APPENDIX D

DOCUMENTS SUPPORTING HYDRAULIC ANALYSIS

All Model Information

- ADD, MDD, and PHD System Calculations
- Storage Analysis Calculations
- Sumas Water System Map - Nodes
- Sumas Water System Map - Pipes
- Sumas Water System Map – Hydrant Locations

2010 Model

- 2010 Peak Hourly Demand Spreadsheet
- 2010 Steady State KYPipe Input Data and Results
- 2010 Fire Flow Results - PHD demands at nodes, no pumps on
- 2010 Extended Period Simulation – Summary of Original Data
- 2010 Extended Period Simulation: Tank Water Level with only Pump 4R on
- 2010 Extended Period Simulation: Tank Water Level with only Pump 5 on

2016 Model

- 2016 Peak Hourly Demand Spreadsheet
- 2016 Steady State KYPipe Input Data and Results
- 2010 Fire Flow Results – PHD demands at nodes, no pumps on
- 2010 Extended Period Simulation: Tank Water Level with Pumps 4R and 5

2030 Model

- 2030 Peak Hourly Demand Spreadsheet
- 2030 Steady State KYPipe Input Data and Results
- 2030 Fire Flow Results – PHD demand at nodes, no pumps on
- 2030 Fire Flow Results – PHD demands at nodes, Pump 4R on
- 2030 Fire Flow Results – MDD demands at nodes, no pumps on
- 2030 Extended Period Simulation: Tank Water Level with Pumps 4R and 5

EXISTING CONDITION – 2010

Existing System: Information based on water meter records for 2009.

496 Total Users	Total Annual Consumption	8,633,787 cubic feet (198 acre-ft)
	(Monthly Master Meter Readings)	176,933 gallons/day
21 Large Users (> 800 gpd MDD)	Annual Consumption (24%)	2,087,061 cubic feet 42,770 gallons/day
475 Residential and Small Commercial (<800 gpd MDD) Users	Annual Consumption (76%)	6,546,726 cubic feet 134,163 gallons/day

Average Daily Demand (ADD)

2010 System ADD = 176,933 gpd

For 2010:

$$\text{System ADD} = \left(\frac{176{,}933\,gallons}{day}\right)\left(\frac{1}{496\,TotalUsers}\right) = 357\,gallons/day/User$$

$$\text{Residential ADD} = \left(\frac{134{,}163\ gallons}{day}\right)\left(\frac{1}{475\ \text{Res} + Comm.Users}\right) = 282\ gal\ /\ day\ /\ User$$

Equivalent Residential Units (ERUs)

From Residential ADD: 1 ERU = 282 gallons/day

ERUs for Large Users:

$$\text{ERUs} = \left(\frac{42{,}770\,gallons}{day}\right)\left(\frac{1}{282\,gallons/day/user}\right) = 152$$

Total ERUs: 475 + 152 = 627

Maximum Daily Demand (MDD)

MDD = Peaking Factor * ADD

Daily meter readings for well pumps 4 and 5 (which supply water to combined Sumas and Sumas Rural Water Association systems) have been recorded and are shown in the attached figure. From this information the annual average daily pumping volume is 55,100 cubic feet per day (412,000 gpd). Daily peaking pumping volumes are at approximately 100,000 cubic feet per day, or 1.8 times the annual average. Based on this information a 2.0 peaking factor is very conservative and will be used for this analysis.

MDD = 2.0 * 282 gpd/ERU = 564 gpd/ERU

2010 System MDD = 2.0*ADD
= 2.0 * 176,933 gpd
= 353,866 gpd = 246 gpm

Peak Hourly Demand (PHD)

$$\text{PHD} = \left(\frac{MDD}{1440}\right)(C * N + F) + 18$$

where: PHD = peak hourly demand (gpm)
MDD = maximum daily demand (gpd/ERU)
N= number of service connections to be served in ERUs
C and F are coefficients based the number of ERUs
- when N is between 15 and 50 ERUs: C = 3.0 and F = 0
- when N is between 51 and 100 ERUs: C = 2.5 and F = 25
- when N is between 101 and 250 ERUs: C = 2.0 and F = 75
- when N is between 251 and 500 ERUs: C = 1.8 and F = 125
- **when N is greater than 501 ERUs: C = 1.6 and F = 225**

N = 627 ERUs
C = 1.6, F = 225
MDD = 564 gpd

$$\text{PHD} = \left(\frac{564\, gpd}{1440}\right)(1.6 * 627 + 225) + 18 = 499 gpm$$

Sumas PHD = 499 gpm

For Fire Flow Analysis: $\frac{MDD}{PHD} = \left(\frac{246 gpm}{499 gpm}\right) = 0.49$ Global reduction factor for PHD Model

6 Year Future Condition - 2016

The future estimated additional services are based on the existing population of 1,319 people in 2010 and include a constant projection of 35.5 people per year assuming 2.5 people per household (2004 Comprehensive Plan, page 3-11) for the residential users (see attached growth projection graph). The projection for large users is one additional large user every two years. One large industrial user is assumed to use 30 gpm peak and 10,000 gpd.

Future 2016 Population: 1,530 people

2016 Equivalent Residential Units (ERUs)

$$\text{2016 Residential Connections} = \frac{1{,}530\, people}{2.5\, people/connection} = 612$$

Large Users:
2010 Total Large Users: 152 ERU's
Assume 282 gpd = 1 ERU (same as existing condition)

2016: 3 Large User Additional ERUs:

$$\text{ERUs} = \left(\frac{30{,}000\, gallons}{day}\right)\left(\frac{1}{282 gallons/day/ERU}\right) = 106$$

2016 Total ERUs: 612 + 152 + 106 = **870**

2016 Average Daily Demand (ADD)

$$\text{System ADD} = \left(\frac{282\, gallons}{day - ERU}\right)(870\, ERU's) = 245{,}340\, gallons/day$$

2016 Maximum Daily Demand (MDD)

MDD = 2.0 * ADD = 2.0 * 245,340 gpd = 490,680 gpd = 341 gpm
= 2.0 * 282 gpd/ERUr = 564 gpd/ERUr

2016 Peak Hourly Demand (PHD)

$$\text{PHD} = \left(\frac{MDD}{1440}\right)(C*N+F)+18$$

where: N = 870 ERUs
C = 1.6, F = 225

MDD = 564 gpd/ERU

$$PHD = \left(\frac{564\,gpd}{1440}\right)(1.6*870+225)+18 = 652\,gpm$$

2016 Sumas PHD = 651 gpm

For Fire Flow Analysis: $\frac{MDD}{PHD} = \left(\frac{341\,gpm}{651\,gpm}\right) = 0.52$ Global reduction factor for PHD Model

20 Year Future Condition - 2030

The future estimated additional services are based on the existing population of 1,319 people in 2010 and include a constant projection of 35.5 people per year assuming 2.5 people per household (2004 Comprehensive Plan, page 3-11) for the residential users (see attached growth projection graph). The projection for large users is one additional large user every two years. One large industrial user is assumed to use 30 gpm peak and 10,000 gpd.

Future 2030 Population: 2,030 people

2030 Equivalent Residential Units (ERUs)

$$\text{2030 Residential Connections} = \frac{2{,}030\,people}{2.5\,people/connection} = 812$$

Large Users:
2010 Total Large Users: 152 ERU's
Assume 282 gpd = 1 ERU (same as existing condition)

2030: 10 Large User Additional ERUs:

$$\text{ERUs} = \left(\frac{100{,}000\,gallons}{day}\right)\left(\frac{1}{282\,gallons/day/ERU}\right) = 355$$

2016 Total ERUs: 812 + 152 + 355 = **1,319**

2030 Average Daily Demand (ADD)

$$\text{System ADD} = \left(\frac{282\,gallons}{day - ERU}\right)(1{,}319\,ERU's) = 371{,}958\,gallons/day$$

2030 Maximum Daily Demand (MDD)

MDD = 2.0 * ADD = 2.0 * 371,958 gpd = 743,916 gpd = 517 gpm
= 2.0 * 282 gpd/ERU = 564 gpd/ERU

2030 Peak Hourly Demand (PHD)

$$\text{PHD} = \left(\frac{MDD}{1440}\right)(C * N + F) + 18$$

where: N = 1,319 ERUs

C = 1.6, F = 225
MDD = 564 gpd/ERU

$$PHD = \left(\frac{564\,gpd}{1440}\right)(1.6 * 1{,}319 + 225) + 18 = 933\,gpm$$

2030 Sumas PHD = 933 gpm

For Fire Flow Analysis: $\frac{MDD}{PHD} = \left(\frac{517\,gpm}{933\,gpm}\right) = 0.55$ Global reduction factor for PHD Model

FUTURE CONDITION - 2016

2016 Operation Storage: no operational storage requirements assumed.

2016 Equalizing Storage:

$ES = (PHD - Q_S)$ (150 min), but not less than zero

From PHD Calcs.: PHD = 652 gpm
Q_S = Due to the need for water allocations to the City and its wholesale customers, rate is reduced from pumping capacity to allocation rate = 652 gpm

ES = (652 gpm – 652 gpm) (150 min) = 0 **therefore no equalizing storage required.**

2016 Fire Suppression Storage:

No change from 2010 condition.
$FSS = (FF)(t_m)$
FSS = (1,000 gpm) (120 min) = 120,000 gallons

For this reservoir, 120,000 gallons equals 5.7 feet of reservoir height.

2016 Standby Storage:

Multiple Source: Single Source Minimum Standby Storage minus pumping capacity of supply without largest pump

$SB_{TMS} = (2\text{ days})(ADD)(N)-t_m(Q_S-Q_L)$

N = Number of ERUs = 870

$SB_{TMS} = (2\text{ days})(282)(870)-1{,}440(1{,}676-866) < 0$ therefore use minimum requirements of 200 gallons per ERU

SB_{TMS} = (200 gallons/ERU)(870 ERUs) = 174,000 gallons

For this reservoir, 174,000 gallons equals 8.2 feet of reservoir height.

20 YEAR FUTURE CONDITION - 2030

2030 Operation Storage: no operational storage requirements assumed.

2030 Equalizing Storage:

ES = (PHD - Q_S) (150 min), but not less than zero

From PHD Calcs.: PHD = 933 gpm
Q_S = Due to the need for water allocations to the City and its wholesale customers, rate is reduced from pumping capacity to allocation rate = 700 gpm

ES = (933 gpm – 700 gpm) (150 min) = 34,950 gallons

For this reservoir, 34,950 gallons equals 1.7 feet of reservoir height.

2030 Fire Suppression Storage:

No change from 2010 condition.
FSS = (FF) (t_m)
FSS = (1,000 gpm) (120 min) = 120,000 gallons

For this reservoir, 120,000 gallons equals 5.7 feet of reservoir height.

2030 Standby Storage:

Multiple Source: Single Source Minimum Standby Storage minus pumping capacity of supply without largest pump

SB_{TMS} = (2 days)(ADD)(N)-t_m(Q_S-Q_L)

N = Number of ERUs = 1,319

SB_{TMS} = (2 days)(282)(1,319)-1,440(1,676-866) < 0 therefore use minimum requirements of 200 gallons per ERU

SB_{TMS} = (200 gallons/ERU)(1,319 ERUs) = 263,800 gallons

For this reservoir, 263,800 gallons equals 12.5 feet of reservoir height.

Storage Analysis

The city of Sumas and Sumas Rural Water Association (SRWA) each have 500,000 gallon reservoirs which work in tandem to provide all of the storage requirements for both the city of Sumas and the SRWA. The two reservoirs are each concrete tanks 60 feet in diameter and 24 feet high (21,149 gallons per ft. of tank height per tank). The reservoirs have a base elevation of 186 feet. The source for the reservoirs is the Sumas Well Field which contains two pumps: Pump #4R- 810 gpm at 155 ft. of head, and Pump #5 - 866 gpm at 155 ft. of head.

For this analysis each tank is assumed to be independent of the other with each system having its own tank.

EXISTING CONDITION – 2010

Operation Storage:

The city's operational and maintenance personnel are not aware of any pump manufacturer's requirements regarding excessive cycling times. Under normal operating condition with two cycling pumps, once a pump is activated it will operate for a few hours. This will allow each pump to remain out of service for more than the common 15 minute downtime requirement. No other operational storage requirements are considered.

Equalizing Storage:

Reference: DOH *Water System Design Manual*, December 2009
City of Sumas ADD, MDD, and PHD Calculations (PHD Calcs.), 11/2010

$ES = (PHD - Q_S)$ (150 min), but in no case less than zero, pg. 101

ES = Equalizing storage component (gallons)
PHD = Peak Hourly Demand (gpm)
Q_S = Sum of all installed and active supply source capacities except emergency supply (gpm)
= Sum of all pump capacities = 810+866= 1,676 gpm

From PHD Calcs.: PHD = 499 gpm

ES = (499 gpm – 1,676 gpm) (150 min) < 0 **therefore no equalizing storage required.**

Fire Suppression Storage:

Reference: DOH Water System Design Manual, December 2009
Whatcom County Coordinated Water System Plan Update, February 2000 (guidelines followed by the City of Sumas)

$FSS = (FF)(t_m)$

FSS = Fire suppression storage component (gallons)
FF = Required fire flow rate (gpm), as specified by fire protection authority or under WAC 246-293-640, whichever is greater
t_m = Duration of FF rate (minutes), as specified by fire protection authority or under WAC 246-293-640, whichever is greater

From Whatcom County Coordinated Water System Plan Update, pg. 5-13:
Maximum fire flow is for industrial areas: FF = 1,000 gpm, t_m = 120 min.

FSS = (1,000 gpm) (120 min) = 120,000 gallons

For this reservoir, 120,000 gallons equals 5.7 feet of reservoir height.

Standby Storage:

Reference: DOH *Water System Design Manual*, December 2009
City of Sumas ADD, MDD, and PHD Calculations (PHD Calcs.), 11/2010

Multiple Source: Single Source Minimum Standby Storage minus pumping capacity of supply without largest pump

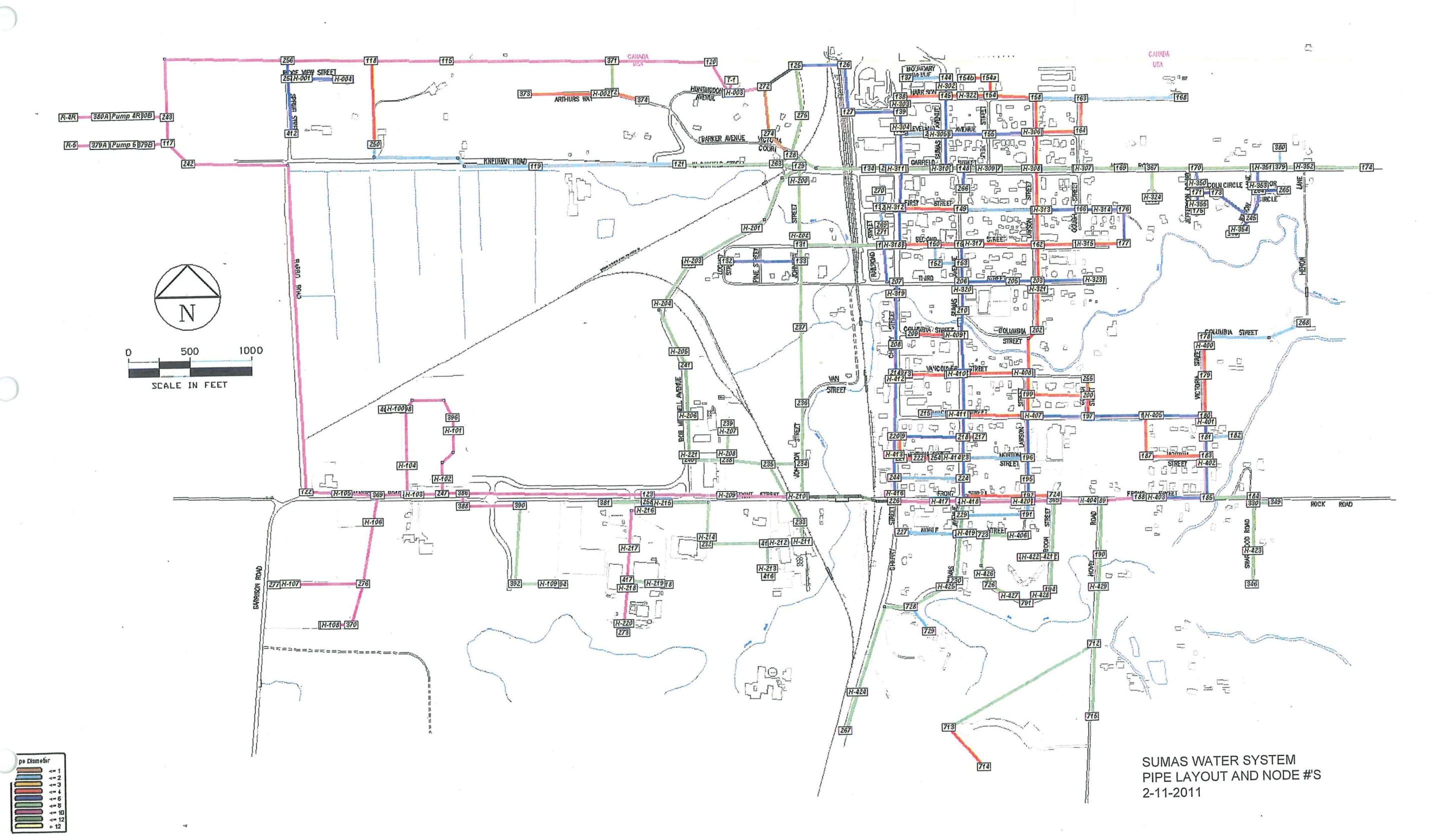
$SB_{TMS} = (2\ days)[(ADD)(N)-t_m(Q_S-Q_L)]$

SB_{TMS} = Total standby storage for multiple source water system (gallons)
ADD = Average day demand for the design year (gpd/ERU) = 282 gpd/ERU
N = Number of ERUs = 627
t_m = Time the remaining sources are pumped on the day when the largest source is not available (minutes), assume 1 day = 1,440 minutes
Q_S = Sum of all installed and continuously available supply source capacities, except emergency sources (gpm) = 866+810= 1,676 gpm
Q_L = The largest capacity source available to the water system (gpm) = 866 gpm

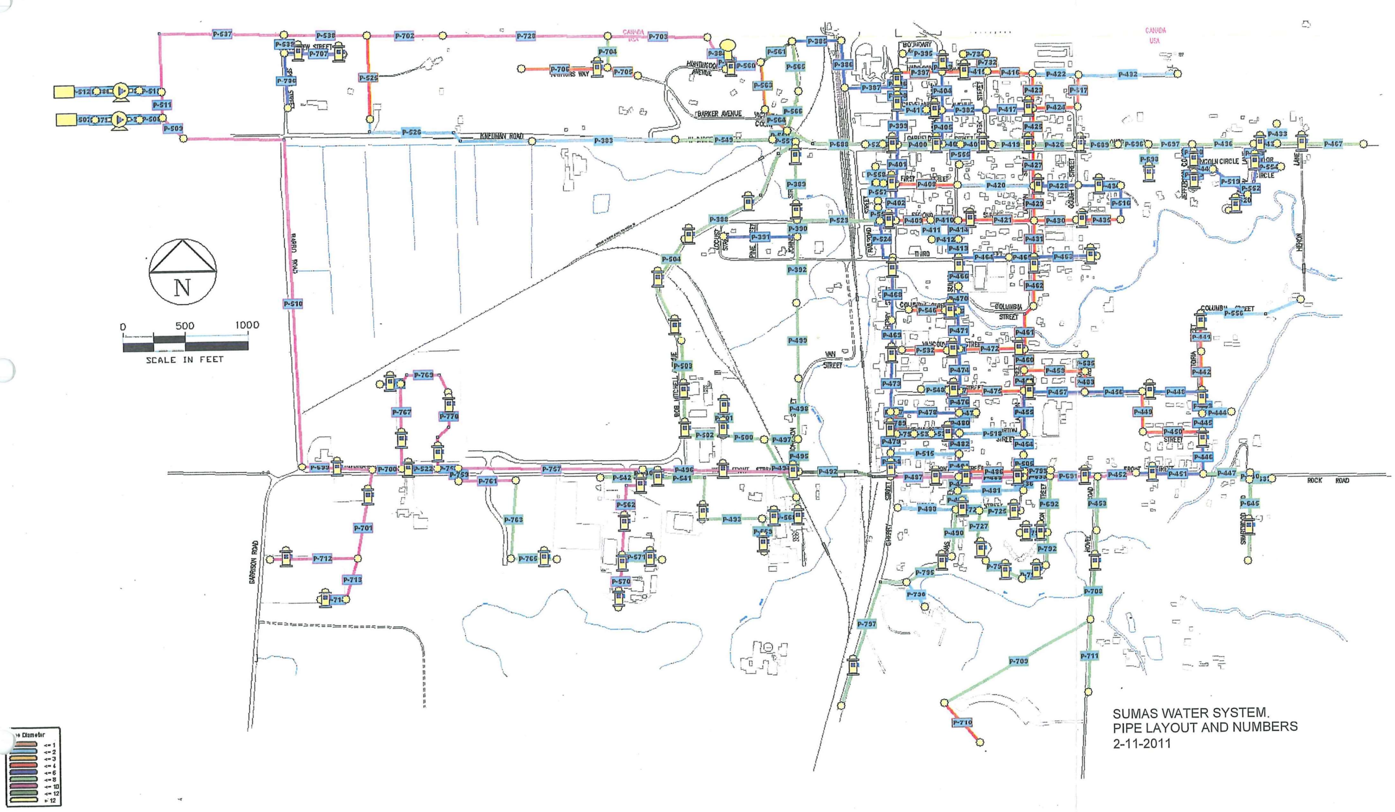
$SB_{TMS} = (2\ days)[(282)(627)-1{,}440(1{,}676-866)] < 0$ therefore use minimum requirements of 200 gallons per ERU

SB_{TMS} = (200 gallons/ERU)(627 ERUs) = 125,400 gallons

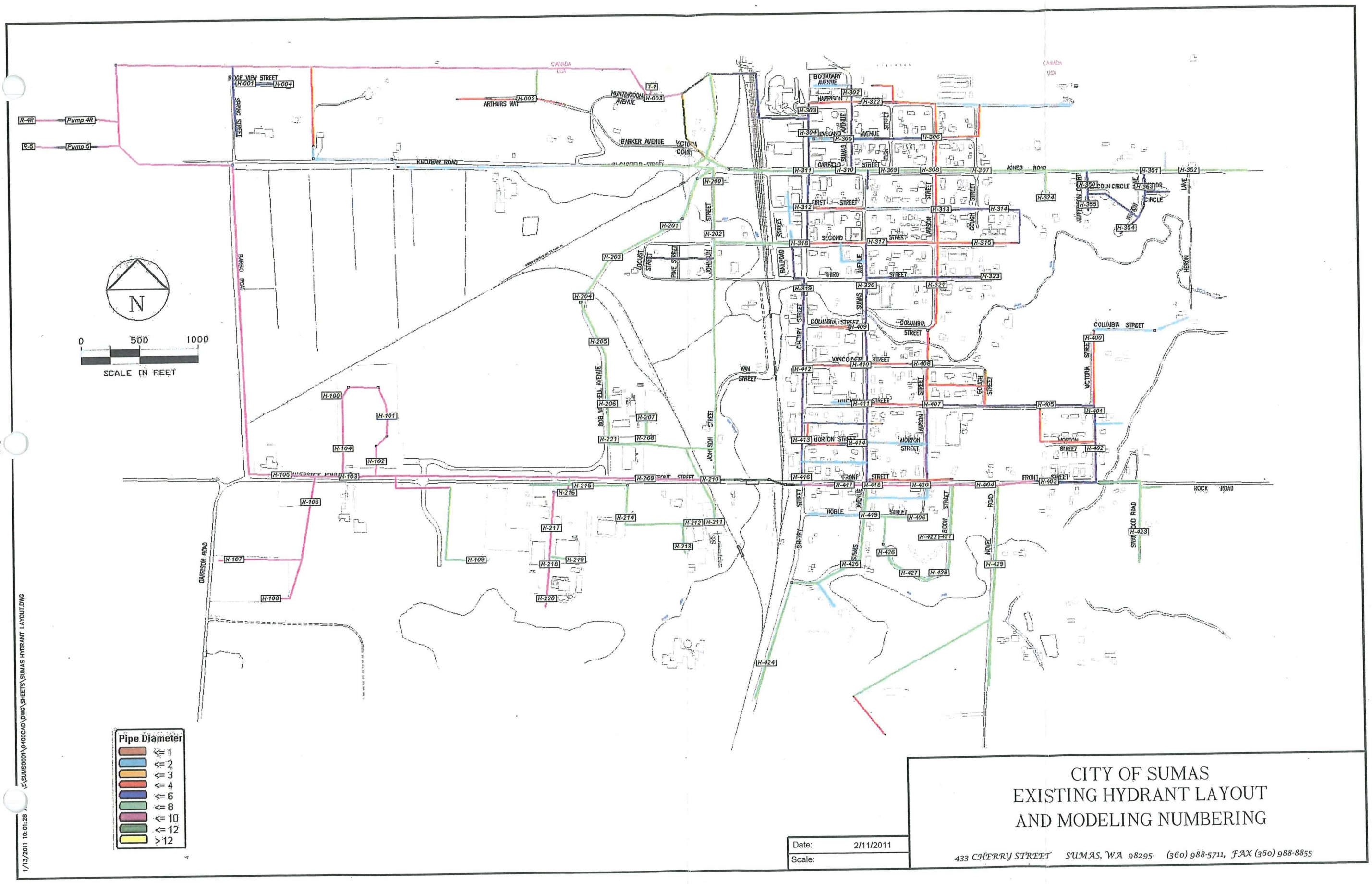
For this reservoir, 125,400 gallons equals 5.9 feet of reservoir height.



SUMAS WATER SYSTEM
PIPE LAYOUT AND NODE #'S
2-11-2011



SUMAS WATER SYSTEM.
PIPE LAYOUT AND NUMBERS
2-11-2011



Date: 2/11/2011
Scale:

CITY OF SUMAS
EXISTING HYDRANT LAYOUT AND MODELING NUMBERING

433 CHERRY STREET SUMAS, WA 98295 (360) 988-5711, FAX (360) 988-8855