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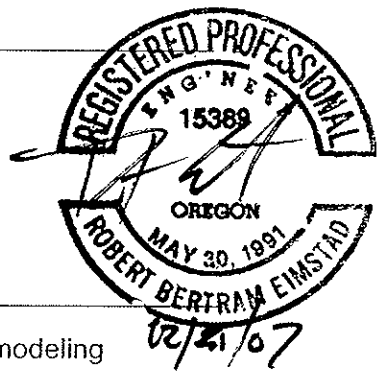
# FINAL Technical Memorandum

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| **Copies To:** | City of Ashland Project Team |
| **From:** | Mark Knudson, P.E., Nicki Pozos, P.E. and Laura Dutt, P.E. |
| **Date:** | July 19, 2007 **WO#:** 7650A.00 |
| **Subject:** | Technical Memorandum 2 - Modeling Results - FINAL |

The purpose of this technical memorandum (TM) is to summarize hydraulic modeling completed to fulfill the requirements of the Water Distribution Model Engineering Services Project. Conceptual-level costs for all projects are provided at the end of this TM to aid in selection of alternatives.

## Fire Flow Requirements

The purpose of this evaluation was to identify improvements required to meet fire flow requirements in commercial and residential areas. Three specific fire flow analyses were conducted as part of this project: (1) Ashland Community Hospital, (2) Ashland High School, and (3) Loop Road residential area.

The commercial area fire flow criterion is to deliver a flow of 4,000 gallons per minute (gpm) for 4 hours, with a maximum pipeline velocity of 10 feet per second (fps) and minimum residual pressure of 20 psi. In general, to meet commercial fire flow criteria, a 14-inch diameter water main is required or a looped 10-inch diameter main is required in the vicinity of commercial property to maintain velocities below 10 fps.

The residential area fire flow criterion is to deliver a flow of 1,500 gpm for 2 hours, with a maximum velocity of 10 fps and minimum residual pressure of 20 psi. In general, to meet residential fire flow criteria, an 8-inch diameter water main is required or a looped 6-inch diameter main is required near the residential area, to maintain velocities below 10 fps.

**Hospital Fire Flows.** A fire flow of 4,000 gpm is required at the Ashland Community Hospital. To meet fire flow criteria, the following improvements are required, as shown in Figure 1:

- *Project 1A*. Upgrade 2,260 LF of existing 4-inch and 6-inch diameter mains to 10-inch diameter mains around the hospital.
- *Project 1B*. Upgrade 730 LF of existing 6-inch and 8-inch diameter mains to 12-inch diameter mains along Maple Street from Siskiyou Boulevard to the hospital.

An alternative to the 10-inch loop would be a 12- to 14-inch main routed directly to the hydrants near the hospital. City staff noted that other construction is planned at the hospital and it may be possible to complete pipeline upgrades in conjunction with that work.

Recommendation. It is recommended that both Projects 1A and 1B be implemented. As noted above, Project 1A may be amended to a larger-diameter non-looped line to coordinate with other construction planned at the hospital. The City should investigate the possible availability of Homeland Security funds to fund a portion of this work.

**High School Fire Flows.** A fire flow of 4,000 gpm is required at the Ashland High School. To meet fire flow criteria, the following improvements are required, as shown in Figure 1:

- *Project 2A.* Upgrade 800 LF of existing 8-inch and 10-inch diameter mains to 12-inch diameter mains along Siskiyou Boulevard from Iowa Street to S. Mountain Avenue. Upgrade 450 LF of existing 6-inch diameter main to 12-inch diameter main along S. Mountain Avenue from Siskiyou Boulevard to Iowa Street.
- *Project 2B.* Upgrade 1,780 LF of existing 6-inch diameter main to 12-inch diameter main along Iowa Street from S. Mountain Avenue to Wightman Street.
- *Project 3.* Upgrade 490 LF of existing 6-inch diameter main to 8-inch diameter main along Morton from Iowa Street to Holly Street.
- *Project 4.* Upgrade 880 LF of existing 4-inch diameter main to 6-inch diameter main along Holly Street from Taylor Street to Harrison Street.
- *Project 5.* Upgrade 800 LF of existing 4-inch diameter main to 6-inch diameter main along Euclid Street from Pracht Street to Pennsylvania Street.

Note that either Project 2A or 2B is required to meet fire flows, not both projects.

It was also evaluated whether completing both Projects 2A and 2B would offer benefits by creating a 12-inch loop in the system and increasing utilization of the Wightman 12-inch main, which is currently underutilized. It was found that the new loop did not increase utilization of the Wightman main. Furthermore, if separation of the Granite and Crowson service areas is pursued, as recommended below, this loop would no longer be operable and Project 2B would no longer provide the needed fire flows at the high school.

Based on input from City staff, Project 2A could be amended such that a new main would cut across the High School property, rather than along Siskiyou Boulevard. This line would be shorter and would avoid infeasible construction along Siskiyou Boulevard. In addition, improvements to the High School property are planned and it may be possible to construct a new line in conjunction with these improvements.

City staff also noted that pipeline upgrades along Iowa Street may be possible in conjunction with planned future road improvements. Such upgrades would still supplement fire flows to the High School if the zones were connected with a new PRV station rather than valved off.

Recommendation. It is recommended that Project 2A (with routing changes to avoid Siskiyou Boulevard) be completed to deliver needed fire flows to the High School. The City should coordinate with the School District to investigate options for coordinating this project with other improvements at the school.

Projects 3 through 5 along Holly and Euclid Streets are recommended to address high velocities under fire flow conditions. These projects have a lower priority and would ideally be completed in conjunction with other roadway projects if the opportunity arises.

**Loop Road Residential Area.** A fire flow of 1,500 gpm is required along Loop Road. To meet fire flow criteria, the following improvements are required, as shown in Figure 1:

- *Project 6.* Install 1,320 LF of 8-inch main connecting South Mountain and Park Estates Pump Station (PS) service areas. Refer to next section for further discussion of recommendations for the South Mountain and Park Estates PS service areas.

Recommendation. It is recommended that Project 6 be implemented, as discussed further below.

## South Mountain Pump Station

The purpose of this evaluation was to investigate options for eliminating the South Mountain PS by serving both Crowson Zone 4 (currently served by South Mountain PS) and Crowson Zone 8 via the Park Estates PS. Two alternatives were evaluated for their ability to provide fire flows of 1,500 gpm within Crowson Zone 4 without exceeding pipeline velocities of 10 fps and maintaining residual pressures of at least 20 psi.

**Alternative 1**. The first alternative includes constructing 1,320 LF of either a 6-inch or 8-inch main to connect Crowson Zone 8 and Crowson Zone 4. This alternative assumes that the Park Estates PS will provide flow to both zones during normal operating conditions. The South Mountain PS would be maintained to provide supplemental flow during fire flow conditions. The following fire flows are attainable with this configuration:

- An 8-inch diameter connecting main provides available fire flow of 1,200 gpm with a residual pressure of 29 psi.
- A 6-inch diameter connecting main provides available fire flow of 1,200 gpm with a residual pressure of 26 psi.

It is not possible to attain a fire flow of 1,500 gpm with a minimum residual pressure of 20 psi with both pump stations on-line in their current capacities. Thus, this alternative does not meet the stated residential fire flow criteria.

**Alternative 2**. The second alternative includes constructing 1,320 LF of 8-inch main to connect Crowson Zone 8 and Crowson Zone 4 (Project 6), as well as expansion of the Park Estates PS (additional free-standing skid-mounted fire pump; Project 7). This alternative assumes that the Park Estates PS would provide flows to both zones during both normal

operation and fire flow conditions, with the South Mountain PS taken out of service. The additional fire pump should be sized to provide the necessary hydraulic head required to maintain minimum pressures of 20 psi. The pipeline velocity of an 8-inch diameter connecting main at a flow rate of 1,500 gpm is 9.6 fps. Based on this, an 8-inch diameter connecting main is sufficiently sized to provide the required fire flow of 1,500 gpm without exceeding the velocity criterion of 10 fps. City staff concurred with the recommendations of this alternative.

**Recommendation**. It is recommended that Alternative 2 be implemented. The City should investigate the possible availability of interface fire fighting funds to fund a portion of this work.

## Park Estates Pump Station

Under the current system configuration, the allowable minimum water level in Crowson Reservoir (and the usable capacity of the reservoir) is limited by the suction head required for the Park Estates PS. The purpose of this evaluation was to determine whether changes to the system configuration could be made to allow the full capacity of Crowson Reservoir to be utilized.

It was determined that it would be possible to connect the water treatment plant (WTP) clearwell directly to the Park Estates PS, rather than going through Crowson Reservoir. The piping network is already in place to do this, however valves would need to be either closed or added to the system in order to isolate the direct connection. This change would require replacement of the pumps at the Park Estates PS to suit the new suction head requirements (Project 8). However, due to the open water surface in Crowson Reservoir, the pressure available in the pipeline would not be significantly greater than that in the reservoir. Also, this would change the location of the first customer, decreasing the contact time available to meet CT requirements.

**Recommendation**. It was agreed that this change in system configuration is not justified. However, it is recommended that if pumps at the Park Estates PS are upgraded to serve the area currently served by the South Mountain PS, the pumps should be selected to have lower suction head requirements, if possible.

## Alsing Reservoir Service Area

The purpose of this evaluation was to determine system changes required to increase the turnover in Alsing Reservoir. A target of 30 percent turnover per day at peak day demands was sought for Alsing Reservoir. Under the existing system configuration, the reservoir turnover is approximately 18 percent per day at peak day demands. Increased turnover in Alsing can be achieved through the following improvements:

- *Operational Change*. Open the valve at Bellview and Siskiyou Boulevard, allowing flow from the 6-inch diameter pipeline along Bellview to flow into the 12-inch main along

Siskiyou Boulevard. It is recommended that a control valve be added at this location with automatic flow control and possibly SCADA monitoring. This would allow the City to control pumping costs and adjust flow settings seasonally, if desired.

- *Project 9A.* Upgrade 188 LF of existing 8-inch main along Ranch Road to 12-inch diameter main.
- *Project 9B.* Increase capacity of the Hillview PS by replacing existing pumps with larger capacity pumps. Under this alternative, pumping at the Hillview PS increases from one pump operating for 7 hours per day, to both pumps working for 12 hours per day under current system demands. Increasing the capacity of the PS would improve reliability for meeting current and projected future demands.

The proposed improvements are shown in Figure 1. The enlarged service area is shown in Figure 2. Under the new system configuration, the reservoir turnover would be increased to approximately 27 percent turnover every day at peak day demands. City staff noted that they currently open the valve at Bellview and Siskiyou to decrease demands on Crowson Reservoir when the reservoir level gets too low. No upgrades along Green Meadows Way are required under this alternative; the peak velocity in this pipeline is 3.77 fps.

An alternative strategy for increasing turnover in Alsing Reservoir that had been identified in previous work was also evaluated. Rather than simply bleeding into a lower pressure zone, the alternative approach would actually increase the size of the Alsing Reservoir service area. This approach would require opening the valve at Tolman Creek Road near Siskiyou Boulevard, as well as upgrading over 3,000 LF of mains to 12-inch diameter. Due to the extent of required upgrades, this approach would be far more expensive than the above option and is not recommended.

**Recommendation**. It is recommended that the City implement Projects 9A and 9B and the above-mentioned operational changes to increase turnover in Alsing Reservoir. To further decrease demands on Crowson Reservoir, it is recommended that Alsing Reservoir be filled using time-of-day pumping. This would allow the reservoir to fill in the middle of the night when Crowson Reservoir is full, then help supply peak hour demands during the morning hours. The required control systems are in place, although the control logic would need to be changed. Such control logic may need to be adjusted on a seasonal basis.

## Fallon Reservoir Service Area

The purpose of this evaluation was to determine system changes required to increase the service area of Fallon Reservoir, thereby increasing turnover in the tank. A target of 30 percent turnover per day at peak day demands was sought for Fallon Reservoir. Under the existing system configuration, the reservoir turnover is approximately 14 percent per day at peak day demands. The following changes would increase the Fallon service area, as shown in Figure 2:

- *Operational Changes.* This change can be accomplished through the opening/closing of existing valves:

- Close valve on Wrights Creek Drive (12-inch main) near Wimer Street.
- Close valve on Skycrest Drive (16-inch main) near Sunnyview Street.
- Open the closed valve (6-inch main) at Skycrest Drive and Sunnyview Street.
- Open the closed valve (6-inch main) at North Mountain Avenue and Walnut Street.

Under the new system configuration, the reservoir turnover would increase to approximately 23 percent per day at peak day demands. As more development occurs in the service area, the reservoir turnover would increase to approximately 30 percent every day at peak day demands for projected build-out condition.

City staff noted that the service area of Fallon Reservoir was once increased in the past due to a maintenance issue. Under these conditions, the pump station was running continuously without filling the reservoir. Based on further modeling, the Strawberry Pump Station is projected to operate for 9 hours per day versus the current 4 to 5 hours per day, based on one pump in operation. If actual system conditions vary from those predicted in the model, it may be necessary to increase the service area only in the winter, when demands are lower and turnover in Fallon Reservoir is a greater concern. Aside from concerns related to the pump station capacity, staff concurred with the recommendations.

It is further recommended that the City consider implementing time-of-day pumping, so that Fallon Reservoir would fill in the middle of the night when Crowson Reservoir is full, then help supply peak hour demands during the morning hours. The required control systems are in place, although the control logic would need to be changed.

**Recommendation**. It is recommended that the City implement the above projects to increase the Fallon Reservoir service area on either a seasonal or a year-round basis. It is also recommended that the City consider changing the pump station controls to implement time-of-day pumping.

## Walker, Main and Clay Streets

The purpose of this evaluation was to identify potential projects to increase looping in the distribution system and supply water for anticipated future developments. A combination of new pipelines and PRVs are recommended along these alignments to increase looping in the system and provide water to projected developments (~1350 residential units and 788,000 SF of commercial property), as shown in Figure 1:

- *Project 10.* Install 4,180 LF of 8-inch main along E. Main Street (from Walker to Clay Street) and Clay Street (from E. Main Street to Creek Dr.).
- *Project 11.* Install two PRVs, as follows:
  - Along Wightman Street just north of Siskiyou Boulevard (287 gpm capacity; downstream pressure setting of 60 psi).
  - Along Tolman Creek Rd, around 500 feet north of Ashland Street (120 gpm capacity, downstream pressure setting of 68 psi).

The two new PRVs would work in conjunction with existing PRV-23 along Clay Street (existing downstream setting at 95 psi). It was noted by City staff that the proposed 8-inch diameter main along E. Main Street seemed too small, given that other pipes in the vicinity have a 12-inch diameter. However, predicted flows through this new section are insufficient to warrant a larger diameter and any infill development in this area is expected to be residential development south of E. Main Street.

**Recommendation**. It is recommended that Projects 10 and 11 be implemented.

## Isolation of Granite and Crowson Reservoir Service Areas

The purpose of this evaluation was to determine what operational changes would be necessary to isolate Granite and Crowson Reservoir service areas, and then use the model to determine if demands and fire flows can be met under the new system configuration. The following system changes are required to isolate the Granite and Crowson Reservoir service areas and are presented in Figure 2:

- *Operational Changes*. The following changes to existing components are required:
  - Reduce pressure setting at PRV Nos. 8, 14, 15, and 16 for operation only during fire flow and/or other potential emergency situations.
    - PRV-8: new downstream setting 25 psi (existing setting 45 psi)
    - PRV-14: new downstream setting 50 psi (existing setting 65 psi)
    - PRV-15: new downstream setting 55 psi (existing setting 85 psi)
    - PRV-16: new downstream setting 55 psi (existing setting 90 psi)
  - Close valves along Wightman to shift boundaries of the pressure zone from "Granite Zone 1" to "Crowson Zone 6" (see red/black hatched area on Figure 2). This adjustment of the pressure zone boundary also facilitates better utilization of the 12-inch Wightman main.
  - Connect Granite Reservoir directly to WTP using the 16-inch main, rather than being connected via Crowson Reservoir. Control the operating height in Granite Reservoir using the existing altitude valve.

These changes dramatically affect the water level fluctuations in Granite Reservoir as shown in Figure 3. Under the existing system configuration, the reservoir turnover is approximately 8 percent every day at peak day demands. Under the new system configuration, the reservoir turnover is approximately 100 percent per day at peak day demands. With the TAP project on-line, the turnover in Granite Reservoir with the new system configuration will be reduced to approximately 60 percent per day at peak day demands. The Granite Reservoir service area is being reduced by closing the valves along Wightman Street, however the adjustments to the PRV's prevent flow from the 24-inch WTP direct main (through PRV-8) into the service area during normal operating conditions. It also prevents Crowson Reservoir from supplying water to Granite Reservoir service area through PRVs 14, 15 and 16 during

normal operating conditions.

Under the proposed configuration, it would not be possible to meet commercial fire flow requirements (4,000 gpm) in the Granite service area without the use of PRV 8 (direct flow from WTP via 24-inch main) and PRVs 14, 15, and 16 (flow from Crowson Reservoir). This is due to the size (12- and 14-inch) of mains downstream of Granite Reservoir along Granite Street and also along Siskiyou Boulevard (10-inch main). Thus, it is recommended that these PRV's be set to a lower setting so that they will open during fire and/or other emergencies but not operate during normal conditions so that Granite Reservoir is more fully utilized.

City staff expressed concern that this change may lead to insufficient pressures in a small high-elevation area of the new Granite service area. Based on additional modeling, the pressures in this area are reduced, but are still sufficient. This is because the reduced pressure settings on the four PRVs reduce but do not eliminate flows through the valves. If the valves were completely closed, pressures in the high-elevation area would indeed be insufficient.

**Recommendations.** It is recommended that the above operational changes be implemented to increase isolation of the Crowson and Granite Reservoir service areas. It is further recommended that pressures in the area of concern be monitored during the recommended operational changes to verify actual system performance. PRV settings can then be adjusted upwards as needed to maintain sufficient pressure in areas of concern.

## Service to Railroad District

The purpose of this evaluation was to determine the ability of the existing distribution system to provide service to planned development in the Railroad District. Planned developments include:

- 200,000 SF of general office/retail/light industrial space.
- Up to 160 residential units.

The existing 10- and 12-inch mains in the vicinity of the Railroad District are sufficient to provide both residential and commercial fire flows. However, the 8-inch line connecting to the Railroad District would need to be replaced with a larger-diameter main (12 or 14 inches).

**Recommendation.** The existing mains are sufficient to serve planned development in the Railroad District, with the exception that the existing 8-inch diameter connector will need to be replaced with a larger-diameter line.

## Service to Crowman Area

The purpose of this evaluation was to determine the ability of the existing distribution system to provide service to planned development in the Crowman District. Planned developments include:

- 600,000 SF of general office/retail/light industrial space.
- Up to 480 residential units.

The existing 10-inch diameter main is sufficient to provide regular service and residential fire flows to the Crowman District. However, the line is insufficient to meet commercial fire flow requirements (4,000 gpm), with or without the planned new developments. Upgrades to address this fire flow deficiency were not evaluated. It is recommended that the City complete a comprehensive fire flow evaluation for the City, focused on areas requiring commercial fire flows, rather than addressing areas of concern on an individual basis as they arise.

**Recommendation**. The existing piping is insufficient to deliver commercial fire flows to the Crowman District. It is recommended that a comprehensive fire flow evaluation of the City's system be conducted such that fire flow deficiencies can be addressed on a system-wide basis.

## Crowson II Reservoir

The purpose of this evaluation was to determine the impact of a second Crowson Reservoir on anticipated reservoir level fluctuations during peak day conditions. The existing system configuration sends the majority of the treated water from the WTP through Crowson Reservoir. Under the existing system configuration, Crowson reservoir turnover is approximately 160 percent every day at peak day demands.

A second Crowson Reservoir was added to the model with identical characteristics to the existing reservoir. The additional reservoir decreases turnover from 160 percent per day at peak day demand) to 80 percent turnover per day (for both reservoirs). The 80 percent turnover per day assumes that the Granite Reservoir service area will be isolated as described above.

The addition of a second Crowson Reservoir will achieve the desired increase in operational flexibility for both Crowson Reservoirs and provide the required level of storage capacity needed for the distribution system.

**Recommendation**. It is recommended that the City proceed with the planned Crowson II Reservoir.

## Ashland Loop Road Reservoir

It is desirable to have storage in the area served by the Park Estates PS. A capacity of 250,000 gallons was previously recommended, based on requirements for operational, fire, and emergency storage. The cost of a reservoir of this size was estimated at $1.66 M by Brown and Caldwell in the *Crowson II and Ashland Loop Road Reservoir Siting Study* (October 2006). The cost was very high for a reservoir of this capacity because the site on Ashland Loop Road is small for a reservoir of this size and extensive cut and fill were

required. As such, it was recommended that a fire pump be installed at the Park Estates PS to meet fire flow requirements and that remaining needs for operational and emergency storage be met through the Crowson II Reservoir.

However, it is desirable to have some storage in the area served by the Park Estates PS to provide some operational and emergency storage, even if is unable to meet all of the storage needs for the area. City staff and Brown and Caldwell indicated that a 50,000 gallon reservoir could be accommodated on the Ashland Loop Road site without extensive cut and fill. It is recommended that this assumed capacity be confirmed, and adjusted as appropriate, during preliminary engineering of the new reservoir.

**Recommendation**. It is recommended that the City construct a new reservoir at the Ashland Loop Road site with an approximate capacity of 50,000 gallons. It is recommended that the capacity be adjusted according to site constraints during the preliminary design phase.

## Conceptual Level Cost Estimates

Conceptual level cost estimates for all projects are presented in Table 1. These estimates are at an accuracy of +50/-30 percent and are provided to aid in comparison of improvement alternatives. All costs are total project costs including engineering design and permitting and are based on May 2007 dollars. Estimated costs for pipeline improvements were based on a unit cost of $30 per inch-diameter*foot. The provided costs for upgrading the Park Estates and Hillview Pump Stations assume that existing pumps could be replaced without requiring significant modifications to the existing pump stations. It is recommended that project costs be refined, as appropriate, based on project-specific constraints and escalated to the anticipated midpoint of construction.

## Recommendations

Recommended projects to address each area of concern are noted above. These projects have been included in the overall total in Table 1.

In addition to the identified projects, it is strongly recommended that the City conduct a comprehensive fire flow evaluation for the City, focused on areas requiring commercial fire flows. Such an evaluation would allow fire flow requirements to be effectively addressed on a system-wide basis.

**Table 1 Summary of Proposed Projects and Conceptual Costs**
**Water Distribution Model Engineering Services**
**City of Ashland**

| Project | Estimated Cost[1] |
|---|---|
| **Fire Flow Requirements** | |
| Hospital | |
| Project 1A: 10-inch loop upgrade (2,260 LF) | $ 680,000 |
| Project 1B: 12-inch upgrade (730 LF) | $ 260,000 |
| Sub-total - Hospital (Projects 1A & 1B) | $ 940,000 |
| High School | |
| Project 2A (Alt. 1): 12-inch upgrade (1,250 LF) | $450,000 |
| Project 2B (Alt. 2): 12-inch upgrade (1,780 LF)[2] | $ 640,000 |
| Project 3: 8-inch upgrade (490 LF) | $ 120,000 |
| Project 4: 6-inch upgrade (880 LF) | $160,000 |
| Project 5: 6-inch upgrade (800 LF) | $ 140,000 |
| Sub-total - High School (Projects 2A, 3, 4& 5) | $ 870,000 |
| Loop Road | |
| Project 6: New 8-inch main (1,320 LF) | $ 320,000 |
| Total - Fire Flow Improvements (Projects 1A, 1B, 2A, 3, 4, 5 & 6) | **$ 2,130,000** |
| **Park Estates Pump Station** | |
| Project 7 (Fire Flow Pump) | |
| Project 8 (New Pumps / Suction Head) | |
| Total - Park Estates PS (Projects 7 & 8) | **$ 300,000**[3] |
| **Alsing Reservoir Service Area** | |
| Alternative 1 | |
| Project 9A: 12-inch main upgrade (188 LF) | $ 70,000 |
| Project 9B: Upgrades to Hillview PS | $ 80,000[3] |
| Total - Alsing Reservoir Service Area (Projects 9 & 10) | **$ 150,000** |
| **Walker/Main/Clay Street Upgrades** | |
| Project 10: New 8-inch main (4,180 LF) | $ 1,000,000 |
| Project 11: New PRVs (2) | $ 100,000 |
| Total - Walker/Main/Clay Upgrades (Projects 10 & 11) | **$ 1,100,000** |

| Table 1 Summary of Proposed Projects and Conceptual Costs<br>Water Distribution Model Engineering Services<br>City of Ashland | |
|---|---|
| **Project** | **Estimated Cost[1]** |
| **Ashland Loop Road Reservoir** | |
| Project 12: New Reservoir (50,000 gallons) | **$ 170,000[4]** |
| **Overall Total Estimated Project Cost** | **$3,850,000** |

Notes:

1. Conceptual-level total project costs.
2. Project 2B not recommended.
3. Costs for Park Estates and Hillview Pump Stations assume existing pumps can be replaced with higher-capacity pumps without significant modifications to the existing pump stations.
4. Cost based on: $110,000 construction cost ($80,000 for steel tank, $30,000 for valving and piping); 30% estimating contingency, and 20% ELA.

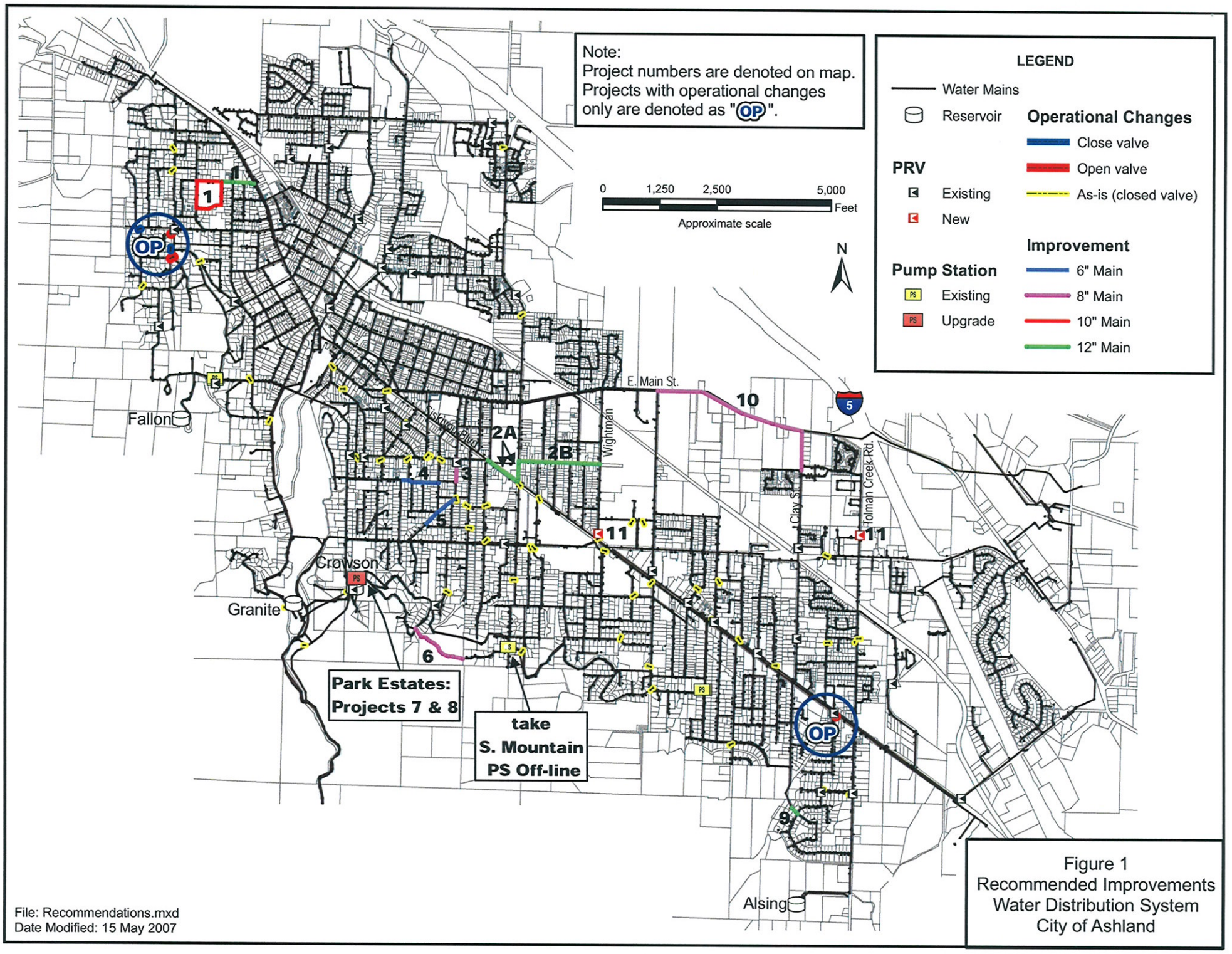


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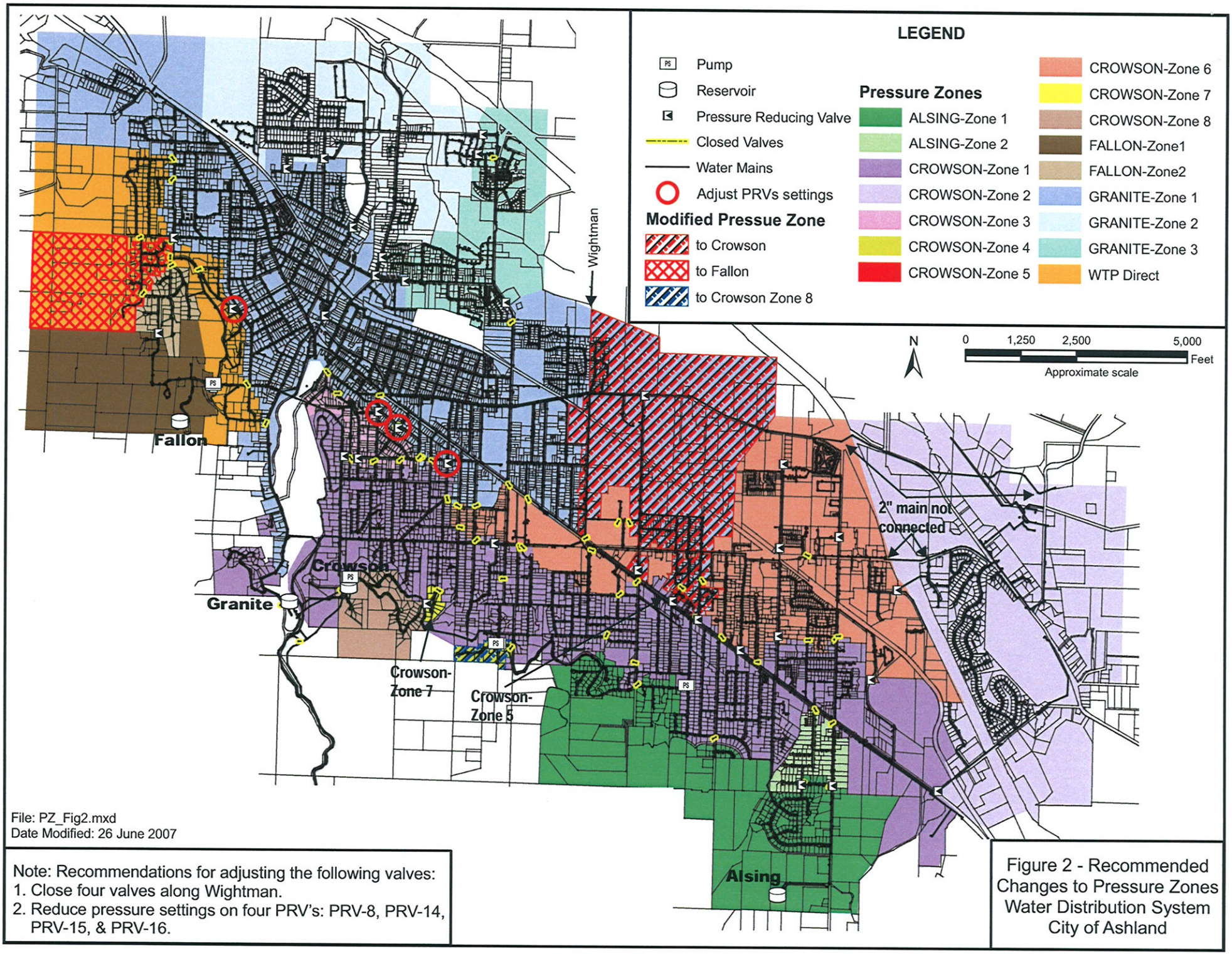
Figure 1
Recommended Improvements
Water Distribution System
City of Ashland

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Note: Recommendations for adjusting the following valves:
1. Close four valves along Wightman.
2. Reduce pressure settings on four PRV's: PRV-8, PRV-14, PRV-15, & PRV-16.

Figure 2 - Recommended Changes to Pressure Zones Water Distribution System City of Ashland

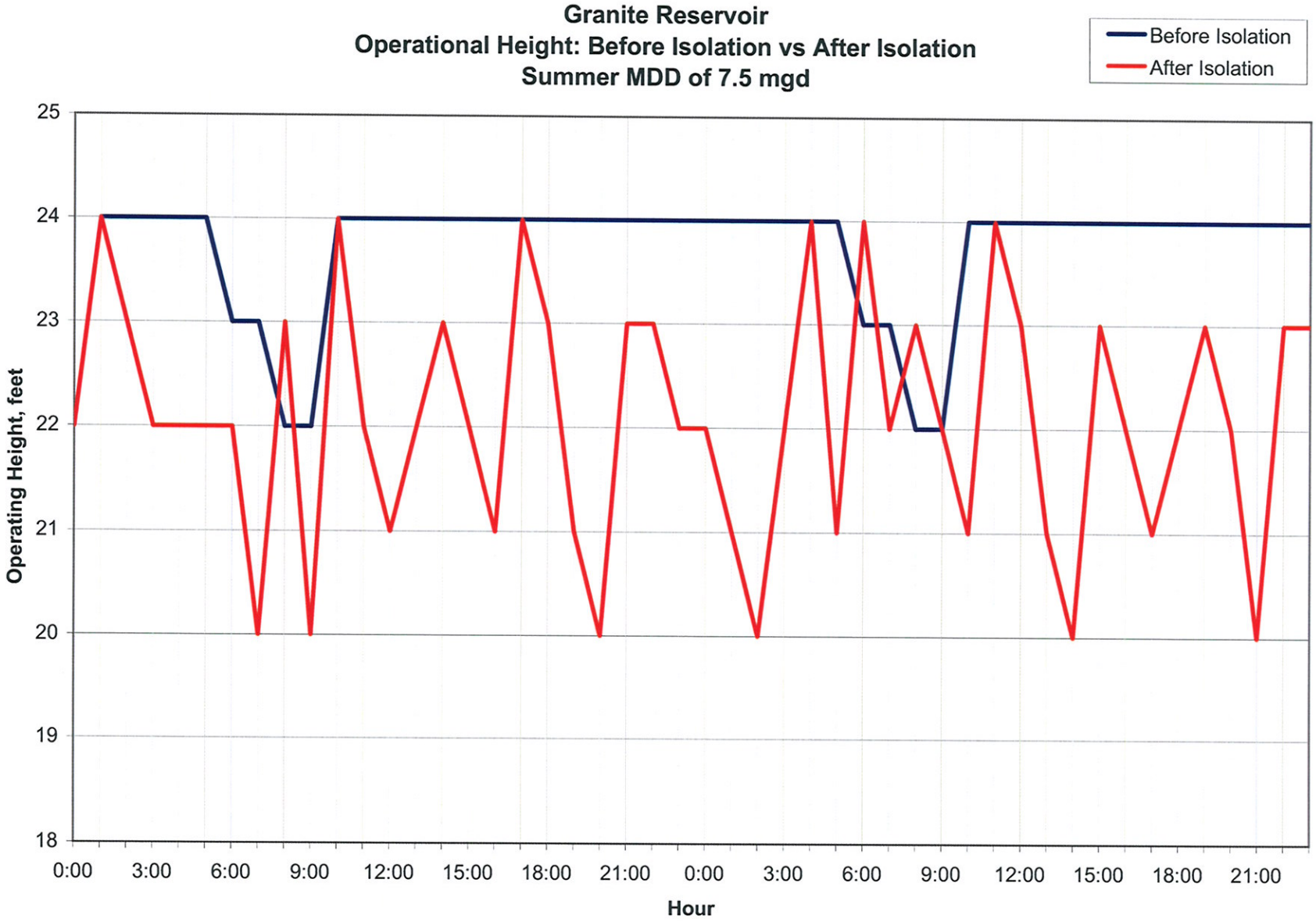


**Figure 3**
**GRANITE RESERVOIR TURNOVER**
**WATER DISTRIBUTION SYSTEM**
CITY OF ASHLAND

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