improvement and a suggested priority grouping (5 total) for implementation. The total project cost for all improvements, excluding water treatment, is \$618,500.

Priority A improvements consist of replacement of the low zone tank and completing the pressure regulator station on Seacape Drive near the community center. These improvements will be funded from the State emergency fund. Priority B includes all supply improvements and the construction of the intertie and pressure regulator station along Highway 1. Replacement of the high zone tank is the Priority C project. All remaining distribution system improvements have been included under Priority D but a strong argument can be made for including them in Priority C, based on improvements in fire flows. Telemetry has been given the lowest priority.

A timetable has not been shown on Table 11-1 because funding is an unknown. Ideally, all the improvements listed should be completed within 10 years or less to provide maximum benefit to customers.

Table 11-1 also indicates the approximate annual and monthly cost per customer for each improvement priority group. These costs assume that FMHA financing is obtained at a rate of 8-1/2 percent per year for a term of 35 years. The costs shown in the table are in addition to the current rates for water service.

TABLE 11-1

PRIORITIZED PROJECT IMPROVEMENTS

Description	Project Cost	Priority Number	Priority Group
Supply Improvements	\$23,300	3	B
Low Zone Reservoir (Concrete) (1)	\$130,000	1	A
High Zone Reservoir (Concrete)	\$233,800	5	C
Distribution System Improvements			
D-1 Complete PRV (Seacape)	\$4,000	2	A
D-2 330'-6"/PRV (Hwy 1 & Frank Valley)	\$36,700	4	B
D-3 190'-6"/PRV (Hwy 1 & Sunset)	\$29,200	8	D
D-4 250'-4" (Sunset - Pacific)	\$13,800	11	D
D-5 500'-4" (Charlotte's Way - Sunset)	\$42,500	6	D
D-6 300'4" (Cove Ln.)	\$14,500	10	D
D-7 370'-4" (Starbuck ext.)	\$22,100	7	D
D-8 470'-8" (High Zone Res. - Starbuck)	\$48,600	9	D
Telemetry System (allowance)	\$20,000	12	E
TOTAL PROJECT COST (6)	\$618,500		

Project Description	Project Cost	Annual Cost (2)	Monthly Customer Cost (3)
Priority A Improvements	\$134,000	(4)	(4)
Priority B Improvements	\$60,000	\$5,411	\$2.82
Priority C Improvements	\$233,800	\$21,086	\$10.98
Priority D Improvements	\$170,700	\$15,395	\$8.02
Priority E Improvements	\$20,000	\$1,804	\$.94
TOTAL PROJECT COST (6)	\$618,500	\$43,697	\$22.76

- (1) A 100,000 gallon redwood tank will cost \$70,000.
- (2) Based on an interest rate of 8.5 percent and a term of 35 years.
- (3) Assuming 160 service equivalents.
- (4) State Department of Health Services emergency funding.
- (5) Cost will be \$74,000 with a 100,000 gallon redwood tank.
- (6) Total cost will be \$558,500 with a 100,000 gallon redwood tank.
- (7) Filtration, if needed, will cost \$185,000.
- (8) Filtration and activated carbon treatment will cost \$260,000.
- (9) Cost basis is 1988.

APPENDICES

APPENDIX A

WELL LOGS AND SERVICE RECORDS

STATE OF CALIFORNIA
 THE RESOURCES AGENCY
 DEPARTMENT OF WATER RESOURCES
 WATER WELL DRILLERS REPORT

#1
 Do not fill in
 No. 228634

Form No. 10-1
 520-81

State Well No. _____
 Other Well No. _____

OWNER: Name Muir Beach Comm Serv Dist
P O Box 200
Sausalito, CA Zip 94965

(12) WELL LOG: Total depth 35 ft. Depth of completed well 37 ft.
 from ft. to ft. Formation (Describe by color, character, size or material)

LOCATION OF WELL (See instructions):
 County Marin Owner's Well Number _____
 address if different from above Muir Beach
 map Muir Woods Range _____ Section _____
 (Distance from cities, roads, railroads, fences, etc.)

Log of Hole #1
 0 - 7 Brown clay & sand
 7 - 12 Brown clay & gravel
 12 - 16 Brown clay
 16 - 19 Blue clay & sand water
 19 - 25 Blue clay
 25 - 26 Blue clay & sand water
 26 - 30 Blue clay
 30 - 33 Brown clay tight
 33 - 35 Brown clay & boulders
DRY HOLE BACKFILLED

- (3) TYPE OF WORK:
 New Well Deepening
 Reconstruction
 Reconditioning
 Horizontal Well
 Destruction (Describe destruction materials and procedures in item 12)
 (4) PROPOSED USE:
 Domestic
 Irrigation
 Industrial
 Test Well
 Stock
 Municipal
 Other

Log of Hole #2 (finished well)
 0 - 8 Brown clay & embedded gravel
 8 - 10 Gravel
 10 - 13 Brown clay & gravel
 13 - 15 Blue sandy clay & gravel
 16 - 30 Blue clay & gravel
 30 - 33 Tight blue clay & gravel
 33 - 34 Green clay & gravel
 34 - 37 Brown clay & boulders

WELL LOCATION SKETCH

EQUIPMENT:
 Reverse
 Air
 Bucket

(6) GRAVEL PACK:
 Yes No Size 3/8 pas
 Diameter of bore 24"
 Packed from 11 to 37 ft.

CASING INSTALLED:
 Plastic Concrete

(8) PERFORATIONS:
 Type of perforation or size of screen

in	To ft	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	37	8"	.188	15	35	.040

WELL SEAL:
 surface sanitary seal provided? Yes No If yes, to depth 11 ft.
 struts sealed against collarings? Yes No Interval _____ ft.
 d. of sealing concrete on pack

WATER LEVELS:
 surface water, if known _____ ft.
 static level after well completion 8 ft.

WELL TESTS:
 well test made? Yes No If yes, by whom? _____
 pump Bailer Air lift
 to water at start of test 8 ft. At end of test 22 ft.
 time 65 min and water 32 hours. Water temperature _____
 test log made? Yes No If yes, attach copy to this report

Work started 7-23- 19 82 Completed 7-27- 19 82

WELL DRILLER'S STATEMENT:
 This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
 SIGNED: Ward Thompson *Ward Thompson*
 (Well Driller)
 NAME: Weeks Drilling & Pump Co
 (Person, firm, or corporation) (Typed or printed)
 Address: 6100 Sebastopol Rd.
 City: Sebastopol, CA Zip: 95472
 License No. C177681 Date of this report: 8-6-82

WELKS DRILLING & PUMP CO. 75 JBU

P.O. Box 176
 6100 Sebastopol Rd.
 SEBASTOPOL, CALIFORNIA 95472
 823-3184 or 542-3272

UKIAH . PH. 462-9080

WELL INFO.
 WELL PROD. 8 1/2" PIP GPM
 SIZE CASING 8 1/2" PIP
 DEPTH: _____
 STATIC LEVEL: _____
 PUMPING LEVEL: _____
 DATE ORDERED: 4-18-86
 SALESMAN: Lowell

CUSTOMERS
 NAME: Muir Beach Community Service
 ADDRESS: John Sword
Star Route 221
94565
Sausalito, Ca.
 CITY STATE ZIP: _____

PUMP INFO.
 MAKE PUMP: RED JACKET HP: 15
 TYPE PIP: BLASK SIZE: 3" VOLTAGE: 28' + 8mp
 INSTALLATION DATE: _____
 CUSTOMER'S ORDER NUMBER: 393-6762

INSTRUCTIONS

- #1 Baled well No. fail 37' to bottom
- #2 Water hammered static approx 15'
- #3 Leveled + baled
- #4 Pumped to clear, Very low Pumping 100 GPM
- #5 Put into service Production 75 GPM at 240 lbs

Call 41-40-39 amper
 46. Max amper

Note
 Leak Connection
 6386

Used acid to clean scales.

MATERIALS USED	UNIT	PRICE	AMOUNT
3" Lauromatic check	1	181.38	
Blue scale check	30	70	
Roll of white tape		200	
TOTAL		184.28	1279.34

CASH	
CHARGE	
OTHER	
MATERIAL USED	
EXTRA MATERIAL USED	184.28
TOTAL MATERIAL	11.06
SALES TAX	1104.00
LABOR - SEE REVERSE SIDE	
EXTRA LABOR	
EQUIPMENT	
TOTAL	

ABOVE WORK AUTHORIZED BY: [Signature]
 SIGNATURE: [Signature]
 RECEIVED FOR BILLING: [Signature]
 DATE: 4-28-86
 BY: R.W.

SEE REVERSE SIDE FOR LABOR DETAILS

DUPLICATE
Retain this copy

WATER WELL DRILLERS REPORT

(Sections 7079, 7080, 7081, 7082, Water Code)

#2 Do Not Fill In

THE RESOURCES AGENCY OF CALIFORNIA DEPARTMENT OF WATER RESOURCES

No 19407

State Well No. _____

Other Well No. _____

(1) OWNER:

Name Myra Bech Coman
Address Step Route
Sausalito, Calif. 94965

(2) LOCATION OF WELL:

County Marin Owner's number, if any _____
Township, Range, and Section Myra Beach
Distance from cities, roads, railroads, etc. 1/4 mile N. of State Hwy 1
on Myra Beach Rd

(3) TYPE OF WORK (check):

New Well Deepening Reconditioning Destroying
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic Industrial Municipal Irrigation Test Well Other

(5) EQUIPMENT:

Rotary
Cable
Other

(6) CASING INSTALLED:

STEEL: OTHER: _____
SINGLE DOUBLE

				If gravel packed		
From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft.	To ft.
0	37	8 5/8"	10ga	30"	0	37

Size of shoe or well ring: _____ Size of gravel: BA

Describe joint: welded

(7) PERFORATIONS OR SCREEN:

Type of perforation or name of screen: Torch

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
17	37	1	5	3/16

(8) CONSTRUCTION:

Is a surface sanitary seal provided? Yes No To what depth 8' ft.

Are any strata sealed against pollution? Yes No If yes, note depth of strata _____

From _____ ft. to _____ ft.

Method of sealing: Cement on pack

(9) WATER LEVELS:

Depth at which water was first found, if known _____ ft.

Standing level before perforating, if known _____ ft.

Standing level after perforating and developing 6' ft.

(10) WELL TESTS:

Is pump test made? Yes No If yes, by whom? Bail

Yield: 50 gal./min. with 4 ft. drawdown after _____ hrs.

Temperature of water cool Was a chemical analysis made? Yes No

Is electric log made of well? Yes No If yes, attach copy _____

(11) WELL LOG:

Total depth 37 ft. Depth of completed well 37 ft.

Formation: Describe by color, character, size of material, and structure _____

ft. to _____ ft.

Work started 10-23 19 70 . Completed 10-26 19 70

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME _____ (Person, firm, or corporation) (Typed or printed)

Address _____

[SIGNED] _____ (Well Driller)

License No. _____ Dated _____, 19____

SKETCH LOCATION OF WELL ON REVERSE SIDE

APPENDIX B

DISTRIBUTION SYSTEM HYDRAULIC MODEL

Muir Beach - Proposed/800gpm Fire @33 (MB22) (AT PELICAN INN)

Data file name : b:mb22.DAT

Hazen-Williams formula used

Iteration stops when max relative flow change is .00100 in any pipe

Multiplicative factor of each consumption is 1.00000

	Length	Diameter	Flow	Headloss	Height	Pressure	Velocity
Units:	FEET	INCHES	US GPM	FEET	FEET	PSI	FT/SEC

There are 36 pipes and 32 nodes

For checking purposes, note that the last node # is 35

The total demand (to be met by water sourced) is 865.50

Pump data for 3 pumps at source nodes

The number of data points for the pump curve is 5

Node No.	P	Elev of	Pump Flows and related heads				
No.	Parl	Pump	0.	30.	60.	75.	90.
1	1	35.	980.	910.	670.	475.	220.
			0.	100.	200.	300.	400.
17	1	495.	0.	0.	0.	0.	0.
			0.	100.	200.	300.	400.
21	1	260.	0.	0.	0.	0.	0.

PRV #	in pipe #	Ref source #	Working HGL	K-value	CHKV action?
1	35	17	240.00	.000	YES
2	36	1	240.00	.000	YES
3	37	17	240.00	.000	YES
4	39	17	240.00	.000	YES

Net unbalanced flow in subnet 1 is -.00000

The number of pseudo loops is 2

Bandwidth of matrix = 5

Number of loops = 7

Node	Flow	Pump HGL	Total HGL
1	-86.550	278.65	313.65
17	-519.300	.00	495.00
21	-259.650	.00	260.00

Iteration # 1 Max change in flow is 2030.585

Iteration # 2 Max change in flow is 182.793

Iteration # 3 Max change in flow is 62.012

Iteration # 4 Max change in flow is 0.720

Iteration # 5 Max change in flow is .177

PRVS and/or checkvalves become testable after 5 iterations

PRV in pipe 35 turned on at iteration # 5

PRV in pipe 37 turned on at iteration # 5

PRV in pipe 39 turned on at iteration # 5

Iteration # 6 Max change in flow is 172.509

Iteration # 7 Max change in flow is 140.127

Iteration # 8 Max change in flow is 120.660

Iteration # 9 Max change in flow is 110.998

Iteration # 10 Max change in flow is 113.593

Iteration # 11 Max change in flow is 139.473

Iteration # 12 Max change in flow is 107.551

Iteration # 13 Max change in flow is 69.407

Iteration # 14 Max change in flow is 39.168

Iteration # 15 Max change in flow is 20.470

Iteration # 16 Max change in flow is 10.248

Iteration # 17 Max change in flow is 5.037

Iteration # 18 Max change in flow is 2.469

Iteration # 19 Max change in flow is 1.217

Check valve action reqd; Pipe # 35 Iteration no. 19

Pipe no. 35 containing a checkvalve is being removed

Flow in pipe was -238.793

Pipe no. 37 containing a checkvalve is being removed

Flow in pipe was -110.963

Number of pipes is now 34

The number of pseudo loops is 2

Bandwidth of matrix = 3

Number of loops = 5

Node	Flow	Pump HGL	Total HGL
1	-115.023	220.00	255.00
17	-347.234	.00	495.00
21	-402.443	.00	260.00

Iteration # 1 Max change in flow is 136.709

Iteration # 2 Max change in flow is 15.103

Iteration # 3 Max change in flow is 4.352

Iteration # 4 Max change in flow is 2.017

PRVS and/or checkvalves become testable after 4 iterations

Iteration # 5 Max change in flow is .964

Iteration # 6 Max change in flow is .466

Number of iterations= 6

Pipe Dia	Up Node	Down Node	Pipe No.	Flow	Head Loss	Velocity	Upstream HGL	Downstream HGL
4.00	1	2	1	106.025	36.71	2.71	255.00	218.29
4.00	2	3	2	-355.022	-196.73	-9.07	218.29	415.02
4.00	3	4	3	-355.022	-47.30	-9.07	415.02	462.32
6.00	4	5	4	-355.522	-8.08	-4.03	462.32	470.40
6.00	5	6	5	-146.445	-1.07	-1.66	470.40	471.48
6.00	6	7	6	-256.639	-11.02	-2.91	471.48	482.50
6.00	7	8	7	-405.216	-9.56	-5.51	482.50	492.06
6.00	8	9	8	.500	.00	.01	492.06	492.06
6.00	7	10	9	220.577	9.44	2.50	482.50	473.06
6.00	10	11	10	213.577	1.98	2.42	473.06	471.08
2.00	11	12	11	2.500	.04	.26	471.08	471.04
2.00	12	13	12	2.000	.07	.20	471.04	470.97
2.00	12	14	13	.000	.00	.00	471.04	471.04
6.00	11	5	14	211.077	.68	2.40	471.08	470.40
6.00	6	15	15	106.694	1.47	1.21	471.48	470.01
4.00	15	16	16	102.694	12.06	2.62	470.01	457.15
6.00	8	17	17	-486.716	-2.94	-5.52	492.06	495.00
4.00	21	22	21	272.759	9.71	6.96	260.00	250.29
4.00	22	23	22	272.758	21.05	6.96	250.29	228.44
4.00	23	24	23	2.000	.00	.05	228.44	228.44
4.00	23	25	24	35.114	.59	.90	228.44	227.06
4.00	25	26	25	-92.194	-3.86	-2.35	227.06	232.12
2.00	26	27	26	1.500	.04	.15	232.12	232.07
4.00	26	28	27	-97.694	-7.09	-2.49	232.12	240.00
4.00	23	29	28	232.645	8.66	5.94	228.44	219.79
4.00	29	30	29	349.953	33.78	8.94	219.79	186.00
4.00	30	31	30	347.453	54.55	8.87	186.00	131.45
4.00	31	32	31	1.000	.00	.03	131.45	131.45
4.00	31	33	32	345.953	36.08	8.83	131.45	95.37
4.00	33	34	33	-459.547	-117.06	-11.73	95.37	212.43
4.00	29	35	34	-120.308	-5.31	-3.07	219.79	225.10
6.00	2	34	36	461.047	5.06	5.23	218.29	212.43
4.00	25	35	38	122.000	2.76	3.14	227.06	225.10
4.00	16	28	39	101.694	217.15	2.60	457.15	240.00

Node	Elevation	Demand	HGL	Pressure
1	35.00	-106.03	255.00	95.24
2	35.00	.00	218.29	79.35
3	115.00	.00	415.02	129.88
4	155.00	.50	462.32	133.04
5	200.00	2.00	470.40	117.06
6	225.00	3.50	471.48	106.70
7	420.00	8.00	482.50	27.06
8	470.00	1.00	492.06	9.55
9	475.00	.50	492.06	7.39
10	300.00	7.00	473.06	74.92
11	275.00	.00	471.08	84.88
12	255.00	.50	471.04	93.52
13	240.00	2.00	470.97	99.99
14	260.00	.00	471.04	91.36
15	230.00	4.00	470.01	103.90
16	230.00	1.00	457.15	98.33
17	495.00	-406.72	495.00	.00
21	260.00	-272.76	260.00	.00
22	200.00	.00	250.29	21.77
23	65.00	3.00	228.44	70.75
24	100.00	2.00	228.44	55.60
25	105.00	4.50	227.86	53.18
26	110.00	4.00	232.12	52.86
27	30.00	1.50	232.07	87.48
28	80.00	4.00	240.00	69.26
29	30.00	3.00	219.79	82.16
30	20.00	2.50	186.00	71.06
31	40.00	.50	131.45	39.59
32	40.00	1.00	131.45	39.59
33	35.00	805.50	95.37	26.13
34	35.00	1.50	212.43	76.81
35	60.00	2.50	225.10	71.47

RESIDUAL PRESSURE ~ 26 PSI - OK

Max unbalanced head in a pseudo-loop is .0002
 associated with source node # 18

Maximum unbalanced head in any loop .3981 in loop # 3

APPENDIX C

MONTHLY WATER PRODUCTION DATA