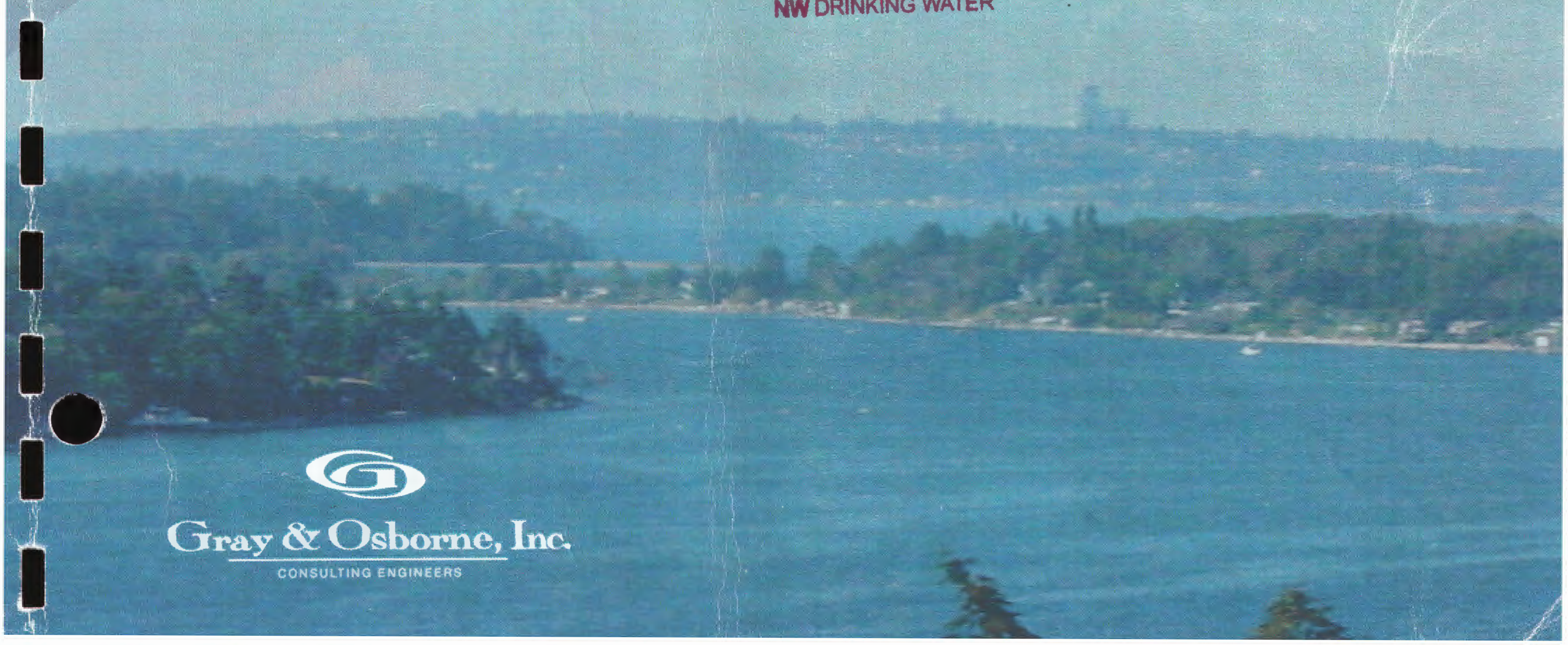
Dockton Water Association

Water System Plan Amendment

January 2005



Gray & Osborne, Inc.
CONSULTING ENGINEERS

DOCKTON WATER ASSOCIATION

KING COUNTY **WASHINGTON**

WATER SYSTEM PLAN AMENDMENT

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STATE OF WASHINGTON
33786
REGISTERED
PROFESSIONAL ENGINEER
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Approved
Department of Health
Office of Drinking Water

Engineer

Jan 19, 2005

Date

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NW DRINKING WATER

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LIST OF ABBREVIATIONS

DWA	Dockton Water Association
DOH	Department of Health
WSP	Water System Plan
ERU	Equivalent Residential Unit
DU	Dwelling Unit
PSI	Pounds per square inch
gpd	gallons per day
gpm	gallons per minute
BPS	Booster Pump Station
MPA	Microscopic Particulate Analysis
HGL	Hydraulic Grade Line
PVC	Polyvinyl Chloride
ADD	Average Day Demand
MDD	Maximum Day Demand
PHD	Peak Hour Demand
WAC	Washington Administrative Code
CT	Contact Time
CIP	Capital Improvement Plan
OS	Operational Storage
ES	Equalizing Storage
SB	Standby Storage
FSS	Fire Suppression Storage
Q_S	Total Source Capacity
Q_L	Largest Capacity Source
t_m	Time the remaining sources are pumped
WSDM	Water System Design Manual

INTRODUCTION

The Dockton Water Association's (DWA) Water System Plan (WSP) was approved by the Department of Health (DOH) in June 2002. This WSP Amendment provides a description of selected facilities with known deficiencies, an analysis of them, and a list of capital improvement projects that address the identified problems.

EXISTING PRODUCTION

DWA currently has 360 residential connections and 3 commercial connections. The three commercial accounts (County Park, Fire Station, and PTI Communications Station) have different water use patterns than a typical residential account. The WSP established that the County Park uses 4.7 times as much water as the average single-family residence; therefore it equals 4.7 ERUs (Equivalent Residential Unit). The fire station consumes 0.04 ERUs and the PTI Communications station consumes 0.02 ERUs. Each residential connection equals one ERU.

PROJECTED DEMANDS

PROJECTED 6-YEAR AND 20-YEAR DEMANDS

Water system demands for the years 2006 and 2020 are projected in the 2002 WSP, Table 2-1. The WSP Amendment does not propose any changes to these demands, but does address demands at buildout capacity.

BUILDOUT DEMANDS

All parcels within the DWA service area are zoned RA-2.5, RA-5, or RA-10, which limits each parcel's maximum density to one dwelling unit (DU) per 2.5 acres, 5 acres, or 10 acres, respectively. Many parcels at the north end and along the shoreline of the service area were developed to greater densities than allowed by current zoning regulations. There are no commercially zoned areas within the DWA service area although there are three pre-existing commercial accounts. Table 1 lists the number of DUs by zoning classification that can be developed within the service area.

TABLE 1

Buildout Population Projections

Zoning	Total Dwelling Units	Projected Population[1]
RA-2.5	390 [2]	823
RA-5	103	217
RA-10	152	321
Total	**645**	**1,361**

(1) Based on 2.11 persons per household
(2) Reflects pre-existing smaller parcels in northern area and along shoreline.

A total of 645 parcels can be developed within the service area. The 2002 WSP identified an average household size in 2020 of 2.11 persons per household. Therefore, the projected buildout population is estimated to be 1,361 people.

All future dwelling units are zoned single-family residential and are expected to have similar water use patterns as current residential customers. Water production records indicate that the average residential customer uses approximately 200 gallons per day. Table 2 provides the ERU calculation for the years 2000 to 2003.

TABLE 2

ERU Determination

Year	Total Production (gallons)	Service Connections	Production per Connection[1] (gpd/conn.)
2000	27,017,000	361	205
2001	22,825,000	361	173
2002	24,568,028	361	186
2003	26,538,442	363	200

(1) Includes lost and unaccounted for water.

Table 3 provides the water production demands for three scenarios. The “existing” scenario is 2003 demands, based on the number of existing service connections. The “committed” scenario projects demands based on the 90 additional water shares that have been sold. The “buildout” scenario projects demands at ultimate buildout of the service area.

The “allotted” scenario project demands based on the currently approved number of connections.

Figure 1 shows the daily production for the summers of 2003 and 2004. The data indicate a significant fluctuation in daily production, in part due to varying times of meter reads and daily changes in reservoir storage. Based upon an average daily production of 72,000 gpd and the data below a peaking factor of 3 has been used to estimate peak day demand.

FIGURE 1

Dockton Water Association – Daily Summer Water Production

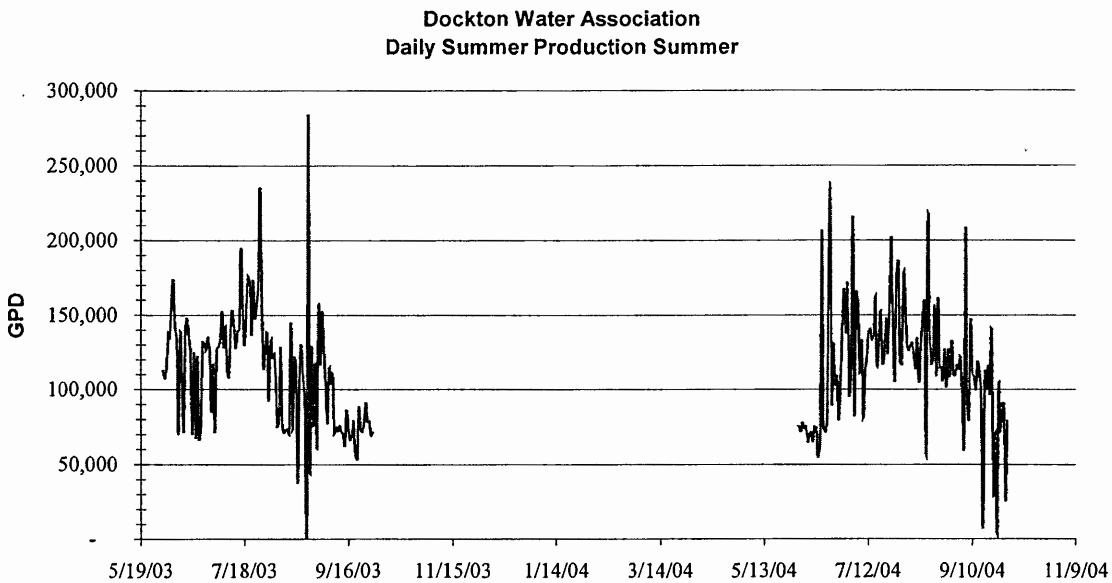


TABLE 3

Water Production, Existing, Allotted, and Buildout

Customer Class	ERUs	Average Day Demand(2) (gpd)	Maximum Day Demand(3) (gpd)	Peak Hour Demand(4) (gpm)
Existing Residential	360	72,000	216,000	324
Park and Other(1)	5	1,000	3,000	5
Total 2003 Existing	**365**	**73,000**	**219,000**	**329**
Committed Residential	450	90,000	270,000	405
Park and Other(1)	5	1,000	300	5
Total Committed	**455**	**91,000**	**273,000**	**410**
Allotted Residential	480	96,000	288,000	432
Park and Other	5	1,000	3,000	5
Total Allotted	**485**	**97,000**	**291,000**	**437**
Buildout Residential	645	129,000	387,000	580
Park and Other(1)	5	1,000	3,000	5
Total Buildout	**650**	**130,000**	**390,000**	**585**

(1) Includes the County Park, PTI Communications station, and Fire Station.
(2) Based on 200 gpd/ERU (Includes domestic demand and lost water)
(3) Maximum Day Demand is equal to 3.0 times the Average Day Demand.
(4) Peak Hour Demand is equal to 2.16 times the Maximum Day Demand.

EXISTING SYSTEM ANALYSIS

DESCRIPTION OF EXISTING FACILITIES

The following sections summarize selected facilities and describe their typical operation. The 2002 WSP provides additional information for each water system facility. Figure 1 provides a basemap showing the location of all water system facilities.

Source

Dockton Springs

The Dockton Springs provide the majority of water used by DWA customers. The site includes well points, a lateral interceptor, two collection basins, chlorination facilities, wetwell/chlorine contact chamber, and a booster pump station (BPS). Chlorination occurs within the lower collection shed. Water that is not pumped to the distribution system flows to a stream that drains to nearby Puget Sound.

DWA captures over 100 gpm at the Dockton Springs site, but, under the current facilities configuration, 80 gpm of source water is diverted into the chlorination chamber. The flow into the chlorination system was measured at 80 gpm in July, August, and

September of 2004. Approximately 25 gpm of unchlorinated water bypasses the system and is discharged over a weir. Well point rehabilitation is planned for the spring of 2005. That rehabilitation should increase the flow in excess of 100 gpm. To be conservative, this analysis assumes 80-gpm source production at Dockton Springs.

The 2002 WSP indicates previous MPA testing results show low probability of surface water influence. The water right for Dockton Springs is 143.6 gpm.

Sandy Shores Well

The Sandy Shores Well is a 423-foot-deep well, with a submersible pump and booster pump combined delivers approximately 100 gpm to the 430 Zone. The water right for the Sandy Shores Well is 100 gpm. Additional information about the Sandy Shores well can be found in the 2002 WSP.

Hake Springs

Hake Springs is the smallest of the three DWA sources. It consists of a single well point, collection basin, and booster pump. The well point currently produces 5.5 gpm into a collection basin. The single pump is capable of supplying 20 gpm to the 246 Zone. Currently, Hake Springs is not in use pending microscopic particulate analyses (MPA) results.

Table 4 summarizes each source's flow, water right, and flow discharge rate to the distribution system.

TABLE 4

Source Capability Summary(1)

Source Name	Source Flow (gpm)	Water Right (gpm)	Instantaneous Pumping Capacity (gpm)	24-hour Pumping Capacity (gpm)
Dockton Park Springs	105(2)	143.6	82/100	80(4)
Hake Springs	5.5	13.5	(5)	5.5
Sandy Shores	75(3)	100	100	75(3)
Total	**185.5**	**257.1**	**205.5**	**160.5**

(1) Table 4 supercedes Table 3-1 in the 2002 WSP.
(2) Includes flow that bypasses the chlorination facility.
(3) Sandy Shores Well instantaneous capacity is 100 gpm. However, DOH reliability criteria recommends assuming 18 hours pumping over a 24 hour period for wells (100 gpm * 18 hours/24 hours = 75 gpm)
(4) New Booster Station will be designed with a 100 gpm discharge rate. Existing 24-hour collection system discharge rate is 80 gpm.
(5) Hake Springs pumping capacity is 20 gpm for short durations. For a 24-hour period, the discharge rate averages 5.5 gpm.

Storage

<u>246 Zone Reservoirs and 268th Street Booster Station</u>

Three partially buried reservoirs are located on SW 268th Street and provide storage capacity for the 246 Zone (Lower Dockton). The total capacity of the three reservoirs is 57,600 gallons. A float controlled inlet valve allows water from the 430 Zone to flow to the reservoirs when demand exceeds the Dockton Springs capacity. Flow between the three reservoirs is severely limited due to small pipes.

A single-pump booster station is located adjacent to the reservoirs and transfers water from the 268th Street Reservoirs to the 430 Zone.

The reservoirs provide a critical link in the system as it is currently configured; they maintain system pressure for the 246 Zone. The reservoirs also act as a wet well for the booster station located at 268th, which pumps to the 430 Zone. Lastly in periods of high demand water from the 430 Zone flows into these reservoirs, supplying water to the 246 zone.

<u>430 Zone Reservoirs (Upper Level)</u>

The Upper Level Reservoirs provide approximately 85 percent of the storage capacity to the system. The two reservoirs are each 26-foot-diameter, 40-foot-tall, concrete tanks providing up to 317,700 gallons of storage. An 8-inch PVC water main connects to a "tee" and supplies each reservoir. This water main functions as both an inlet and outlet pipe for each reservoir.

Table 5 provides the hydraulic grade for each of the four pressure zones.

TABLE 5

Pressure Zone Summary

Name	Hydraulic Grade (feet)	Description
Lower Dockton	246	HGL set by the 268th Street Reservoirs
Upper Level	430	HGL set by Upper Level Reservoirs
Closed Pumped Zone	520	HGL set by 99th Avenue Booster Station
Manzanita	232	HGL set by the Manzanita PRV
Lower Sandy Shores	193	HGL set by the Sandy Shores PRV

WATER SYSTEM DEFICIENCIES

The following sections describe the deficiencies at the Dockton Springs site, 268th Street Reservoir site, and Upper Level Reservoir site.

Dockton Springs Deficiencies

The Dockton Springs BPS has one pump that is able to provide 82 gpm flow to the 246 Zone and ultimately the 268th Street Reservoir site. There are no backup pumps to provide service if the primary pump fails. Additionally, backup power is not available if the primary power source is interrupted.

The electrical controls and power source at the existing Dockton Springs BPS do not meet current electrical codes and do not appear to conform to earlier codes. Several control panels lack circuit breakers, have exposed wiring, or are wired poorly. The electrical panels are all mounted within four feet of permanent equipment. New components to correct these deficiencies would not fit into the existing building while providing adequate space for performing maintenance activities.

All collected source water is currently chlorinated as it enters the wetwell. If the booster pump is turned off manually, approximately 80 gpm of chlorinated water is discharged to a stream and eventually makes its way to Puget Sound

268th Street Site Deficiencies

The 268th Street Reservoirs in ground tanks and were built as needed starting in 1938 with the most recent reservoir completed in 1972. Leakage is suspected from these tanks and their wooden roofs require maintenance. The tanks also cannot be taken out of service for repairs as a group without significant work to provide for temporary bypass pumping, piping and storage. The three tanks cannot be isolated from one another. The isolation valves will not fully close and the piping configuration is not known.

The 268th Street BPS is located in a small, wooden building containing just enough space for a single pump and motor control panel. The electrical panel is mounted within two feet of the pump, in violation of current and past electrical codes.

Many of the facilities at this location are on land not owned by DWA. Easements, land purchase or leases will need to be arranged if DWA continues to utilize these facilities.

430 Zone Reservoir Deficiencies

Both the 430 Zone Reservoirs are connected to the system through a single 8-inch PVC water main. The inlet/outlet pipes to each reservoir enters the reservoir at the bottom of the reservoir, near the center. This piping configuration does not promote reservoir mixing, resulting in stratification of water and high detention times for water in the upper portions of the reservoirs. The chlorine residual level within the reservoirs frequently drops below the minimum allowed by DOH. When this occurs, the tanks must be drained and refilled with freshly chlorinated water. While the tanks are low on water, there is not sufficient fire suppression storage or standby storage available in case of an emergency.

A DOH Sanitary Survey from December 2003 (included in Appendix A) states that "a lack of circulation" in the Upper Level Reservoirs creates a "challenge to maintaining a chlorine residual."

SYSTEM CAPACITY AND RELIABILITY

There are four major components to the DWA water system: source, treatment, storage, and distribution. An analysis of overall system capacity and reliability must include an analysis of all four.

RELIABILITY CONSIDERATIONS AND REQUIREMENTS

The Washington Department of Health (DOH) 2001 Water System Design Manual (WSDM) discusses reliability as excerpted below.

> Reliability – "a recognition of the various uncertainties inherent in infrastructure services and, more formally as the likelihood that infrastructure effectiveness will be maintained over an extended period of time, or, as the probability that service will be available at least at specified levels throughout the design life of the infrastructure system." (p. ii)
>
> "Reliability relates to the dependability the system exhibits, and the degree of confidence consumers have, regarding its ability to deliver water to the point of use when it is desired." (p. iii)
>
> Source reliability relates to the dependability of drinking water sources (surface water bodies, springs, and ground water aquifers) to provide an adequate or desired quantity of water over a given period of time. For surface waters, reliability of supply usually entails probabilistic analysis of historical data related to rainfall, snow pack, runoff and flow rates, especially during years of extended periods without significant precipitation (drought). … Superimposed upon predictions of probabilistic availability for water is another component associated with the consumer's understanding and acceptance of restricted water uses in times of low availability." (p. iv)
>
> "It is appropriate that individual communities choose their own level of source reliability for surface water dependent systems. When establishing a local standard, potential impacts to consumers should be expressed in terms that can be readily understood so that informed decisions can be made regarding acceptable levels of source reliability." (p. v)

The following presents a brief summary of DOH recommendations that are intended to promote high levels of system reliability for service to customers:

1. Development of two or more sources with a supply capacity able to replenish depleted fire suppression storage within a 72-hour period while concurrently supplying the maximum day demand.

2. Sources capable of providing the maximum day demand for the system with 18 hours of pumping. (This recommendation generally applies to ground water sources.)

3. With the largest source out of service, remaining sources(s) able to provide a minimum of the average day demand for the system.

4. Pump stations with power connections to two independent primary public power sources, or either portable or in-place auxiliary power available.

5. The firm yield of surface water sources is that associated with the lowest flow and/or longest period of extended low precipitation on record. (p. 5-18)

> "It is fundamental to the initiation and continued growth of any water system to have sufficient water to meet consumer requirements, both during normal periods and in times when peak demands are placed on the system. While distribution of water during peak periods of demand may involve use of storage, the basic quantity needed by a system's customers is what can be produced over a maximum day demand period. A rare exception to this would be when a system has multiple days of storage to provide peak day service when its sources cannot meet the maximum day demand on their own. For reliability purposes, DOH recommends developing source capacity such that they are able to replenish depleted fire storage within a 72-hour period while concurrently supplying maximum day demand." (p. 7-2 DOH WSDM)

The Washington Administrative Code (WAC 246-290-22) only requires that a water purveyor's source production be able to meet maximum demand. It does not add the additional guidelines of fire suppression storage replenishment or the 18 hours per day pumping.

Source of Supply Analysis

DWA should plan for a maximum day production per ERU of 600 gpd/ERU. DWA is obliged to serve 90 units that have already been committed, but are not yet consuming water. Assuming the current 365 ERUs, plus 90 currently unserved, DWA should plan on a maximum day demand of 273,000 gpd (190 gpm) for the system (Table 3). This does not include any conservation that may be achieved either through a decrease in consumption or a reduction in lost and unaccounted for water. The 2002 WSP indicates that DWA has historically had lost and unaccounted for water in the range of 30 percent. Lost and unaccounted for water for the period January through November 2004 was 25 percent. Reducing lost and unaccounted for water was not evaluated as part of this WSP amendment. We recommend that DWA undertake an aggressive leak detection program to identify and repair leaks. Water mains that have had maintenance problems and have a history of leaks should be prioritized for replacement. DWA spent $2,000 on leak detection in the fall of 2004 and has budgeted $3,000 to repair those leaks in 2005. DWA found and repaired a faulty switch at its 268th reservoir in September 2004. This faulty switch was causing significant overflow at this reservoir.

Due to the WDOH reliability recommendations DWA should also plan for fire storage replenishment. Fire flow requirements for the DWA service area are 1,000 gpm for 2 hours. Although DWA cannot provide this flow throughout much of its service area, DWA does hope to increase fire flow where affordable and practicable. This additional demand for fire storage replenishment will add an additional 40,000 gpd (28 gpm) demand to the system over a 3-day period.

DWA's sources should have a maximum production rate, upon completion well point rehabilitation and the booster pump station project, of 259,920 gpd (assuming 18 hours of pumping from Sandy Shores) and 295,920 gpd assuming pumping all sources 24 hours per day. The booster station will be designed for a discharge rate of 100 gpm. Based upon the successful rehabilitation of several well points at the Dockton Springs site in the spring of 2004 and the observed increase in flow rate this discharge rate should be obtainable. However, since these projects have not been completed, Table 6 provides a comparison of the system's demands and the existing source capacity.

TABLE 6

Comparison of DWA Production to Maximum Day Demand

Scenario	Maximum Day Demand (gpd)		Source Capacity (gpd)	
	Domestic Demands(1)	Domestic Demands and Fire Suppression Storage Replenishment(2)	All sources pumped 24 hours per day(3)	Sandy Shore Well pumped 18 hours per day(4)
Existing	219,000	259,000	267,100	231,100
Committed	273,000	313,000	267,100	231,100
Allotted	291,000	331,000	267,100	231,100
Buildout	390,000	430,000	267,100	231,100

(1) From Table 3.

(2) The DOH Water System Design Manual recommends that fire suppression storage be replenished within 72 hours. Fire suppression storage is 120,000 gallons, or 40,000 gpd.

(3) Dockton Springs capacity = 80 gpm * 60 min * 24 hours = 115,200 gpd;
Hake Springs capacity = 5.5 gpm * 60 min * 24 hours = 7,920 gpd;
Sandy Shores Well capacity = 100 gpm * 60 min * 24 hours = 144,000 gpd.

(4) Dockton Springs capacity = 80 gpm * 60 min * 24 hours = 115,200 gpd;
Hake Springs capacity = 5.5 gpm * 60 min * 24 hours = 7,920 gpd;
Sandy Shores Well capacity = 100 gpm * 60 min * 18 hours = 108,000 gpd.

Based on Table 6, which assumes peaking factor of 3.0 to calculate maximum day demand and further assumes existing pumping capacity, DWA does not have enough capacity to serve the committed or allotted connections. In order to address this shortfall, and to be able to serve the committed and allotted connections, DWA will need to complete a successful rehabilitation of existing well points at the Dockton Springs site and boost the capacity to 100 gpm. If this rehabilitation is successful and the production is increased to 100 gpm the 24-hour production capacity will increase to 295,920 gallons, sufficient to cover the allotted connections.

The DOH reliability recommendations also suggest that DWA be capable of meeting its average day demand with its largest source out of service. The Sandy Shores Well is the largest source, and is capable of producing 100 gpm (144,000 gpd). Table 7 provides a comparison of the average day demand and the source capacity with the largest source out of service. DWA is able to provide average day service to its allotted water service connections with the Sandy Shores Well out of service.

TABLE 7

Comparison of DWA Production to Average Day Demand

Scenario	Average Day Demand (gpd)(1)	Source Capacity with Largest Source Out of Service (gpd)(2)
Existing	73,000	123,100
Committed	91,000	123,100
Allotted	97,000	123,100
Buildout	130,000	123,100

(1) From Table 3.
(2) Sandy Shores (100 gpm) is currently the largest source. Dockton Springs at 80 gpm and Hake Springs at 5.5 gpm..

HYDRAULIC MODELING

This section presents information on the computer hydraulic model of the DWA water system and the results of hydraulic analyses conducted to evaluate the existing hydraulic capabilities of the water system. The Washington State Department of Health's WAC 246-290 requires hydraulic modeling as a component of water system plans.

The DWA water system was analyzed using MWHSoft's H2ONet hydraulic modeling software, which operates in an AutoCAD computer-aided design and drafting environment. The H2ONet model was created using a water system base map. Reservoir elevations, well capacities, and booster station settings were determined from planning documents, construction drawings and conversation with DWA staff.

The H2ONet model is configured with a graphical user interface. Each water system element (pipes, valves, and reservoirs) is assigned a unique graphical representation within the model. Each element is assigned a number of attributes specific to its function in the actual water system. Typical element attributes include spatial coordinates, elevation, water demand, pipe lengths and diameters, and critical water levels for reservoirs. With attributes of each system element as the model input, the H2ONet software produces the model output in the form of flows and pressures throughout the simulated water system. A model node map is included in Appendix B.

Model Demands

A key element in the hydraulic modeling process is the distribution of demands throughout the water system. Total demands on the system are based on the existing and projected demands from Table 3.

Three demand sets were used in the hydraulic analysis.

- 2003 Average Daily Demands (ADD): These demands were used while calibrating the model. 2003 demands were based on the 2003 water production records.

- Buildout Maximum Day Demands (MDD): These demands were used to evaluate the system's ability to meet the buildout maximum day demands plus required fire flows at DOH's requirement of at least 20 psi minimum throughout the system.

- Buildout Peak Hour Demands (PHD): These demands were used to evaluate the system's ability to meet the buildout peak hour demands at DOH's requirement of at least 30 psi minimum throughout the system.

Calibration

The calibration of a hydraulic model provides a measure of assurance that the model is an accurate and realistic representation of the actual system. The H2ONet hydraulic model of the DWA water system was calibrated using data obtained from fire hydrant tests at various locations throughout the water system. Four fire hydrant tests were conducted, with the assistance of DWA personnel, on April 9, 2004 and two additional tests on September 15, 2004. During these tests, static and residual pressures were recorded as DWA staff opened hydrants and recorded flow rates. Static pressure is system pressure at a specific location under normal daily operation. Residual pressure is the pressure recorded adjacent to a fire hydrant that has been opened up and is flowing freely. Typically this pressure is recorded at the fire hydrant nearest to the one being flowed. Field results were used to calibrate the hydraulic model through verification of pipe type, size, and elevations and adjustment of pipe friction coefficients.

The testing locations include four points spread throughout the distribution system. A description of each testing location is presented in Table 8. The location of each test is shown on the model node map located in Appendix B.

TABLE 8

Hydrant Testing Locations

Test Number	Location	Zone Grade (feet)	Static Pressure (psi)	Flow (gpm)	Residual Pressure (psi)
1	Manzanita	232	70	950	56
2	Pumped Zone	520	87	840	28
3	Upper Level	430	43	860	31
4	Lower Dockton	246	67	530	13
5	Upper Sandy Shores/ Lower Dockton	430/246	55	1,140	13
6	Lower Sandy Shores	193	75	470	65

The system conditions at the time of each test were recorded. The water level in the SW 268th Street Reservoir was at 245 feet and the 430 Zone Reservoirs level were at 397 feet. It should be noted that the 430 Zone Reservoirs are not typically drawn down to this level. However, they were had been drained down due to low chlorine levels and had not yet been filled up. The booster station at the 246 Zone Reservoir was manually turned off during hydrant testing. All source pumps were also set to the "off" position.

Using the system conditions observed during each hydrant test, the hydraulic model was adjusted to generate static pressure and residual pressure at the measured hydrant flow rate. The total system demand at the time of the hydrant tests was assumed to be the average day demand for 2003. Model output was calibrated to points in the model equivalent to the locations of the hydrant tests.

The pressure in the system is in part dependent upon the friction within the pipes. The friction is dependent upon pipe material, the amount of tuberculation within the pipes and age of the pipes. Friction factors for the pipes in the modeled system are adjusted throughout the calibration process until the model output best approximates the measured values. Hazen-Williams C-factors (friction factors) between 130 and 140 are used throughout the system. These friction factors are typical values for most pipe. The friction factors for the pipe also compensates for minor system losses through valves and fittings.

The model output was produced for two data comparisons, static pressure and residual pressure. The values measured in the hydrant flow tests were compared to the model output values in Table 9.

TABLE 9

Calibration Results

Test No.	Static Pressure (psi)			Residual Pressure (psi)			
	Field	Model	Difference	Flow (gpm)	Field	Model	Difference
1	70	71	1	950	56	58	2
2	87	92	5	840	28	28	0
3	43	42	-1	860	31	28	-3
4	67	68	1	530	13	9	-4
5	55	55	0	1,040	13	9	-4
6	75	75	0	470	65	63	-2

Calibration of the hydraulic model produced results that are within 5 psi of actual field test data for static pressure and 4 psi of residual pressure. Hydraulic models are required to be within 5 psi of measured pressure readings for long-range planning, according to the DOH Design Manual, Table 8-1.

Peak Hour Analysis

According to WAC 246-290, a water system must maintain a minimum pressure of 30 psi in the distribution system under peak hour demand conditions. The existing distribution system has been modeled under 2003 and buildout peak hour demand scenarios. Results of these analyses are located in Appendix B.

The peak hour analysis revealed no system deficiencies. The minimum system pressure (45 psi in 2003 and 43 psi at buildout) occurs near the Sandy Shores Well, at a localized high spot in the system.

The homes served by the Hake Road water main (2-inch PVC) experience relatively low pressures during peak demand periods. The hydraulic model indicates that this water main can provide up to 40 gpm while maintaining 30 psi to all service connections. Assuming a peak day factor of 3 and a peak hour factor of 3 (i.e., peak hour demand is 9 times greater than average day demand) the anticipated buildout demand on Hake Road is 32 gpm.

Available Fire Flow Analysis

The DOH *Water System Design Manual* states that a water system should be designed to provide adequate fire flow under maximum day demand conditions, while maintaining a minimum system pressure of at least 20 psi throughout the system.

The fire flow requirement is 1,000 gpm for 2 hours throughout the water system. The DWA water system cannot meet the fire flow requirements in most areas. Complete results of fire flow modeling are presented in Appendix B. A map showing each model node can also be found in Appendix B.

Table 10 lists the typical fire flow available in each zone and their required flow during buildout maximum day demand conditions with the 20 psi constraint. The actual flow may be greater than that shown. The flow shown is that which is available while maintaining a minimum service pressure of 20 psi.

TABLE 10

Available Fire Flow Results with Existing System(1)

Model Node(1)	Pressure Zone	Available Fire Flow at Buildout(3) (gpm)	Required Fire Flow (gpm)	Meets Fire Flow Requirement?
40	246	310	1,000	No
156	430	310	1,000	No
130	520	810	1,000	No
126	232	850	1,000	No

(1) A complete list of results and a model node map can be found in Appendix B.
(2) Available fire flow is limited by a minimum system pressure of 20 psi, not specifically the fire flow at any specific location.

DWA cannot currently provide fire flow at a level meeting the King County criteria of 1,000 gpm for 2 hours. However, new and replacement water mains will be sized to provide fire flow, so long as water quality problems are not created due to long residences time of the water in the dead end pipeline, and smaller water mains are supported by hydraulic modeling.

PROPOSED CAPITAL IMPROVEMENT PROJECTS

The following sections address the deficiencies identified in the Existing System Analysis Section.

OVERVIEW

The proposed work include constructing a new booster pump station at Dockton Springs to pump to the 430 Zone, a transmission main, decommissioning the booster station and reservoirs on 268th Street, and improving circulation in the 430 Zone Reservoirs. The following sections provide additional information on each phase of the project.

DOCKTON SPRINGS BPS PROJECT

The existing Dockton Springs booster station will be replaced. The new booster station will include two identical pumps each capable of providing 100 gpm to the 430 Zone.

The two pumps will alternate active operation, while the non-active pump is available as a backup. As discussed below, a new transmission line will be installed to the 430 Zone, allowing for the elimination of the entire facility, reservoirs and booster station, on 268th Street.

New electrical control panels will be installed along with the pumps. The new panels will be designed to meet current electrical codes. Provisions will be made for an emergency generator to provide backup power as part of the upgrades.

A new building will be constructed to house the booster pumps and electrical panels. The building will provide adequate space to perform pump maintenance and provide additional storage space. The existing pump building will remain and will continue to house the chlorination facilities. The existing clearwell will remain in operation.

The new booster station will also be equipped with a PRV station so that, in the event of a pressure drop in the 246 Zone, water can flow from the 430 Zone to the 246 Zone through the transmission line.

Chlorine Contact Basin

The proposed improvements at Dockton Springs include reconfiguring the collection basin piping. An automatic control valve will be installed upstream of the contact basins. The valve will close when there is no demand from the booster station, and the chlorine contact basins are full, to keep water from entering the contact chamber. This will prevent chlorinated water from discharging into Puget Sound. The chlorine contact chamber will also allow for more drawdown to occur in the existing clearwell as it will not be used to meet chlorine contact time (CT).

Transmission Main

A new water main will be constructed from the Dockton Springs BPS to the existing water main at SW 268th Street and 94th Avenue SW. Approximately 2,200 feet water main will be installed, including 6-inch HDPE from the booster station to 264th Street and 8-inch ductile iron from 264th Street to 268th Street. The water main will be constructed partially within a utility easement, acquired by DWA, and partially within existing King County right-of-way.

Services provided from the transmission main will require individual pressure reducing valves (PRV) because pressures will exceed 80 psi in some areas. There are currently only a few services that will need to be modified with individual PRVs. These services are currently served by the 246 Zone and have low-pressure problems.

268th Street Reservoir Removal

The three reservoirs and booster station located on SW 268th Street will be removed from service and decommissioned once the Dockton Springs BPS Project is complete. This project phase will eliminate known health and safety liabilities, remove an inadequately designed BPS, and ultimately save the DWA from making costly repairs and upgrades to these facilities.

PRV STATION PROJECT

Two pressure reducing valve (PRV) stations will be added to the distribution system to replace the 268th Street facilities. A dual PRV (2 inch and 6 inch) will be installed at the intersection of SW 268th Street and 99th Ave SW. The 2-inch PRV will provide domestic flows to the 246 Zone while the 6-inch PRV will provide additional capacity during an emergency situation, such as during a fire. A second PRV station will be located at the Dockton Springs site and will consist of a 4-inch and 1-1/2-inch PRV. This PRV will provide a second flow path from the 430 Zone to the 246 Zone. Pressure sustaining pilots at both PRV stations will maintain 30 psi in the 430 Zone.

430 ZONE RESERVOIR PROJECT

The site piping to the 430 Zone Reservoirs will be reconfigured to provide a top-fill, bottom draw configuration. The new piping configuration will include an 8-inch tee in the existing pipe, an outlet check valve, and inlet check valve, and isolation valves. An 8-inch steel water pipe will be installed on the exterior wall of each reservoir. The pipe will enter the reservoir approximately three-quarters of the reservoir height. The existing inlet/outlet pipe will remain in place and continue to serve as the outlet pipe.

By improving the reservoirs to a top-fill, bottom-draw configuration, the DWA will be able to keep chlorine residuals above the minimum DOH requirement and reduce the amount of water wasted. The new piping configuration will promote reservoir mixing.

Table 11 provides a summary of the capital improvement projects identified within the Water System Plan Amendment.

TABLE 11

Capital Improvement Program Summary

Project Number	Project Name	Year Planned	Total Project Cost
1	PRV Station Project	2004	$ 50,000
2	Dockton Springs BPS Project	2005	$ 537,000
3	430 Zone Reservoir Project	2006	$ 57,000
Total CIP Cost			**$ 644,000**

FUTURE SYSTEM ANALYSIS

The following sections provide an engineering analysis of the projects proposed in the CIP. The hydraulic model was modified to reflect the proposed Dockton Springs BPS and transmission main, pressure reducing valve stations, and removed 268th Street Reservoirs. The storage analysis indicates that the two 430 Zone Reservoirs are sufficient to provide all storage requirements throughout the buildout scenario for the entire water system.

HYDRAULIC MODELING

The hydraulic model was updated to include the 268th PRV and BPS projects proposed in the Capital Improvement Plan (CIP). The hydraulic analysis revealed that the available fire flow in 246 Zone (Lower Dockton) will increase as a result of the projects.

Table 12 presents the available fire flow at a specific location in each pressure zone with the BPS and 268th PRV.

TABLE 12

Available Fire Flow Results with New BPS and PRV at 268th Street(1)

Model Node(1)	Pressure Zone	Available Fire Flow at Buildout(2) (gpm)	Required Fire Flow (gpm)	Meets Fire Flow Requirement?
40	246	610	1,000	No
156	430	290	1,000	No
130	520	810	1,000	No
126	232	850	1,000	No

(1) A complete list of results and a model node map can be found in Appendix B.
(2) Available fire flow is limited by a minimum system pressure of 20 psi, not specifically the fire flow at any specific location.

Additional distribution improvements are necessary for DWA to achieve 1,000 gpm throughout much of its system. These upgrades have been discussed with DWA. As DWA installs new and replacement mains they will be sized to provide fire flow, so long as water quality problems do not develop in dead end lines and as DWA's finances allow for such installation.

STORAGE ANALYSIS AT BUILDOUT

The proposed booster station project will remove the three small reservoirs located on SW 268th Street. Once the project is completed, the two 430 Zone Reservoirs will provide all storage for the water system. The following analysis concludes that the

430 Zone Reservoirs have sufficient storage capacity to meet water system demands at buildout.

Storage requirements are determined according to the DOH *Water System Design Manual* (April 2001). The storage requirements are based on the sum of the following:

- Operational Storage (OS)
- Equalizing Storage (ES)
- Standby Storage (SB)
- Fire Suppression Storage (FSS)

Figure 2 illustrates the relationship between the storage components and the water system facilities.

Operational Storage (OS)

Operational storage is the volume of the reservoir devoted to supplying the water system while, under normal operating conditions, the source(s) of supply are in "off" status. This volume is dependant upon the sensitivity of the reservoir water level sensors and the tank configuration necessary to prevent excessive cycling of booster pump motors. Operational storage is in addition to other storage components, thus providing a factor of safety for equalizing, standby, and fire suppression storage.

The proposed BPS will be activated when the 430 Zone Reservoirs drop one foot from the shut-off elevation. Therefore, the operational storage in the 430 Zone Reservoirs is equal to two feet of storage volume in both reservoirs (15,880 gallons).

Equalizing Storage (ES)

Equalizing storage is typically used to meet diurnal demands that exceed the average daily and peak day demands. The volume of equalizing storage required depends on peak system demands, the magnitude of diurnal water system demand variations, the source production rate, and the mode of system operation. Sufficient equalizing storage must be provided in combination with available water sources and pumping facilities such that peak system demands can be satisfied.

Equalizing storage is calculated using the following equation:

$$ES = (PHD - Q_S)*(150 \text{ minutes})$$

ES = Equalizing storage volume (gallons)
PHD = Peak hourly demand (gpm)
Q_S = Total source of supply capacity, excluding emergency sources (gpm)

The ES calculation for the buildout scenario is shown below:

PHD	=	585 gpm
Q_S	=	205.5 gpm
ES	=	(585 – 185.5)*(150)
		60,675 gallons

The peak hour demand is 585 gpm at buildout, as shown in Table 3. The source of supply capacity is 185.5 gpm, with the Sandy Shores well operating at 100 gpm capacity as it would during a peak hour demand period. The required equalizing storage volume based on demands at buildout capacity is 60,675 gallons.

Standby Storage (SB)

Standby storage is provided in order to meet demands in the event of a system failure such as a power outage or an interruption of supply. The amount of emergency storage should be based on the reliability of supply and pumping equipment, standby power sources, and the anticipated length of time the system could be out of service.

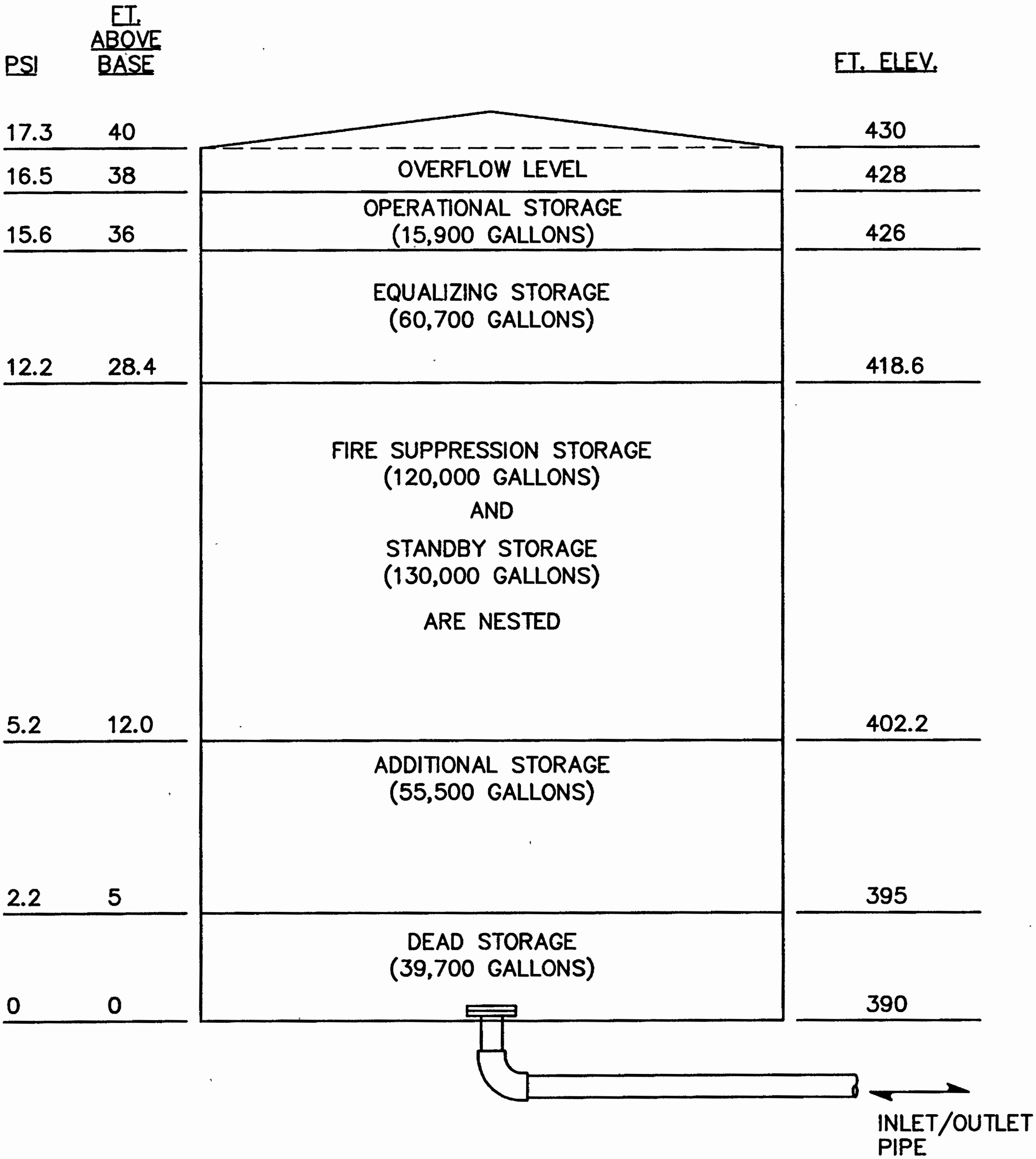
Standby storage is calculated using the following equation:

		The larger of:
SB	=	$(2\ \text{days})*(\text{ADD}) - t_M*(Q_S - Q_L)$
		or
		(200)*(ERUs)
SB	=	Required standby storage volume (gallons)
ADD	=	Average daily demand for the design year (gpd)
Q_S	=	Total source capacity, excluding emergency sources (gpm)
Q_L	=	Largest capacity source unavailable (gpm)
t_M	=	Time the remaining sources are pumped (minutes)

At buildout, the SB requirement is calculated as follows:

ADD	=	130,000 gpd				
Q_S	=	180.5				
Q_L	=	100 gpm (Sandy Shores Well or Dockton Springs)				
t_M	=	2,880 minutes				
SB	=	(2)*(130,000) – (2,880)*(180.5 – 100)	<u>or</u>	SB	=	(200)*(650)
	=	28,160 gallons			=	130,000 gallons

The total source capacity, Q_S, is from Table 4 and represents the 24-hour pumping capacity rate. The Dockton Springs site should have the capacity to pump at 100 gpm after additional well point rehabilitation and booster pump station completion. If that rehabilitation is successful both Dockton Springs and Sandy Shores will have a pumping rate of 100 gpm. The largest capacity source unavailable during an emergency is Sandy Shores well.

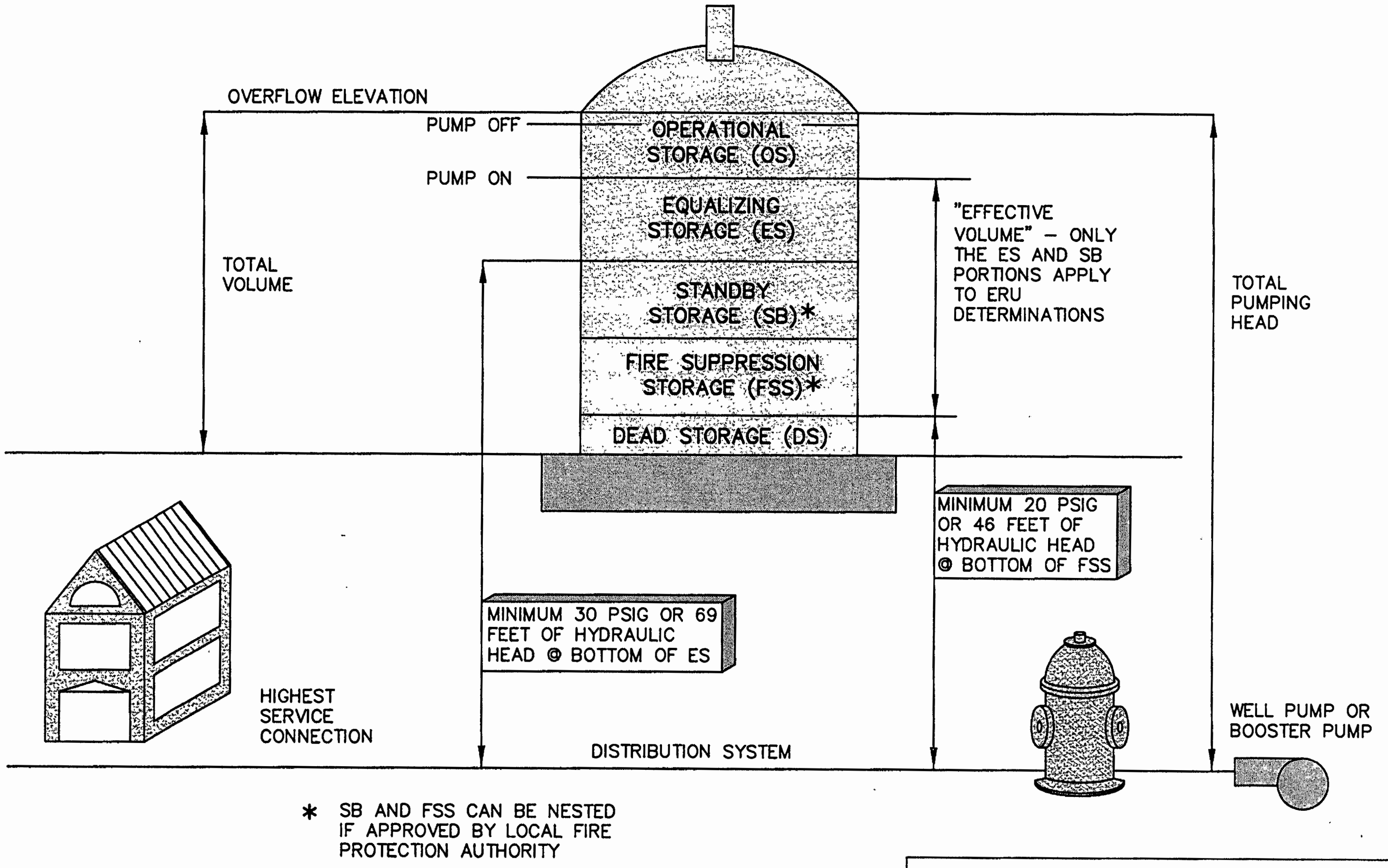


NOT TO SCALE

DOCKTON WATER ASSOCIATION

FIGURE 4
UPPER LEVEL RESERVOIR STORAGE ANALYSIS

Gray & Osborne, Inc.
CONSULTING ENGINEERS



DOCKTON WATER ASSOCIATION

FIGURE 3

RESERVOIR STORAGE COMPONENTS

Gray & Osborne, Inc.
CONSULTING ENGINEERS

The required standby storage volume is based on demand at buildout capacity and is 130,000 gallons.

Fire Suppression Storage (FSS)

Fire suppression storage is provided to ensure that the volume of water required for fighting fires is available when necessary. Fire suppression storage also reduces the impact of fire fighting on distribution system water pressure. The amount of water required for fire fighting purposes is specified in terms of rate of flow in gallons per minute (gpm) and an associated duration. Fire flows must be provided at a residual water system pressure of at least 20 psi throughout the system.

Fire suppression storage is calculated using the following equation:

$$FSS = (FF)*(t_M)$$

FSS = Required fire suppression storage volume (gallons)
FF = Fire flow requirement (gpm)
t_M = Duration of fire flow rate (minutes)

The fire flow requirement within the DWA service area is 1,000 gpm for 2 hours. The fire suppression storage volume required is equal to 120,000 gallons.

Dead Storage

Dead storage is defined as the capacity of a reservoir that cannot be used for other storage components. The bottom 5 feet of the reservoir was assumed to be full in order to provide a factor of safety during an emergency. Therefore each reservoir has 5 feet of dead storage, since this volume cannot be used for either standby storage or fire suppression storage. Five feet of dead storage equals 39,700 gallons.

Storage Capacity Analysis

The total required storage volume is calculated based on the sum of the operational storage, equalizing storage, and the greater of the standby storage and fire suppression storage components. At buildout, the DWA storage requirement is projected to be 246,300 gallons. The combined reservoir volume of the two 430 Zone Reservoirs is 301,800 gallons, of which 39,700 gallons is considered dead storage. Table 13 summarizes the storage analysis presented in this chapter. The 430 Zone Reservoirs are capable of meeting the storage volume requirements at buildout. Figure 3 illustrates the storage components within the Upper Level Reservoirs at buildout.

TABLE 13

Buildout Storage Analysis Summary

Storage Component	Volume (gallons)
(+) Operational Storage (OS)	15,900
(+) Equalizing Storage (ES)	60,700
(+) Standby Storage (SB)	130,000
(+) Fire Suppression Storage (FSS)	120,000
(+) Dead Storage	39,700
Total Required Storage[1]	**246,300**
(+) Reservoir Volume[2]	301,800
Storage Surplus	**55,500**

(1) Standby Storage and Fire Suppression Storage are nested.
(2) Reservoir Volume includes the two Upper Level Reservoirs but not the 268th Street Reservoirs.

Appendix A

Department of Health Sanitary Survey, December 9, 2003

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
20435 72nd Ave. S., Suite 200, K17-12• Kent, Washington 98032-2358

SYSTEM INSPECTION / MEETING SUMMARY

DOCKTON WATER SYSTEM (ID#19550J)

King County

Date: 12/9/2003

Persons Attending:

Susie Kalhorn – DWA
Ray Bucy – DWA
Frank Zellerhoff – DWA
Jim Nilson – DOH

Purpose: Routine Sanitary Survey and follow up to coliform problems

Previous survey date: 2/18/1999

Notes from previous survey:

- Ensure integrity of water system to keep out contamination: maintain positive pressure in all collection and distribution pipes, seal and screen openings, etc.
- Meet disinfection CT requirement for both springs and ensure disinfection residual is maintained throughout distribution system.
- Update of water system plan – *completed and approved, though implementation of some items still needed.*
- Keep up with regular water quality monitoring requirements.

Approval status:	Existing Connects	=	362
	Eng Capacity	=	485

WATER QUALITY HISTORY:

Bacteriological	:	Recent coliform violations in 10/03, 7/02, 6/02, 5/02, 4/02.
Nitrate	:	All results appear <1.0 mg/L.
Other concerns	:	Sandy shores Well has excessive manganese (0.15 mg/L) – an aesthetic concern.

MANAGEMENT & OPERATIONS:

Item	Status
Water System Plan	Approved 2002.
Water Quality Monitoring Report	Lead and copper tap samples due now.
Coliform Monitoring Plan	Due to new dedicated sample stations, plan is being revised. DWA plans on tanking 2 routine samples per month.
Certified Operator	Frank Zellerhoff (also construction contractor)
Flushing Program	Every six months and in response to WQ problems.
Cross Connect Program	In development.
Emergency Response Plan	In development.

FINDINGS / RECOMMENDATIONS

1. Of primary concern during my visit was the coliform problems of last year and last month. While we did not find an obvious source of the problem, the following issues are important in maintaining good water quality in your system:
   - Please continue to ensure that any openings into the water system are either screened or sealed to keep out insects, rodents, debris, etc. The spring basins and 268th Street reservoirs, all with shed roofs, require ongoing inspection and maintenance to ensure their integrity.
   - A reliable chlorine residual in the distribution system is an important barrier in maintaining safe drinking water. Please continue your efforts to ensure that chlorine residual is reaching all parts of the distribution system. A lack of circulation in your reservoirs presents a typical challenge to maintaining a chlorine residual. Measures such as changing operational setpoints, manually allowing reservoirs to drain and fill, and separating inlet and outlet piping with a check valve are all possible strategies. Another challenge to maintaining a chorine residual can be some of the long dead end distribution mains, which can be helped with scheduled flushing.
   - If total coliform continues to be detected in the system, you may want to increase the number of locations and frequency to get a better idea of water quality throughout the whole system. Another water quality parameter to measure is heterotrophic plate counts (HPCs). HPCs measure for a very broad range of microorganisms and the counts provide a quantitative measure of water quality that can be used to identify problem areas.
   - I encourage any testing of raw spring water to gain further knowledge of source water quality.

2. As we walked through the system, I made some notes on some items warranting attention. Please see the notes above highlighted in bold.

Appendix B

Hydraulic Modeling Results
Fire Flow Availability Map with Existing System
Fire Flow Availability Map with Proposed Improvements

Dockton Water Association
2006 Maximum Day Demands plus Fire Flow
Existing System, September 2004

ID	Static Demand (gpm)	Static Pressure (psi)	Critical Design Node	Critical Design Flow (gpm)
24	2.03	47.9	28	350
28	2.03	47.9	28	339
30	2.03	52.2	28	339
38	2.03	66.1	28	339
40	2.03	66.0	28	339
58	2.03	86.8	28	339
60	2.03	69.5	28	339
62	2.03	70.4	28	339
66	2.03	86.8	28	339
72	2.03	91.2	28	339
80	2.03	60.5	146	705
88	2.03	47.5	146	705
90	2.03	47.6	146	794
92	2.03	47.6	146	945
94	2.03	43.3	146	1,124
96	2.03	51.9	146	1,407
100	2.03	88.0	106	927
102	2.03	70.6	106	887
108	2.03	75.0	108	885
110	2.03	88.0	108	885
114	2.03	71.4	108	885
116	2.03	71.4	108	885
118	2.03	67.0	108	885
120	2.03	93.0	108	885
122	2.03	93.0	122	514
126	2.03	67.0	108	885
128	2.03	70.6	134	870
130	2.03	79.3	134	836
132	2.03	88.0	134	836
134	2.03	70.6	134	806
136	2.03	109.7	134	806
138	2.03	105.3	134	806
142	2.03	43.2	146	655
144	0.00	43.2	146	533
146	2.03	41.0	146	462
148	2.03	47.5	150	244
150	2.03	43.1	150	229
152	2.03	47.5	150	244
154	2.03	43.1	156	481
156	2.03	43.1	156	334
158	2.03	90.7	156	334
170	2.03	95.1	178	333
172	2.03	95.0	178	314
178	2.03	64.7	178	293
208	0.00	101.0	106	940
220	2.03	71.4	108	885

Dockton Water Association
Buildout Maximum Day Demands plus Fire Flow
Existing System, September 2004

ID	Static Demand (gpm)	Static Pressure (psi)	Critical Design Node	Critical Design Flow (gpm)
24	3.34	46.9	28	318
28	3.34	46.9	28	308
30	3.34	51.2	28	308
38	3.34	65.0	28	308
40	3.34	65.0	28	308
58	3.34	85.7	28	308
60	3.34	68.4	28	308
62	3.34	69.3	28	308
66	3.34	85.7	28	308
72	3.34	90.1	28	308
80	3.34	60.3	146	673
88	3.34	47.3	146	673
90	3.34	47.4	146	760
92	3.34	47.4	146	907
94	3.34	43.1	146	1,082
96	3.34	51.8	146	1,357
100	3.34	87.7	106	901
102	3.34	70.4	106	862
108	3.34	74.7	108	860
110	3.34	87.7	108	860
114	3.34	71.4	108	850
116	3.34	71.4	108	850
118	3.34	67.0	108	850
120	3.34	93.0	108	850
122	3.34	93.0	122	514
126	3.34	67.0	108	850
128	3.34	70.4	134	845
130	3.34	79.0	134	813
132	3.34	87.7	134	813
134	3.34	70.4	134	785
136	3.34	109.4	134	785
138	3.34	105.0	134	785
142	3.34	43.0	146	625
144	0.00	42.9	146	506
146	3.34	40.7	146	441
148	3.34	47.2	150	236
150	3.34	42.8	150	222
152	3.34	47.1	150	236
154	3.34	42.8	156	456
156	3.34	42.7	156	316
158	3.34	90.3	156	316
170	3.34	94.6	178	320
172	3.34	94.6	178	302
178	3.34	64.2	178	283
208	0.00	100.7	106	912
220	3.34	71.4	108	850

Dockton Water Association
2006 Peak Hour Demands
Existing System, September 2004 Minimum Pressure = 45.3

ID	Demand (gpm)	Elevation (ft)	Grade (ft)	Pressure (psi)
12	4.39	100.0	230	56.4
18	4.39	70.0	226	67.8
20	4.39	60.0	223	70.6
22	4.39	20.0	222	87.6
24	4.39	130.0	239	47.4
26	4.39	70.0	239	73.2
28	4.39	130.0	239	47.3
30	4.39	120.0	239	51.6
32	4.39	70.0	237	72.5
36	4.39	50.0	237	81.0
38	4.39	88.0	239	65.3
40	4.39	88.0	239	65.3
42	4.39	60.0	238	77.2
44	4.39	40.0	238	85.8
46	4.39	60.0	238	77.2
50	4.39	40.0	238	85.9
52	4.39	50.0	238	81.6
54	4.39	20.0	238	94.6
56	4.39	30.0	239	90.4
58	4.39	40.0	239	86.1
60	4.39	80.0	239	68.7
62	4.39	78.0	239	69.6
64	4.39	60.0	239	77.6
66	4.39	40.0	239	86.1
68	4.39	120.0	239	51.6
72	4.39	30.0	239	90.4
80	4.39	270.0	424	66.6
88	4.39	300.0	424	53.6
90	4.39	300.0	424	53.7
92	4.39	300.0	424	53.7
94	4.39	310.0	424	49.5
96	4.39	290.0	424	58.2
100	4.39	340.0	557	93.9
102	4.39	380.0	557	76.5
104	4.39	380.0	557	76.5
106	4.39	380.0	557	76.5
108	4.39	370.0	557	80.9
110	4.39	340.0	557	93.9
114	4.39	70.0	235	71.3
116	4.39	70.0	235	71.3
118	4.39	80.0	235	67.0
120	4.39	20.0	235	93.0
122	4.39	20.0	235	93.0
124	4.39	130.0	235	45.3
126	4.39	80.0	235	67.0
128	4.39	380.0	557	76.6
130	4.39	360.0	557	85.2

Dockton Water Association
2006 Peak Hour Demands
Existing System, September 2004 Minimum Pressure = 45.3

ID	Demand (gpm)	Elevation (ft)	Grade (ft)	Pressure (psi)
132	4.39	340.0	557	93.9
134	4.39	380.0	557	76.6
136	4.39	290.0	557	115.6
138	4.39	300.0	557	111.2
142	4.39	310.0	424	49.2
146	4.39	315.0	423	46.9
148	4.39	300.0	423	53.3
150	4.39	310.0	423	49.0
152	4.39	300.0	423	53.3
154	4.39	310.0	423	49.0
156	4.39	310.0	422	48.7
158	4.39	200.0	422	96.3
162	4.39	20.0	193	75.0
164	4.39	20.0	193	75.0
168	4.39	20.0	193	75.0
170	4.39	190.0	422	100.5
172	4.39	190.0	422	100.5
174	4.39	160.0	422	113.5
176	4.39	160.0	422	113.5
178	4.39	260.0	422	70.2
180	4.39	170.0	422	109.1

Dockton Water Association
Buildout Peak Hour Demands
Existing System, September 2004 Minimum Pressure = 43.1

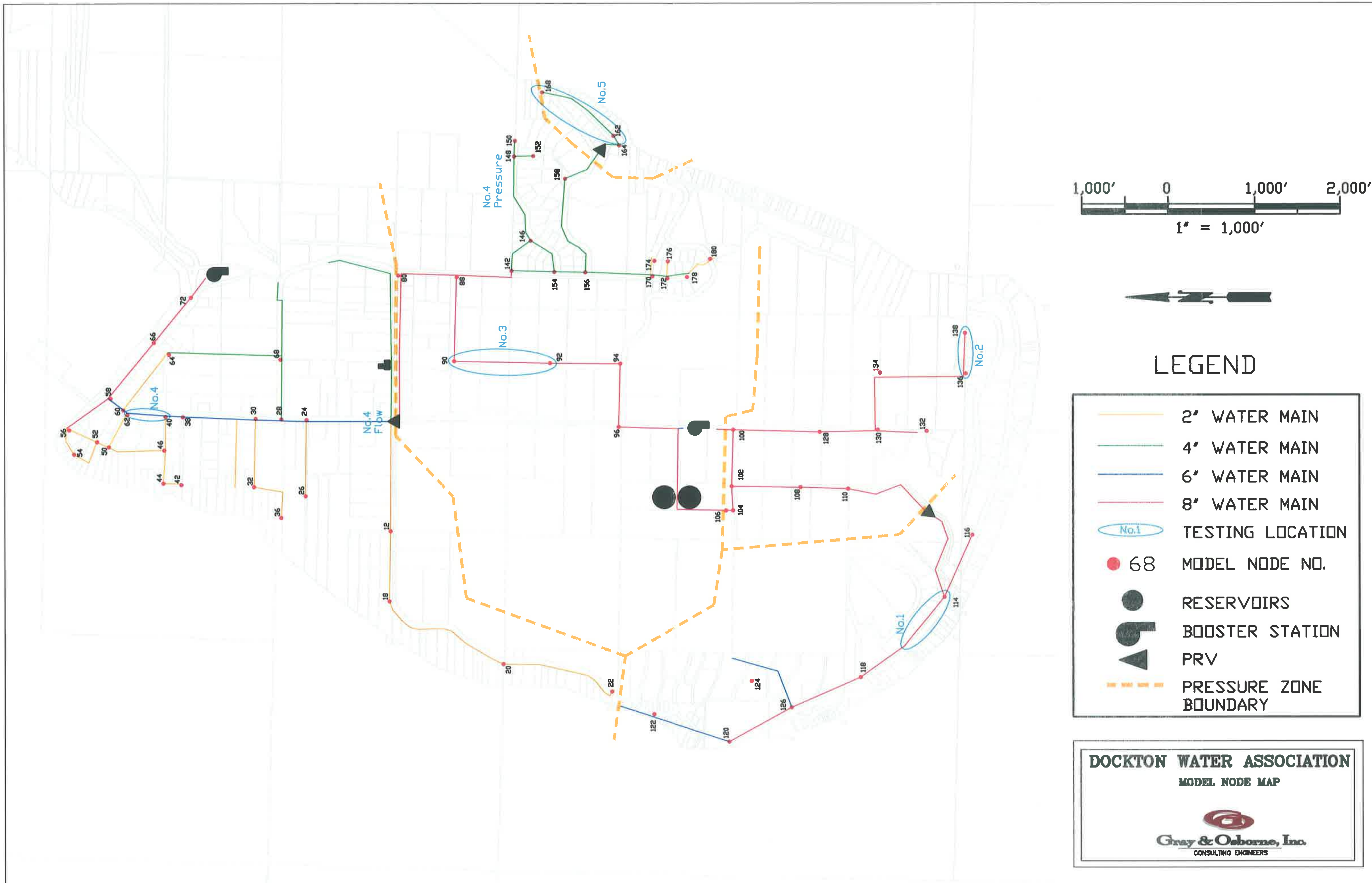
ID	Demand (gpm)	Elevation (ft)	Grade (ft)	Pressure (psi)
12	7.22	100	207	46.4
18	7.22	70	198	55.4
20	7.22	60	189	55.9
22	7.22	20	187	72.4
24	7.22	130	230	43.3
26	7.22	70	229	68.8
28	7.22	130	229	43.1
30	7.22	120	229	47.3
32	7.22	70	225	67.1
36	7.22	50	224	75.3
38	7.22	88	228	60.8
40	7.22	88	228	60.8
42	7.22	60	227	72.5
44	7.22	40	226	80.8
46	7.22	60	227	72.4
50	7.22	40	227	81.2
52	7.22	50	227	76.9
54	7.22	20	227	89.9
56	7.22	30	228	85.8
58	7.22	40	228	81.5
60	7.22	80	228	64.2
62	7.22	78	228	65.1
64	7.22	60	229	73.3
66	7.22	40	228	81.5
68	7.22	120	229	47.3
72	7.22	30	228	85.8
80	7.22	270	422	65.7
88	7.22	300	422	52.7
90	7.22	300	422	52.9
92	7.22	300	422	53.1
94	7.22	310	423	48.9
96	7.22	290	423	57.8
100	7.22	340	554	92.7
102	7.22	380	554	75.3
104	7.22	380	554	75.3
106	7.22	380	554	75.3
108	7.22	370	554	79.6
110	7.22	340	554	92.6
114	7.22	70	234	71.3
116	7.22	70	234	71.3
118	7.22	80	234	66.9
120	7.22	20	234	92.9
122	7.22	20	234	92.9
124	7.22	130	234	45.2
126	7.22	80	234	66.9
128	7.22	380	554	75.3
130	7.22	360	554	84.0

Dockton Water Association
Buildout Peak Hour Demands
Existing System, September 2004 Minimum Pressure = 43.1

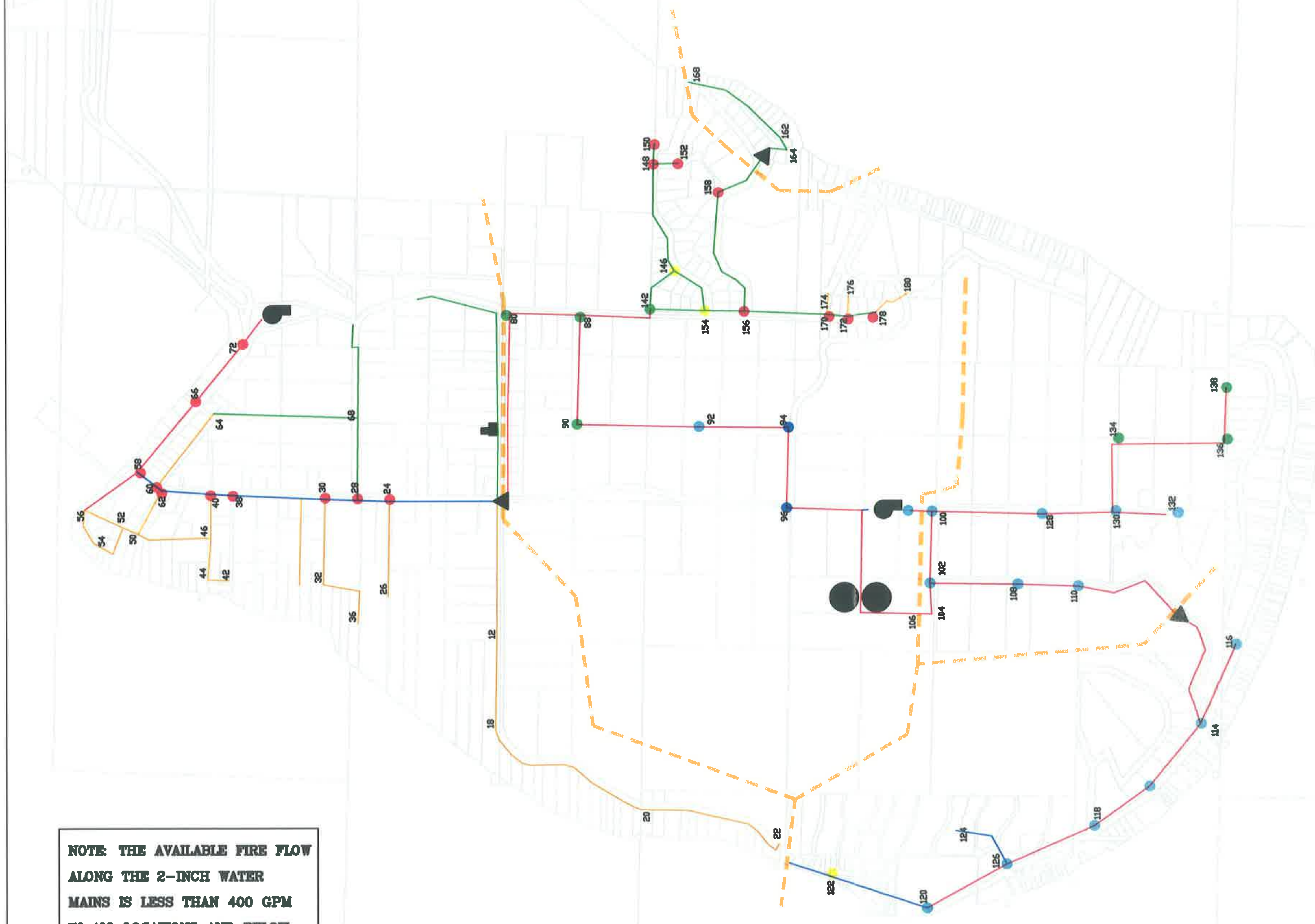
ID	Demand (gpm)	Elevation (ft)	Grade (ft)	Pressure (psi)
132	7.22	340	554	92.7
134	7.22	380	554	75.3
136	7.22	290	554	114.3
138	7.22	300	554	110.0
142	7.22	310	421	48.2
146	7.22	315	420	45.6
148	7.22	300	420	52.0
150	7.22	310	420	47.6
152	7.22	300	420	51.9
154	7.22	310	420	47.7
156	7.22	310	418	47.0
158	7.22	200	418	94.3
162	7.22	20	193	75.0
164	7.22	20	193	75.0
168	7.22	20	193	75.0
170	7.22	190	417	98.5
172	7.22	190	417	98.5
174	7.22	160	417	111.4
176	7.22	160	417	111.4
178	7.22	260	417	68.1
180	7.22	170	417	106.9

Dockton Water Association
Buildout Maximum Day Demands plus Fire Flow
Proposed System, September 2004

ID	Static Demand (gpm)	Static Pressure (psi)	Critical Design Node	Critical Design Flow (gpm)
24	3.34	47.5	146	613
28	3.34	47.5	146	613
30	3.34	51.9	146	613
38	3.34	65.8	146	613
40	3.34	65.8	146	613
58	3.34	86.7	146	612
60	3.34	69.3	146	613
62	3.34	70.2	146	613
66	3.34	86.8	146	612
72	3.34	91.2	146	612
80	3.34	59.4	146	613
88	3.34	46.4	146	613
90	3.34	46.6	146	699
92	3.34	46.9	146	847
94	3.34	42.7	146	1,022
96	3.34	51.5	146	1,300
100	3.34	87.7	106	901
102	3.34	70.4	106	862
108	3.34	74.7	108	860
110	3.34	87.7	108	860
114	3.34	71.4	108	850
116	3.34	71.4	108	850
118	3.34	67.0	108	850
120	3.34	93.0	108	850
122	3.34	93.0	122	514
126	3.34	67.0	108	850
128	3.34	70.4	134	845
130	3.34	79.0	134	813
132	3.34	87.7	134	813
134	3.34	70.4	134	785
136	3.34	109.4	134	785
138	3.34	105.0	134	785
142	3.34	42.1	146	571
144	0.00	42.0	146	465
146	3.34	39.8	146	408
148	3.34	46.3	150	224
150	3.34	41.9	150	211
152	3.34	46.3	150	224
154	3.34	41.9	156	424
156	3.34	41.8	156	297
158	3.34	89.4	156	297
170	3.34	93.7	178	310
172	3.34	93.7	178	293
178	3.34	63.3	178	275
208	0.00	100.7	106	912
220	3.34	71.4	108	850



1,000'
0
1,000'
2,000'
1" = 1,000'
LEGEND
2" WATER MAIN
4" WATER MAIN
6" WATER MAIN
8" WATER MAIN
No.1
TESTING LOCATION
68
MODEL NODE NO.
RESERVOIRS
BOOSTER STATION
PRV
PRESSURE ZONE BOUNDARY
DOCKTON WATER ASSOCIATION
MODEL NODE MAP
Gray & Osborne, Inc.
CONSULTING ENGINEERS
No.1
No.2
No.3
No.4
No.4 Pressure
No.4 Flow
No.5



1,000′ 0 1,000′ 2,000′

1″ = 1,000′

NOTE: THE AVAILABLE FIRE FLOW ALONG THE 2-INCH WATER MAINS IS LESS THAN 400 GPM IN ALL LOCATIONS AND BELOW 200 IN MOST LOCATIONS.

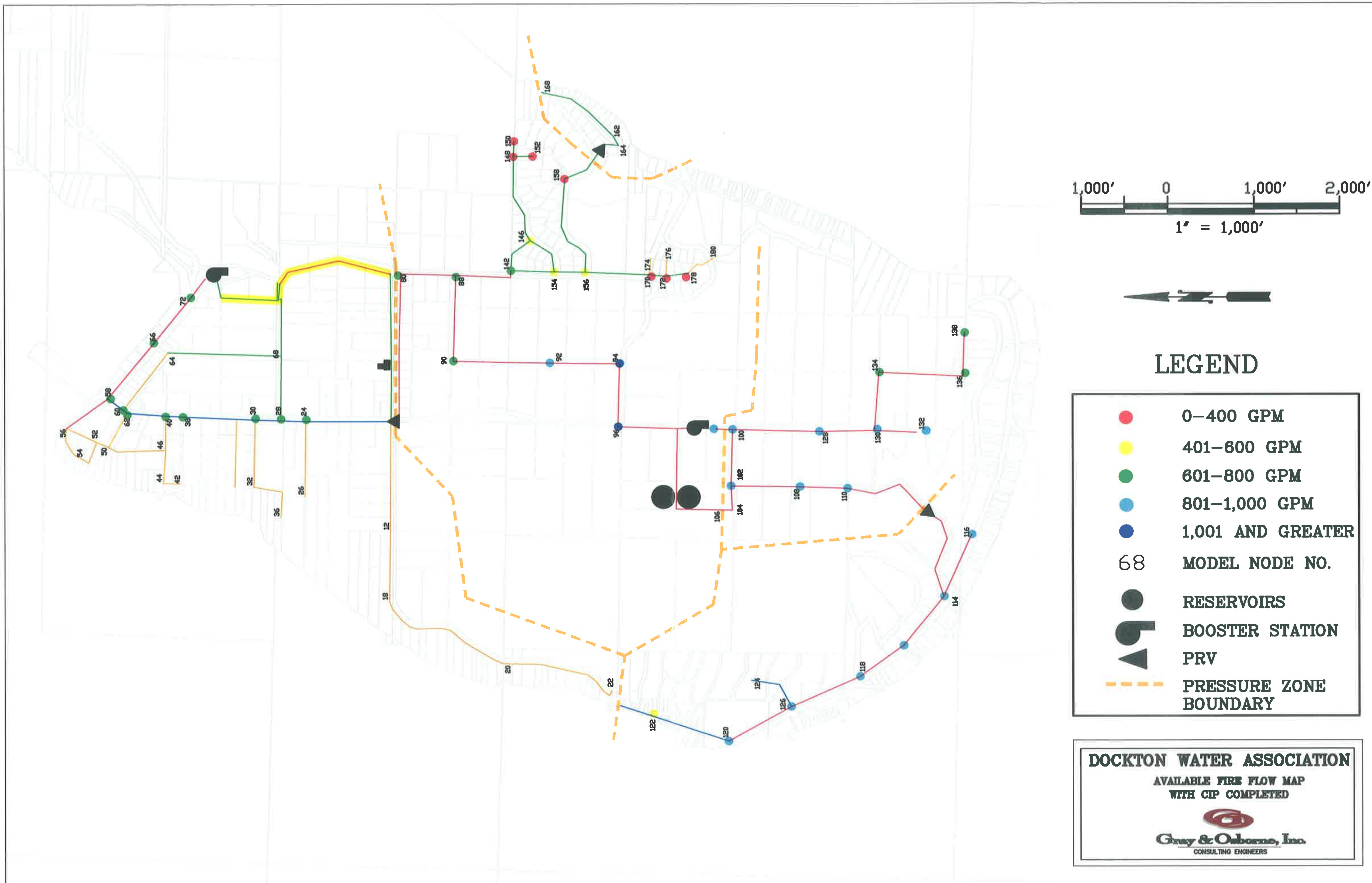
LEGEND

- 0–400 GPM
- 401–600 GPM
- 601–800 GPM
- 801–1,000 GPM
- 1,001 AND GREATER
- 68 MODEL NODE NO.
- RESERVOIRS
- BOOSTER STATION
- PRV
- PRESSURE ZONE BOUNDARY

DOCKTON WATER ASSOCIATION

AVAILABLE FIRE FLOW MAP
EXISTING SYSTEM

Gray & Osborne, Inc.
CONSULTING ENGINEERS


1,000'
0
1,000'
2,000'
1" = 1,000'
LEGEND
0–400 GPM
401–600 GPM
601–800 GPM
801–1,000 GPM
1,001 AND GREATER
68 MODEL NODE NO.
RESERVOIRS
BOOSTER STATION
PRV
PRESSURE ZONE BOUNDARY
DOCKTON WATER ASSOCIATION
AVAILABLE FIRE FLOW MAP
WITH CIP COMPLETED
Gray & Osborne, Inc.
CONSULTING ENGINEERS