

## **MCSD Water Model Technical Report**

**To:** Norman Shopay-General Manager, Greg Orsini-Operations Director  
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**Subject:** **Technical Report Detailing Water Model Results for the McKinleyville Water Distribution System.**

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### **Executive Summary**

This report provides a summary of the water model analysis conducted for the McKinleyville Community Services District (MCSD) water distribution system. The system was analyzed using WaterCAD<sup>v8i</sup> (Select3) water modeling software and was evaluated for pressure, flow, fire flow availability, storage, pump efficiency, and overall system reliability for both current and future demands.

The report includes four analyses and result sets: the current state; addition of 4.5 MG of storage at the Cochran tank site; the addition of 2.5 MG of storage at the end of Mather Road; and 20 year growth projections. Each analysis is based on discussions with District staff, MCSD criteria, and California Department of Public Health (CDPH) requirements.

The current state scenario evaluates the distribution system under existing conditions and proved to have issues in regards to fire flow and minimum storage requirements. Under average daily demand (ADD) 6 hydrants in the high elevation Dows Prairie and three hydrants in the McCluski Hill service areas failed to deliver the required 1000 gpm fire flow. Based on preliminary findings the current system cannot satisfy the five days of average ADD required by MCSD. From storage only, where pumps are off and no water is supplied from Humboldt Bay Municipal Water District (HBMWD), there is approximately 2 days of water. The current system cannot satisfy the high-density build out proposed by the Humboldt County General Plan update in regards to minimum storage, there would be less than two days water available from storage only.

The addition of 4.5 MG of storage increases storage for demand and improves fire flow availability, but cannot provide 1000 gpm to four hydrants in the high elevation Dow's Prairie area; and, three hydrants in the McCluski Hill service areas. With the addition of 4.5 MG, the system still cannot satisfy the five days of storage criterion under average daily demand, there is approximately 4 days of water available from storage only. The addition of 4.5MG of storage cannot handle the Humboldt County proposed high-density

build-out in regards to minimum storage requirements there would only be 2.5 days of water available from storage only.

The model was also analyzed with 2.5 MG of additional storage (including the 4.5 MG at the Cochran tank site) located at the end of Mather Road in the Dow's Prairie area. The addition of 2.5 MG in the Dows Prairie area provides the required 1000 gpm fire flow to all hydrants and satisfies the minimum storage requirement of five days average daily demand (from storage only). The addition of 2.5 MG still does not handle the Humboldt County Proposed high-density build out in regards to minimum storage (3.5 days of water available).

By the year 2020 the average daily demand is expected to be 1.78 MG per day and 2.04 MG per day by 2030. In order to satisfy the MCSD minimum storage requirement by the year 2020, from the current state, 10.5 MG of additional storage will be required. For the year 2030 12 MG of additional storage will be required to satisfy the MCSD minimum storage requirement of five days average daily demand from storage only.

## 1.0 Introduction

This report summarizes the results of the water distribution system analysis conducted for the McKinleyville Community Services District (MCSD) water distribution system (Map 1). The model report includes: a description of the MCSD water distribution system, criteria and requirements, model methodology and development, and model results.

### 1.1 Objectives

- Model MCSD water distribution system using WaterCADv8i (select 3).
- Evaluate the model for minimum storage requirements, extenuating circumstances, build-out potential, future demands, and the addition of new storage tanks to the system.
- Ensure compliance with MCSD criteria and state regulations and provide alternatives for all failed criteria and standards.
- Prepare a technical report summarizing the system information and model results.

## 2.0 System description

The McKinleyville water system has four pressure zones, six storage tanks, two booster stations, and approximately 84 miles of mains (Map 1). The District purchases its wholesale supply from the Humboldt Bay Municipal Water District (HBMWD). Water is diverted at HBMWD's million-gallon tank on Essex Hill and is piped under the Mad River to MCSD's *Ramey* Pump Station at the corner of North Bank and Azalea Roads. Water is then pumped into the primary pressure zone (Zone 2), which serves the entire District except the McCluski Hill area.

### 2.1 Pressure Zones

Pressure Zone 1 services approximately 801 customers and covers all services west of Highway 101. Zone 1 is fed from pressure Zone 2 through four PRV stations and covers 13% of the entire distribution system. Pressure Zone 2 services approximately 4947 customers and covers the central portion of McKinleyville. This zone covers 84% of the distribution system and is fed by four water tanks two (2) at Cochran Road (2.5 MG) and two (2) at Norton Road (2.5 MG) totaling 5 MG. Pressure Zone 3 services approximately 192 customers and comprises 3% of the entire distribution system. Zone 3 is located on the south eastern portion of town where water is supplied to the area through two redwood tanks (.25 MG each). These tanks are fed by a booster station from the

Cochran Road tank site. Pressure Zone 4 located along Blake Road services approximately 12 customers and is fed by a hydro-pneumatic tank fed from Pressure Zone 2. Zone 4 comprises of less than 1% of the distribution system (Map 2)

**2.2 Tanks and Pumps**

Water is supplied to the MCSD water distribution system via the Ramey Pump Station and is stored throughout the system in 6 water tanks. The two tanks at the Norton Road tank site (1 MG and 1.5 MG) and the two tanks at the Cochran Road tank site (1 MG and 1.5 MG) are at a base elevation of 280 ft, provide 5 MG of total storage, and ultimately serve the entire system except for the McCluski Hill service area. McCluski Hill and pressure Zone 3 are served by two redwood tanks, 100,000-gallons and one 150,000-gallon, off of Hewitt Road. A booster station at the Cochran Road tank site pumps water up to the two redwood tanks which are at a base elevation of 401ft.

**2.3 Existing Demands**

The McKinleyville Community Services District (MCSD) supplies water to single-family residential, multi-family residential and commercial services (Table 1). These services provided approximately 552.8 million gallons (MG) of water for an equivalent population of approximately 15,400 people for the entire year 2010. This is approximately 98.3 gallons per day per capita (gpcd), with an average daily demand (ADD) of 1.51 million gallons a day (MGD). To calculate maximum daily demand a multiplier of 2.5 is applied to the average daily demand of 1.51 MG totaling 3.78 MGD. (SHN 2011)

| <b><u>Table 1.</u></b>  |                                     |                           |                                    |
|---|-------------------------------------|---------------------------|------------------------------------|
| <b><u>Service Type and Base Demands For MCSD 2010</u></b>   |                                     |                           |                                    |
| <b>Service Type</b>   | <b>Existing Service Connections</b> | <b>Total Demand (MGD)</b> | <b>Demand Per Connection (gpd)</b> |
| Single-Family Residential   | 4,680                               | 1.19                      | 254                                |
| Multi- Family Residential   | 401                                 | .24                       | 598                                |
| Commercial  | 234                                 | 0.08                      | 343                                |
| <ul style="list-style-type: none"> <li>• Total demand will be delineated between Single Family Residential, Multi-Family Residential, and Commercial users. Total Demand equals ERUs multiplied by Average Daily Demand per ERU, in gallons per day.</li> <li>• MGD: million gallons per day</li> <li>• gpd: gallons per day</li> </ul> |                                     |                           | (SHN 2011)                         |

| <b>Table 2</b>  |                                   |                               |                               |
|---|-----------------------------------|-------------------------------|-------------------------------|
| <b>Storage Capacity Design Demands 2010</b>   |                                   |                               |                               |
| <b>Service Area</b>   | <b>Average Daily Demand (ADD)</b> | <b>Max Daily Demand (MDD)</b> | <b>Peak Hour Demand (PHD)</b> |
| MCSD  | 1.51 MGD                          | 3.41 MGD                      | MDD +<br>.21MG/HOUR           |
| 1. Design Demands based on California Code of Regulations 22 CCR § 64554 (CDPH, 2009)<br>2. MGD: million gallons per day<br>3. ADD: Average Daily Demand is based on date provide in the June 13, 2011, email from Greg Orsini.<br>4. PHD: Peak Hourly Demand values presented in millions of gallons per hour. <span style="float: right;">(SHN 2011)</span> |                                   |                               |                               |

The ADD, MDD, and Peak Hour Demand (PHD) values are calculated according to Title 22 California Code of Regulations (CCR) Section 64554.(b)(3)(A-D) for annual water usage data, and are shown in Table 2. As delineated in the section, the MDD is 2.25 times the ADD, and the PHD is 1.5 times the average hourly MDD. Also, according to Title 22 CCR section 64554.(a)(2), “For systems with 1,000 or more service connections, the system shall have storage capacity to meet four hours of peak hourly demand (PHD) with source capacity, storage capacity, and/or emergency source connections.”(CDPH, 2009) (SHN, 2011)

### **3.0 Criteria Standards and Requirements**

MCSD requirements and specifications for water distribution systems have been developed by MCSD staff. The MCSD standards outlined below were tested and evaluated for each of the five scenarios. These criteria and standards are required to meet, at minimum, all California Waterworks and California Department of Public Health Standards and in some cases include more stringent requirements. (SHN, 2011)

#### **3.1 Operational Storage vs. Total Storage Criterion**

This criterion states that a minimum tank level must be maintained to account for fire flows and/or minimum pressure in the MCSD system. According to MCSD operators, the minimum storage level is approximately 20 feet in each tank. The typical maximum operational storage is around 2.6 MG, while the maximum total storage (actual total tank volume) is 5.25 MG. These numbers may be subject to change based on initial results of the water model, but ultimately the decision will be made by the MCSD Operations group. (SHN, 2011)

### **3.2 Minimum Storage Criterion**

This criterion states that the MCSD water distribution system must have enough storage to sustain 5 days of average daily demand (ADD) and fire flows. SHN will address fire flows in the future, in the form of how many and what type (residential or commercial) fire flows to apply. Also, we will use daily data provided in the spreadsheets or charts from the last 10 years of the system. This data will provide maximum daily events, diurnal patterns, peak hour events, MCSD's largest fire of recent record, and other pertinent data. For now, according to the group's recollection and provided data, the ADD is around 1.5 MGD. (SHN, 2011)

### **3.3 Extenuating Circumstance Criterion**

This criterion states that due to the vulnerability of the MCSD's sole source of water, the minimum state regulations for water storage are not enough to satisfy MCSD needs in the event of an emergency or natural disaster. The main transmission line from HBMWD crosses the Mad River and is the sole source of water for the entire MCSD service area. If that line were to break, MCSD does not currently have a redundant water supply to refill tanks until the transmission line was repaired. The "Earthquake Scenario" is a situation in which a natural disaster destroys the main transmission line and also causes fire within the MCSD service area. MCSD would need enough storage to provide the average person with water as well as fight multiple fires. Although MCSD is currently investigating potential back up water supply sources, MCSD does not have an alternate source of water other than this transmission line. (SHN, 2011)

### **3.4 California Department of Public Health Requirements**

According to the California Department of Public Health and CCR 22 CA ADC § 64554, the system as a whole is required to meet four hours of peak hour demand (PHD) and max daily demand (MDD) at all times. Four hours of PHD is approximately 0.84 MG per four hour period per day, and MDD is approximately 3.41 MG per day. Based on CDPH requirements alone, the system must have a storage capacity of 4.25 MGD. (CDPH, 2009)

### **3.5 California Waterworks Standards**

According to California Waterworks Standards each distribution system shall operate in a manner to assure that the minimum operating pressure in the water main at the user service line connection throughout the distribution system is not less than 20 psi at all times. (CDPH, 2009)

## **4.0 Model Development**

In order to accurately determine system wide reactions to a variety of scenarios WaterCADv8i (select 3) water modeling software was employed. The model is not intended to be an exact replica of the water system. The model is intended to run steady state simulations, extended period simulations, and fire flow simulations. Geographic Information Systems (GIS) data was used to create a skeletonized replica of the water system consisting of links and nodes. Links can be pipes, pumps, or valves. Nodes can be tanks, reservoirs, or pipe junctions. Some important attributes that are given to these links/nodes include, but are not limited to: hydraulic data, elevation data, system characteristics, system geometry, etc.

The model is capable of running various simulations to obtain information pertinent to pipe sizing, system pressures, water tank storage, fire flow capacities, and pumping efficiency. Steady State analyses create a “snap-shot” of the modeled system and are used to determine flow rates and system wide pressures. The results from the Steady State analysis are used to insure flow rates and pressures are within design criteria limits. Extended Period Simulations are employed to validated existing tanks have adequate storage to supply ADD and MDD over a pre-determined period of time (typically 3-5 days). In these simulations the model is run over a defined length of time and results are reported every hour. The overall objective of the model is to understand the water system and evaluate any changes when system components are added or changed.

### **4.1 Limitations**

The work relative to computer model construction and the resulting accuracy/precision are defined by the following limitations:

- 500 link and node maximum limit set forth by the License level of WaterCAD.
- The Ramey Pump Station was modeled as one 240hp variable speed pump.
- Cochran Booster Station was modeled as one variable speed pump.
- The computer only models pipes 4 inches and larger (2 inch and smaller are not included)
- General purpose or shut-off valves are not physically included in the model layout. In the model, pipes can be assigned open or closed attributes. Minor loss coefficients are also included in pipe attributes to model and account for losses created by gate valves, tees, crosses, pipe bends, etc.
- Minor losses are approximated.

- Roughness coefficients are approximated as follows:
  - Polyvinyl Chloride (PVC): 142.5
  - Asbestos Cement (AC) or Mortar Lined Ductile Iron: 133
  - Cast Iron: 123.5
- Single junction nodes were used to represent multiple pipes and connections when they occurred within the same street.
- Service demands and locations within a service area were estimated using 2010 average daily demand data provided by MCSD staff. The demand for each service area was allocated using the Theissen Polygon Method (defined in section 4.4 Demand Allocation).
- Parallel pressure regulating valves (PRV's) leading to the same pressure zone had to be modeled as one.
- Pumps were modeled by manufacturer pump curves.

## 4.2 Model Components

The model layout in WaterCAD is a combination of links and nodes representing various pipes, junctions/demand nodes, tanks, pumps, control valves and a reservoir (Table 3). Pipes and junctions are labeled by number (i.e. 10, 43, 265etc.). Numbering is sequential and serves no other purpose.

**Pipe:** Pipe data was imported from MCSD GIS and provided a skeletonized framework including diameters, pipe materials and lengths. The skeletonized system is not an exact replica of the water system; it is scaled down and simplified for use within the 500 pipe license limit.

**Nodes:** Junction nodes were created where two or more pipes come together or pipe dead ends. Demand nodes are located along a pipe and provide demand information. Data provided at each node includes, elevation, demand and demand patterns.

**Tanks and Reservoirs:** Tanks and reservoirs are defined by their storage capacity, base elevation, and maximum and minimum operating ranges. [Cochran, Norton, Redwood]

**Pump:** Pump data was collected by reviewing system design manuals, pump curves, and SCADA results as well as conversations with MCSD operations staff. [Ramey, Cochran]

**Control Valve:** Control valve data, such as PRV's, was entered directly into the model with the assistance of MCSD Operations staff.

**Reservoir:** Reservoir is defined as an infinite source or supply of water; in this case the Essex water tank from Humboldt Bay Municipal Water District was designated as a reservoir.

| <b><u>Table 3.</u></b><br><b><u>Types and Number of Model Elements</u></b> |               |
|--|---------------|
| <b>Element</b>   | <b>Number</b> |
| Pipes  | 492           |
| Nodes  | 374           |
| Control Valves (PRV)   | 5             |
| Tanks  | 3             |
| Pumps  | 3             |
| Reservoir  | 1             |

### 4.3 Rule-Based Operations

During an extended period simulation Rule-Based controls are defined to simulate system activity over a period of time. Rule-Based controls are logic statements that perform an action on junctions or links throughout the model based on a defined condition to be met. Each rule-based logic statements include a condition statement and its resulting action statement. For example, if the water level in Cochran Water Tank falls below 30 feet, Booster Pump turns on. The following is an example of the Rule-Based operations established for the MCSD water model. These Rule-Based controls allow the model to better represent the system.

**Logical Control: LC1090**

IF Redwood Hydraulic Grade <= 421.00 ft  
THEN Cochran Pump Pump Status = On

**Logical Control: LC1091**

IF Redwood Hydraulic Grade >= 423.70 ft  
THEN Cochran Pump Pump Status = Off

**Logical Control: LC1224**

IF Cochran Tank Hydraulic Grade <= 310.00 ft Or Norton Tank Hydraulic Grade <= 310.00 ft  
THEN Ramey Pump Pump Status = On

**Logical Control: LC1226**

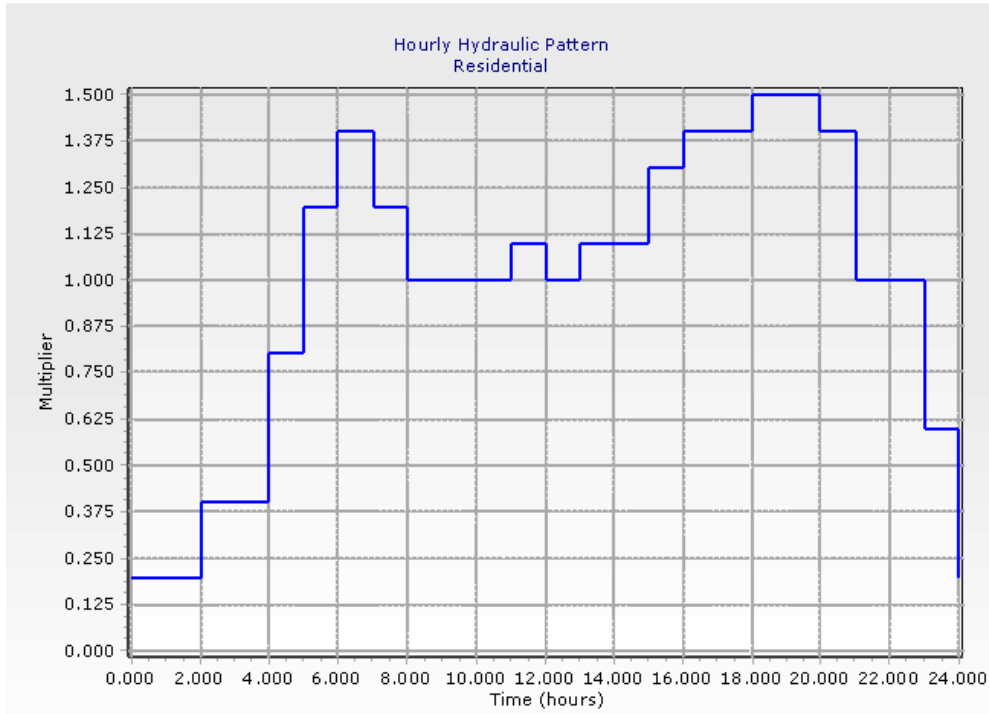
IF Cochran Tank Hydraulic Grade >= 317.20 ft And Norton Tank Hydraulic Grade >= 317.20 ft  
THEN Ramey Pump Pump Status = Off

#### 4.4 Demand Allocation

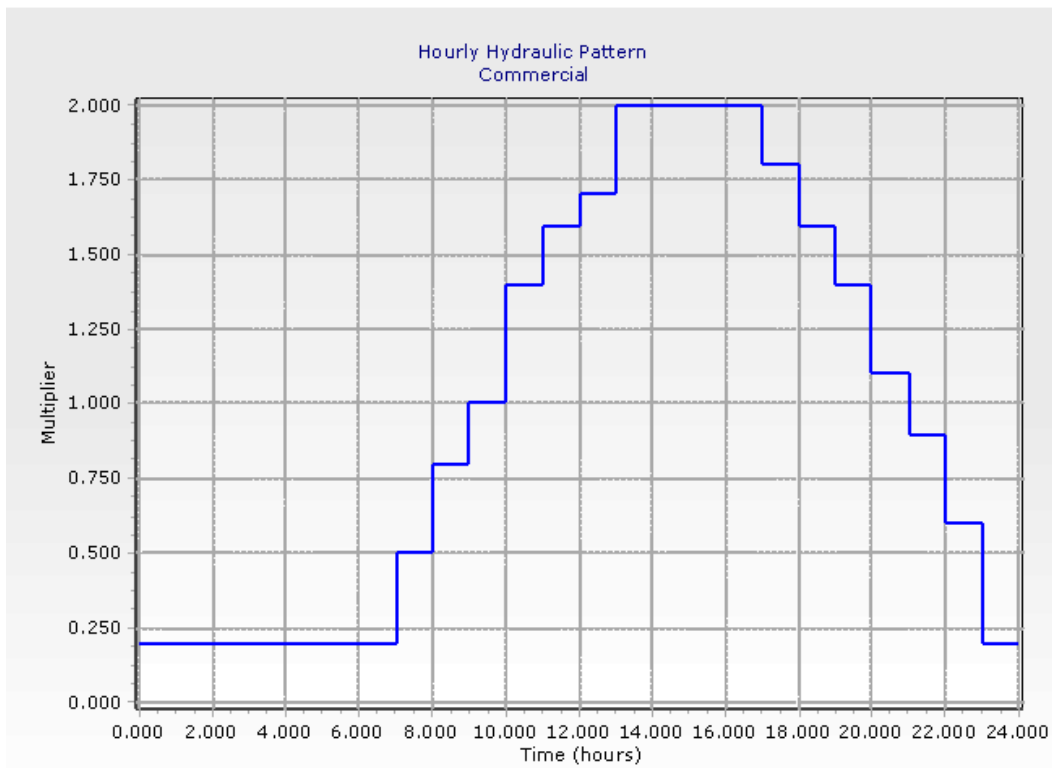
The average daily demand of 1.51 MG per day was allocated based on land use and billing records. Each residential and commercial parcel was assigned a demand based on number of water connections (Table 4). For larger commercial customers such as, laundromats, restaurants, grocery stores, hotels, and gas stations actual usages were used. The demands assigned to each parcel were then allocated to the nearest model node using the thienesen polygon method. This method creates boundary polygons around each node then assigns the node a demand based on the parcels that fell within that polygon.

| <b><u>Table 4.</u></b>  |                  |                |             |                       |                           |
|---|------------------|----------------|-------------|-----------------------|---------------------------|
| <b><u>Demand Calculations Based on Land Use and Number of Connections</u></b> |                  |                |             |                       |                           |
| Land Use  | #<br>Connections | ERU multiplier | ERU         | Total Demand<br>(MGD) | Demand / Parcel.<br>(gpm) |
| <b>Single Family Res.</b>   | 4680             | none           | 4680        | 1.19                  | 0.17                      |
| <b>Multi-Family Res.</b>  | 401              | 1.35           | 945         | 0.24                  | 0.41                      |
| <b>Commercial</b>   | 234              | 2.35           | 315         | 0.08                  | 0.23                      |
| <b>Total</b>  | <b>5315</b>      |                | <b>5940</b> | <b>1.51</b>           |                           |

In order to evaluate how the system reacts over time diurnal curves were set up for both residential and commercial demands (Figure 1-2). Diurnal curves were created by evaluating days with the highest usage for the year 2010, daily trend data from the SCADA, and conversations with MCSD staff. The residential diurnal curve indicates a peak demand between 6:00pm and 8:00pm while the commercial diurnal curve indicates a peak demand generally between 1:00pm and 5:00pm. A full summary of diurnal curves and multipliers can be found in Appendix A.



**Figure 1.** Residential Demand Curve hourly multipliers and demand pattern.



**Figure 2.** Commercial Demand Curve hourly multipliers and demand pattern.

#### 4.5 Model Calibration

Six separate fire flow tests were conducted by MCSD staff to calibrate and validate the accuracy of the hydraulic model in regards to the existing system. Each test site was selected to represent field conditions and known “trouble” areas within each of the four pressure zones. During these tests, static/ residual pressures and flow were recorded while concurrently taking note of tank levels and pump speed to create a “snap shot” of the existing water system. Using this data, scenarios were created within the model to replicate actual field conditions recorded during fire flow testing. After running several iterations of the model slight adjustments were made to elevation, demands, and pipe c-factor until the modeled fire flows and residual and static pressures matched those of the actual test. All modeled static pressures were calibrated to within 4 psi of field measurements while the drop in pressure from static to residual was modeled to within 2 psi (Table 5.) Based on the calibration results outlined in Table 4 the model accurately represents the distribution system and is sufficient for planning and modeling purposes.

| <b><u>Table 5.</u></b>   |                     |                                   |                                      |                    |
|--|---------------------|-----------------------------------|--------------------------------------|--------------------|
| <b><u>Comparison of Static Modeled Pressures vs. Static Recorded Pressures and Percent Variation</u></b> |                     |                                   |                                      |                    |
| <b>Hydrant #</b>   | <b>Location</b>     | <b>Model Pressure Range (psi)</b> | <b>Recorded Pressure Range (psi)</b> | <b>% Variation</b> |
| CH-41  | Terra Vista Ct.     | 44                                | 44                                   | 0%                 |
| DH-116   | Nursery Way         | 71.5                              | 74                                   | 3.3%               |
| EH-86  | Barnett / Silverado | 92.9                              | 92                                   | 1%                 |
| GH-2   | Ocean Dr.           | 88.6                              | 85                                   | 4.23%              |
| DH-82  | Dows Prairie        | 37.8                              | 38                                   | .5%                |
| CH-40  | Terra Vista Ct.     | 44                                | 44                                   | 0%                 |

The model had a difficult time recognizing parallel PRV’s within the system. After a discussion with WaterCAD technical support and MCSD staff a decision was made to combine parallel PRV’s leading to the same pressure zone into one mock station. School Road and Hiller Road PRV’s were combined into one and Eucalyptus Road and Murray Road PRV’s were combined into one resolving the issue.

Initially, the model result produced pressures in Zone 2 (west of Hwy 101) that were consistently 10 psi higher than field records indicated. MCSD staff verified that PRV’s

are operating at the correct pressure: therefore, PRV settings within the model were adjusted to reflect field measurements, thus resolving these issues.

Differences between the model and field results can be attributed to any number of inconsistencies such as; slightly inaccurate elevation data, non-precise operational data, precision and accuracy of test instruments, operator error during testing or data collection, unknown closed or open valves, misappropriation of model demands, unexpected demand consumption, inaccurate pipe “C” or friction factors, or a fire flow test that cannot be closely replicated. Any or all of which can cause minor differences between actual and modeled results.

## 5.0 Results and Discussion

The following discusses model outputs and the systems adequacy to maintain the required flows, pressures, storage and pump efficiency per MCSD and state of California minimum requirements and regulations. Model results have been grouped into four scenarios and result sets: current state, 4.5 MG tank scenario, 2.5 MG tank scenario and 20 year growth scenario. Each result set will include: a steady state analysis testing pressures, flows and fire flow availability; an extended period simulation testing storage capacity and pumping efficiency; extenuating circumstances testing each scenario under “earthquake” conditions; and a high density build-out analysis testing for potential growth in undeveloped areas.

### 5.1 Scenarios

- **Steady state analysis**, including simulated fires (Table 6), was conducted under ADD, MDD, and PHD for each scenario. The steady state analyses were run with all pumps on, and initial tank levels set to full in order to test the system’s ability to operate under normal conditions. Junction pressures, pipe flows, and overall system functionality were evaluated and discussed in later sections.

| <b>Table 6.</b>                                  |             |                   |
|--|-------------|-------------------|
| <b><u>Simulated Fire Locations and Flows</u></b> |             |                   |
| <b>Fire Location</b>                             | <b>Type</b> | <b>Flow (gpm)</b> |
| Terra Vista Ct.                                  | Residential | 1000              |
| Nursery Way                                      | Residential | 1000              |
| Dows Prairie                                     | Residential | 1000              |
| Ocean Avenue                                     | Residential | 1000              |
| Lone Star Dr.                                    | Residential | 1000              |
| Central Avenue                                   | Commercial  | 2000              |
| Rays Shopping Center                             | Commercial  | 2000              |

- **An extended period simulation (EPS)** was set-up to test MCSD requirements and specifications such as, operational storage vs. total storage criterion, minimum storage criterion, and extenuating circumstance criterion. The EPS was run over one, two and five day periods using ADD, MDD, 4 hours of PHD, and simulated fires. The simulation begins on a generic day at midnight with hydraulic and reporting time steps of one hour The EPS results will show storage adequacy, pumping efficiency, and general system response based on MCSD requirements and specifications.

- **Earthquake Scenario:** Due to the vulnerability of the MCSD's sole source of water, the minimum state regulations for water storage are not enough to satisfy MCSD needs in the event of an emergency or natural disaster. The main transmission line from HBMWD crosses the Mad River. If that line were to break, MCSD does not currently have a redundant water supply to refill tanks until the transmission line was repaired. The "Earthquake Scenario" is a situation in which a natural disaster destroys MCSD's sole transmission line and causes fires within the MCSD service area. MCSD would need enough storage to provide the average person with water as well as fight multiple fires.
- **High Density Build-out Scenario:** With the possibility of future development of high-density housing in the MCSD service area, additional demand will need to be satisfied. The proposed new housing, as per the Humboldt County General Plan, will increase the population served by the MCSD by approximately 1,800 ERUs. Providing the average usage for the service area of 254 gal/ERU increases the ADD by 457,200 gpd (SHN 2011).

High density build-out potential was evaluated by placing additional demand nodes in areas zoned for high density development within the model. The additional 457,200 gpd demand was then added to the new high density nodes, based on parcel size and available ERU's, while the remainder was averaged to all existing demand nodes. Future development potential will be evaluated for each scenario analyzing pressures, flows, storage, pumping and overall system reliability.

## 6.0 Current State

Current State evaluates the system under existing conditions. The current state scenario was evaluated for pressures, flows, fire flow availability, minimum storage, extenuating circumstances and potential for high density development.

### 6.1 Parameters / Controls

The current state scenario evaluates the water distribution system under existing conditions. Average daily demand (ADD) (1.51MG/day), max daily demand (MDD) (3.39MG/day), and peak hour demand (PHD)=(MDD + .21MG/hr) usages were used to evaluate pressures, flows, storage, pumping and overall reliability for both steady state and extended period simulations. The extended period analysis is controlled by a set of rule-based operations which control pump and tank activity over a period of time. Logic controls established for the current state scenario are outlined in (Table 7).

| <b><u>Table 7</u></b>  |  |
|--|--|
| <b><u>Rule-Based Logic Controls for Current State 5 Day EPS</u></b>                                      |  |
| Logical Control: LC1090<br>IF Redwood Hydraulic Grade <= 421.00 ft<br>THEN Cochran Pump Pump Status = On | Logical Control: LC1091<br>IF Redwood Hydraulic Grade >= 423.70 ft<br>THEN Cochran Pump Pump Status = Off  |
| Logical Control: LC1224<br>IF Clock Time = 12:00 AM<br>THEN Ramey Pump Pump Status = On                  | Logical Control: LC1247<br>IF Clock Time = 2:00 AM<br>THEN Ramey Pump Pump Status = Off                    |
| Logical Control: LC1248<br>IF Clock Time = 11:00 AM<br>THEN Ramey Pump Pump Status = On                  | Logical Control: LC1249<br>IF Clock Time = 3:00 PM<br>THEN Ramey Pump Pump Status = Off                    |
| Logical Control: LC1250<br>IF Clock Time > 9:00 PM<br>THEN Ramey Pump Pump Status = On                   | Logical Control: LC1251<br>IF Norton Tank Hydraulic Grade <= 310.00 ft<br>THEN Ramey Pump Pump Status = On |

### 6.2 Steady State Analysis

Peak Hour Demand plus a 2000 gpm fire on Central Avenue induced the greatest stress on the system and yielded one junction with a residual pressure of 20 psi or less. (Table 6) Junction 387 falls on the far north east reach of the system at the end of Mather road which serves approximately ten customer connections. This area is at a high elevation and falls within ten feet of the water tanks base elevation. This area is a known low pressure region and is currently being evaluated for additional storage potential.

Junction 373 lies at the end of Archer Road and is also at a high elevation. This junction services approximately 10 customers and falls only 20 feet below tanks base elevation. Under peak hour demand with a fire event this area had a pressure of 26.3psi. Junction J-6 is located at the end of Baird Road where Pressure Zone 4 begins with a hydro-pneumatic tank and also yielded a pressure of 26.3 psi (Table 8).

Under peak hour demand with a fire event the current system can provide adequate pressure to all service connections except that of Junction 387. This area is at a high elevation and would be better served with additional storage in the northern portion of the system.

| <b><u>Table 8.</u></b>  |                     |                             |                       |                       |                 |
|---|---------------------|-----------------------------|-----------------------|-----------------------|-----------------|
| <b><u>PHD plus 2000 gpm Fire: Junction Pressures Less than 30 psi</u></b> |                     |                             |                       |                       |                 |
| <b>Junction #</b>   | <b>Demand (GPM)</b> | <b>Hydraulic Grade (ft)</b> | <b>Pressure (psi)</b> | <b>Elevation (ft)</b> | <b>Location</b> |
| <b>387</b>  | 0.20                | 299.16                      | 19.3                  | 268.60                | End Mather Rd.  |
| <b>373</b>  | 0.43                | 299.25                      | 26.3                  | 253.00                | End Olivier Rd. |
| <b>J-6</b>  | 0.13                | 299.26                      | 26.3                  | 253.00                | End Blake Rd.   |

Under peak hour demand plus a 2000gpm commercial fire on Central Avenue junction 42, 40, 371, had pressures exceeding 100 psi (Table 9). Junctions located adjacent to pumps and PRV's were removed due to known high pressures and to eliminate potential modeling issues associated with . All three junctions with pressures exceeding 100psi are located at the north east reach of the distribution system along Patrick Creek Drive and Little River Drive and were found to be at low elevations. Each of these junctions were analyzed individually and found to be consistent with district field measurements.

Peak hour demand with the 2000 gpm fire on Central Avenue created the greatest velocities within the system. All pipe recorded a velocity of less than 5 ft/ sec and several pipes indicated no or little flow depending on demand and location within the distribution system. Lateral pipes with low demand had very little flow or velocity, while pipes near tanks, pumps and sources of large demand had a much greater flow and velocity depending pump status.

| <b>Table 9.</b>   |                     |                             |                       |                       |                  |
|---|---------------------|-----------------------------|-----------------------|-----------------------|------------------|
| <b>PHD plus 2000 gpm Fire: Junction Pressures Greater than 100 psi.</b> |                     |                             |                       |                       |                  |
| <b>Junction #</b>   | <b>Demand (GPM)</b> | <b>Hydraulic Grade (ft)</b> | <b>Pressure (psi)</b> | <b>Elevation (ft)</b> | <b>Location</b>  |
| <b>42</b>   | 0.58                | 309.17                      | 125.4                 | 19.40                 | Little River Dr. |
| <b>40</b>   | 0.40                | 309.17                      | 122.6                 | 25.90                 | Little River Dr. |
| <b>371</b>  | 0.40                | 309.17                      | 122.0                 | 27.30                 | Little River Dr. |

### 6.3 Fire Flow

Fire flow analyses were performed for both ADD and MDD on model nodes which represent system hydrants. MCSO’s fire hydrant GIS layer was overlaid onto the model to select junctions close to actual hydrant locations. Small diameter mains, dead end nodes and nodes adjacent to tanks and mains which do not serve a hydrant were removed from the fire flow analysis. The hydraulic model was compiled with a minimum flow of 1000 gpm a maximum flow of 2000 gpm, and a minimum residual of 20 psi. (California Fire Code Title 24, Part 9 Appendix B, Section 105.1).

Under MDD, 134 model junctions were tested for fire flow availability. Of the 134 junctions tested, 9 failed to supply the required fire flow (Table 10/Map 3). Junctions 30, 31, 35 and 43 are in the Dows Prairie area of the distribution system where elevations are high with large diameter mains and known low flow rates. The fire flow available for this region is half of the required 1000 gpm.

Junctions 142, 334, and 382 all fall within the McCluski Hill low-pressure zone and did not meet the required minimum flow of 1000 gpm. These junctions fall at higher elevations and are served by the two redwood tanks.

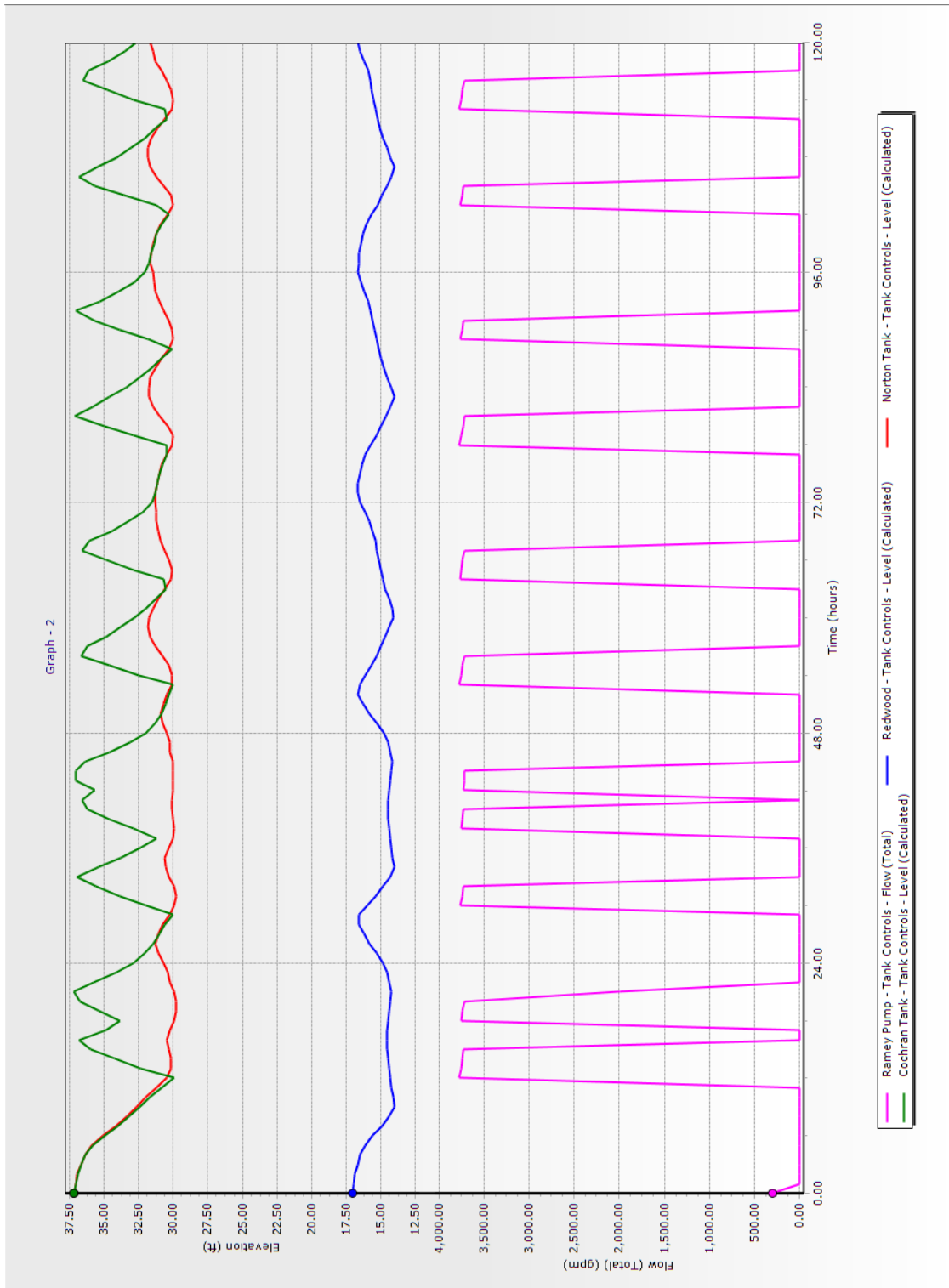
Under maximum daily demand the current system cannot supply the required 1000 gpm fire flow to the high elevation portions of the system. These areas of the system are older and when developed may have been in compliance with the fire protection levels at that time.

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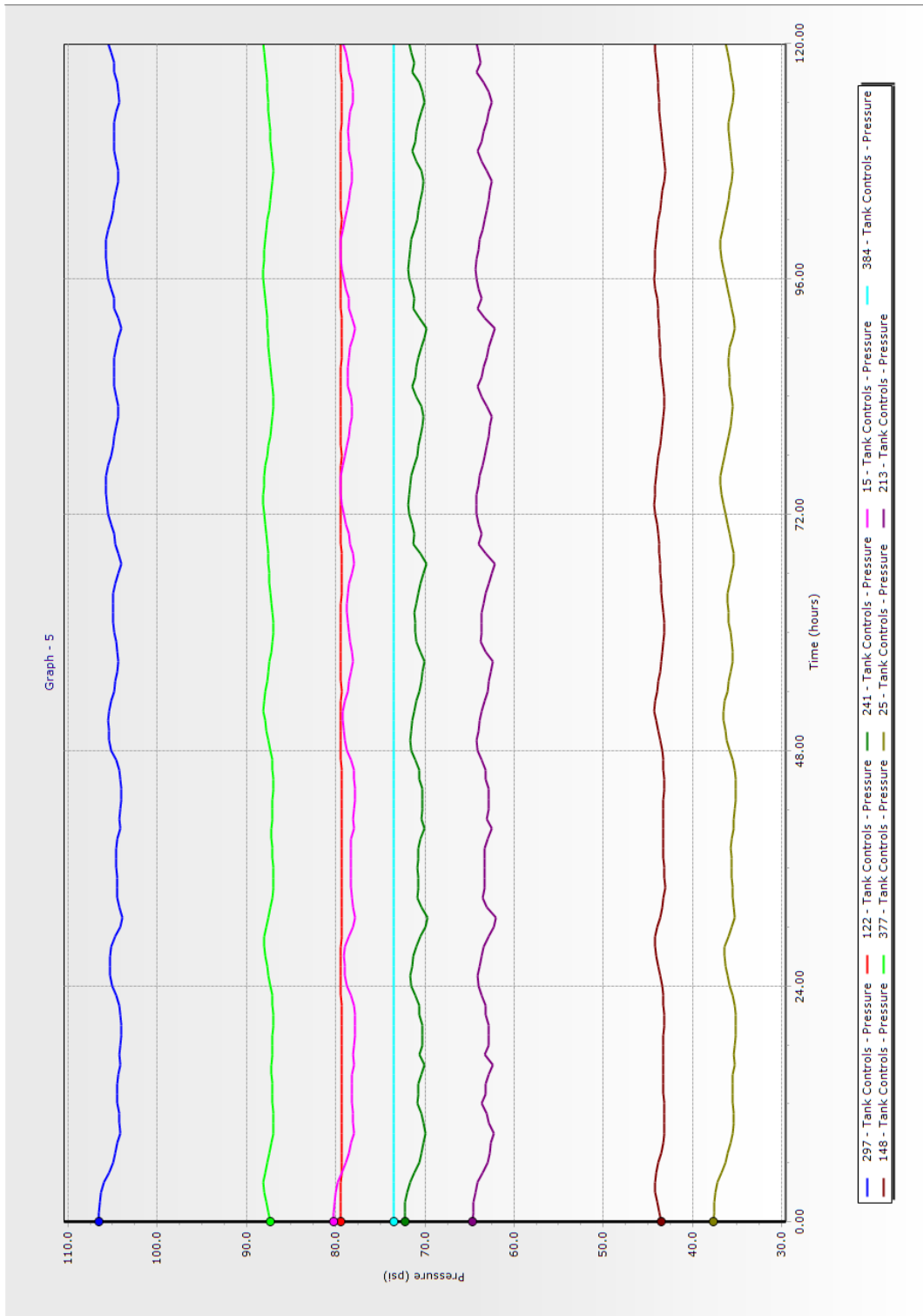
| <b>Junction #</b> | <b>Flow Available</b> | <b>Residual Pressure</b> | <b>Satisfies Fire Flow</b> | <b>Location</b>                |
|-------------------|-----------------------|--------------------------|----------------------------|--------------------------------|
| <b>44</b>         | 825.86                | 53.9                     | False                      | Central / Kjer Rd.             |
| <b>334</b>        | 808.94                | 20.0                     | False                      | Terra Vist Ct.                 |
| <b>382</b>        | 699.05                | 58.3                     | False                      | End of Huntz Rd.               |
| <b>142</b>        | 699.05                | 32.7                     | False                      | Clay Rd / Leona Dr.            |
| <b>35</b>         | 570.31                | 24.3                     | False                      | Dows Prairie / Woody Rd.       |
| <b>43</b>         | 570.30                | 32.2                     | False                      | Dows Prairie / Clam Beach Rd.  |
| <b>30</b>         | 563.58                | 21.8                     | False                      | Dows Prairie / Baird           |
| <b>31</b>         | 522.75                | 20.0                     | False                      | Baird Rd. / Chaffin Rd.        |
| <b>387</b>        | 500.21                | 13.2                     | False                      | End of Mather Rd. (High Elev.) |

#### **6.4 Extended Period Simulation (EPS)**

A five day average daily demand Extended Period Simulation (EPS) was run under the current state to evaluate how the system reacts over time. System responses to pumping and storage conditions under average daily demand are shown in Figure 3. The figure shows tank elevations in relation to pumping schedules and corresponding pressures at 9 nodes (Figure 4) throughout the distribution system. The higher pressures are found in low elevation areas and just before PRV stations. The low pressure nodes are located within the Dows Prairie area where the system is known to have low pressure. Pressure drops directly correspond with lowering elevations in the Water Tanks.



**Figure 3.** 5 day EPS ADD tank elevations matched with pump speed and flow.



**Figure 4.** 5 day EPS ADD corresponding node pressures with tank levels and pumping schedule..

**6.5 Minimum Tank Level Criterion (EPS)**

The hydraulic model was set up to test minimum operating tank levels. The operational/minimum storage criterion states that a minimum tank level must be maintained to account for fire flows and/or a minimum pressure of 20 psi in the MCSD system. According to MCSD operators, the minimum tank level is approximately 20 feet in each tank.

Three scenarios were created under average daily demands to test minimum storage levels in relation to system pressures (20 ft tank level, 10 ft tank level and 5 ft tank level). Under each scenario pressures were evaluated to determine minimum operating tank levels and potential damage or weak spots within the system when tanks levels fall below 20ft (Tables 11-13).

If necessary the district can operate at a minimum tank level of five feet without creating negative pressures within the system. At five foot tank levels five nodes yielded pressures below 20 psi (Table 13). Each of these nodes were located in the northeast reach of the system and can be isolated by valving in the event of an emergency.

| <b><u>Table 11.</u></b>   |                     |                             |                       |                   |
|---|---------------------|-----------------------------|-----------------------|-------------------|
| <b><u>20ft Tank Level Junction Pressures Less than 20 psi</u></b> |                     |                             |                       |                   |
| <b>Junction #</b>   | <b>Demand (GPM)</b> | <b>Hydraulic Grade (ft)</b> | <b>Pressure (psi)</b> | <b>Location</b>   |
| <b>149</b>  | 0.86                | 416.00                      | 7.1                   | Redwood Tank Area |
| <b>387</b>  | 0.21                | 299.94                      | 13.6                  | End Mather Rd.    |

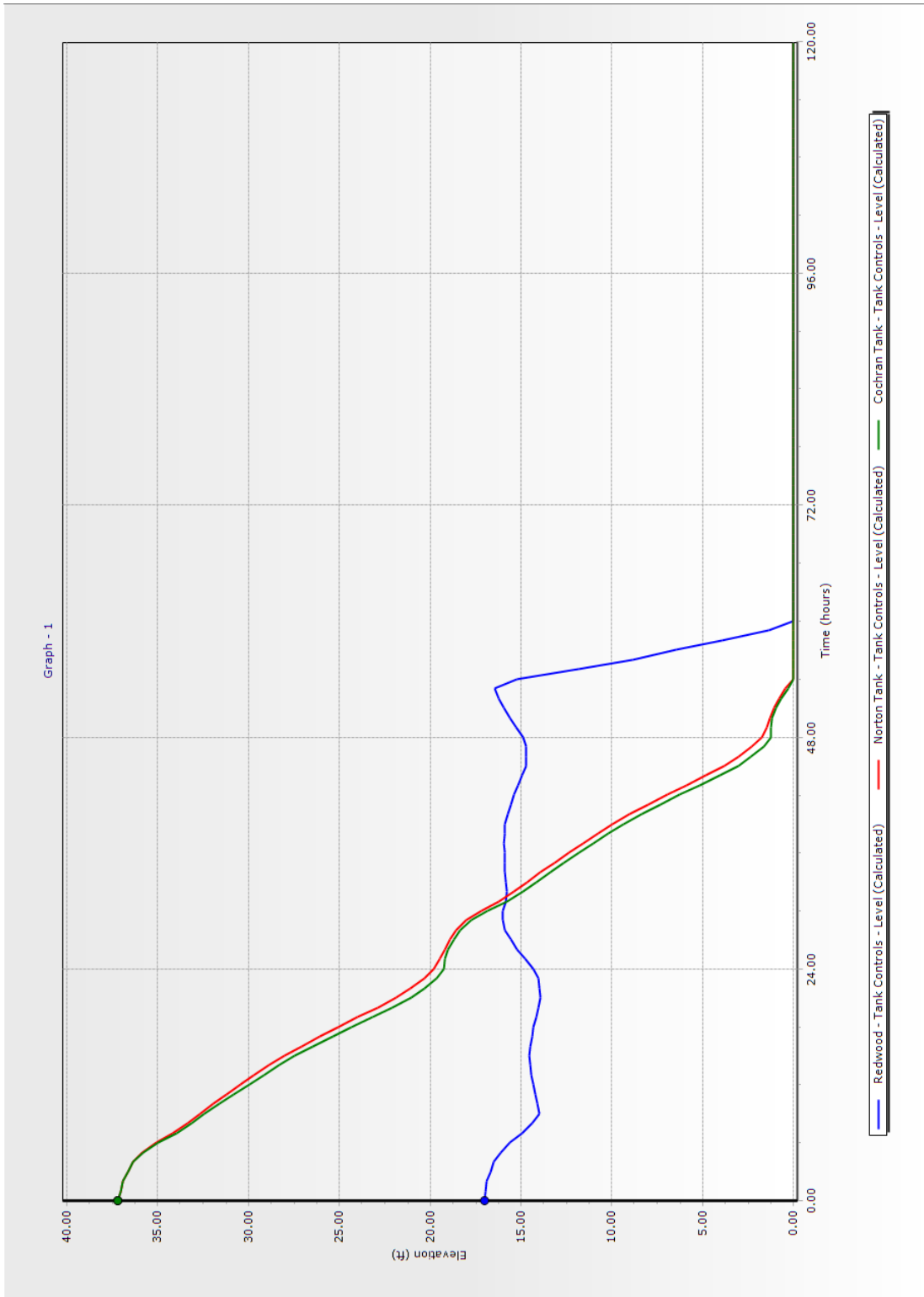
| <b><u>Table 12.</u></b>   |                     |                             |                       |                   |
|---|---------------------|-----------------------------|-----------------------|-------------------|
| <b><u>10ft Tank Level Junction Pressures Less than 20 psi</u></b> |                     |                             |                       |                   |
| <b>Junction #</b>   | <b>Demand (GPM)</b> | <b>Hydraulic Grade (ft)</b> | <b>Pressure (psi)</b> | <b>Location</b>   |
| <b>149</b>  | 0.86                | 411.00                      | 4.0                   | Redwood Tank Area |
| <b>387</b>  | 0.21                | 289.94                      | 9.2                   | End Mather Rd.    |
| <b>373</b>  | 0.44                | 289.98                      | 16.0                  | End Olivier Rd.   |
| <b>J-6</b>  | 0.14                | 289.98                      | 16.0                  | End Baird Rd.     |
| <b>154</b>  | 1.43                | 289.99                      | 19.5                  | Near Cochran Tank |

**Table 13.**  
**5ft Tank Level Junction Pressures Less than 20 psi**

| <b>Junction #</b> | <b>Demand (GPM)</b> | <b>Hydraulic Grade (ft)</b> | <b>Pressure (psi)</b> | <b>Location</b>   |
|-------------------|---------------------|-----------------------------|-----------------------|-------------------|
| <b>149</b>        | 0.86                | 409.00                      | 4.5                   | Redwood Tank Area |
| <b>387</b>        | 0.21                | 284.94                      | 7.1                   | End Mather Rd.    |
| <b>373</b>        | 0.44                | 284.98                      | 13.8                  | End Olivier Rd.   |
| <b>J-6</b>        | 0.14                | 284.98                      | 13.8                  | End Baird Rd.     |
| <b>154</b>        | 1.43                | 284.99                      | 17.4                  | Near Cochran Tank |

**6.6 Minimum Storage Criterion (EPS)**

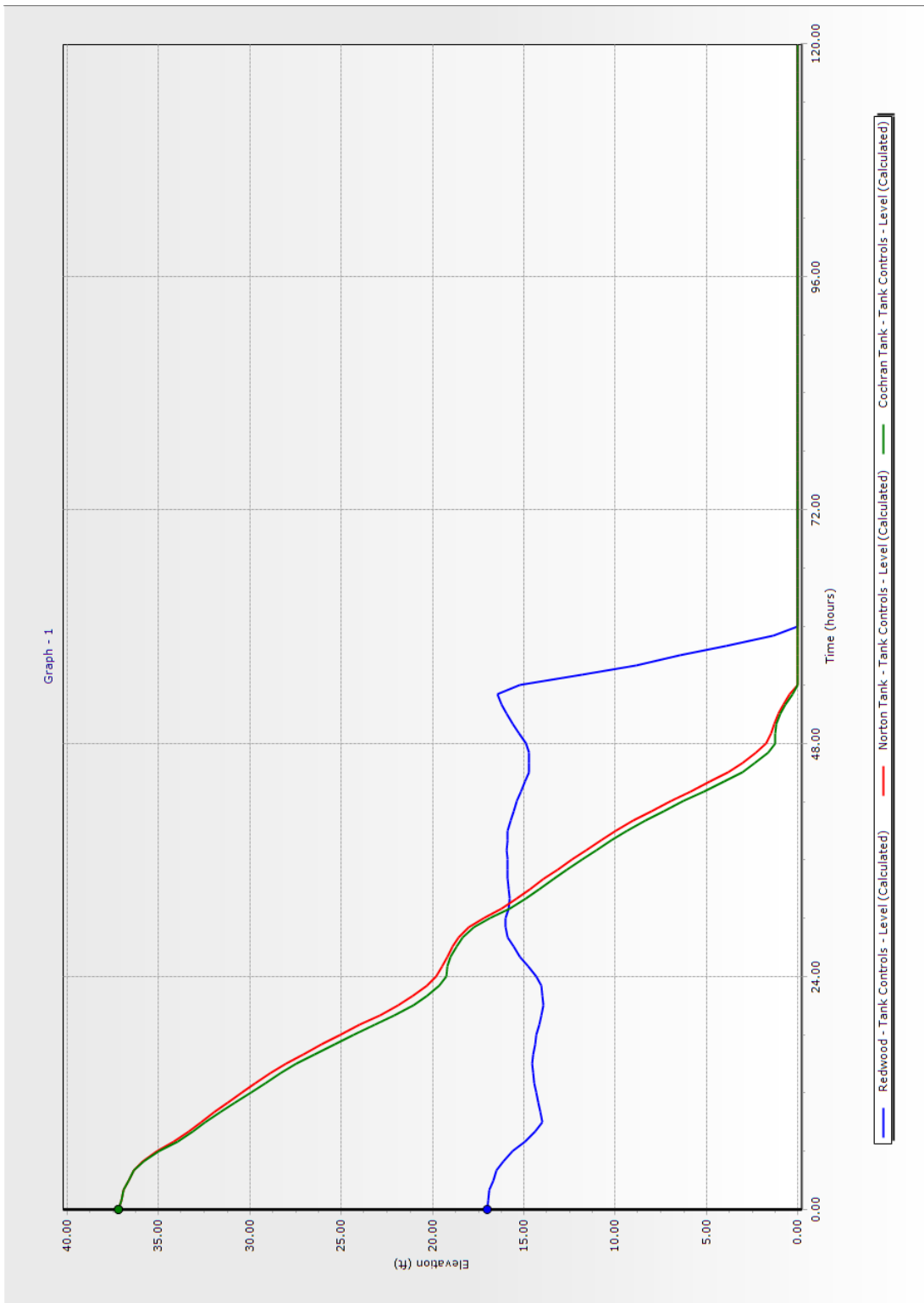
This criterion states that the MCSO water distribution system must have enough storage to sustain 5 days of ADD and fire flows. In order to evaluate five days of storage criterion the main transmission line from HBMWD was set to closed to simulate a broken line, tank levels were set to full, pumps, which fill the tanks from HBMWD were turned off to analyze water from storage only, and a 4 hour commercial fire was placed along Central Avenue. According to the hydraulic model under ADD from storage only there is approximately 40hours (1.75days) of water available for the entire distribution system(Figure 5). The current storage does not satisfy the required criterion for minimum storage set forth by MCSO staff.



**Figure 5.** Five Day EPS ADD tanks full no pumps w/ 4hr commercial fire on day 2 at 9am. (Minimum Storage Requirement)

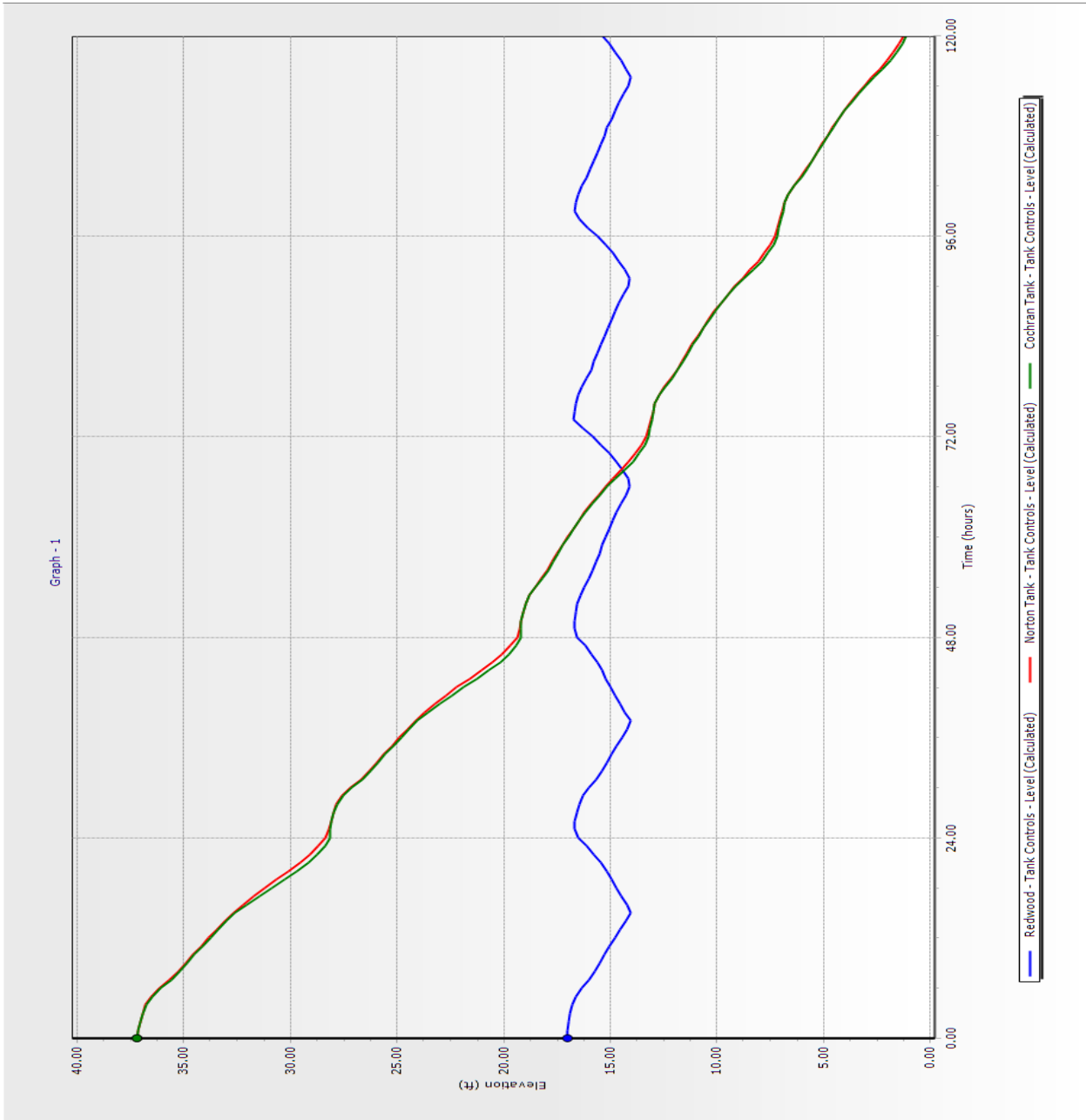
### **6.7 Extenuating Circumstance (Earthquake Scenario)**

Due to the vulnerability of the MCSD's sole source of water, the minimum state regulations for water storage are not enough to satisfy MCSD needs in the event of an emergency or natural disaster. The main transmission line from HBMWD crosses the Mad River. If that line were to break, MCSD does not currently have a redundant water supply to refill tanks until the transmission line was repaired. The "Earthquake Scenario" is a situation in which a natural disaster destroys the main transmission line and also causes fire within the MCSD service area. MCSD would need enough storage to provide the average person with water as well as fight multiple fires (Figure 6).



**Figure 6.** Five Day EPS ADD tanks full no pumps w/ 4hr commercial fire on day 2 at 9am. (Earthquake Scenario No Water Rationing)

Under ADD (no rationing) with one commercial fire the “Earthquake Scenario” shows approximately 44 hours (<2 days) of water available for the entire distribution system. This scenario does not account for water rationing and includes one 4 hour 2000 gpm commercial fire along Central Avenue.



**Figure 7.** Five Day EPS ADD tanks full no pumps w/ 4hr commercial fire on day 2 at 9am. (Earthquake Scenario ½ Reduction in Consumption).

Under ADD with water rationing (evaluated by reducing demand ½ at the start of the analysis) the “Earthquake Scenario” shows approximately 120 hours (5 days) of water available for the entire distribution system. This scenario accounts for ½ reduction in demand and includes one 4 hour 2000 gpm commercial fire along Central Avenue and one 4 hour 1000 gpm residential fire along Chanterelle Dr (Figure 7).

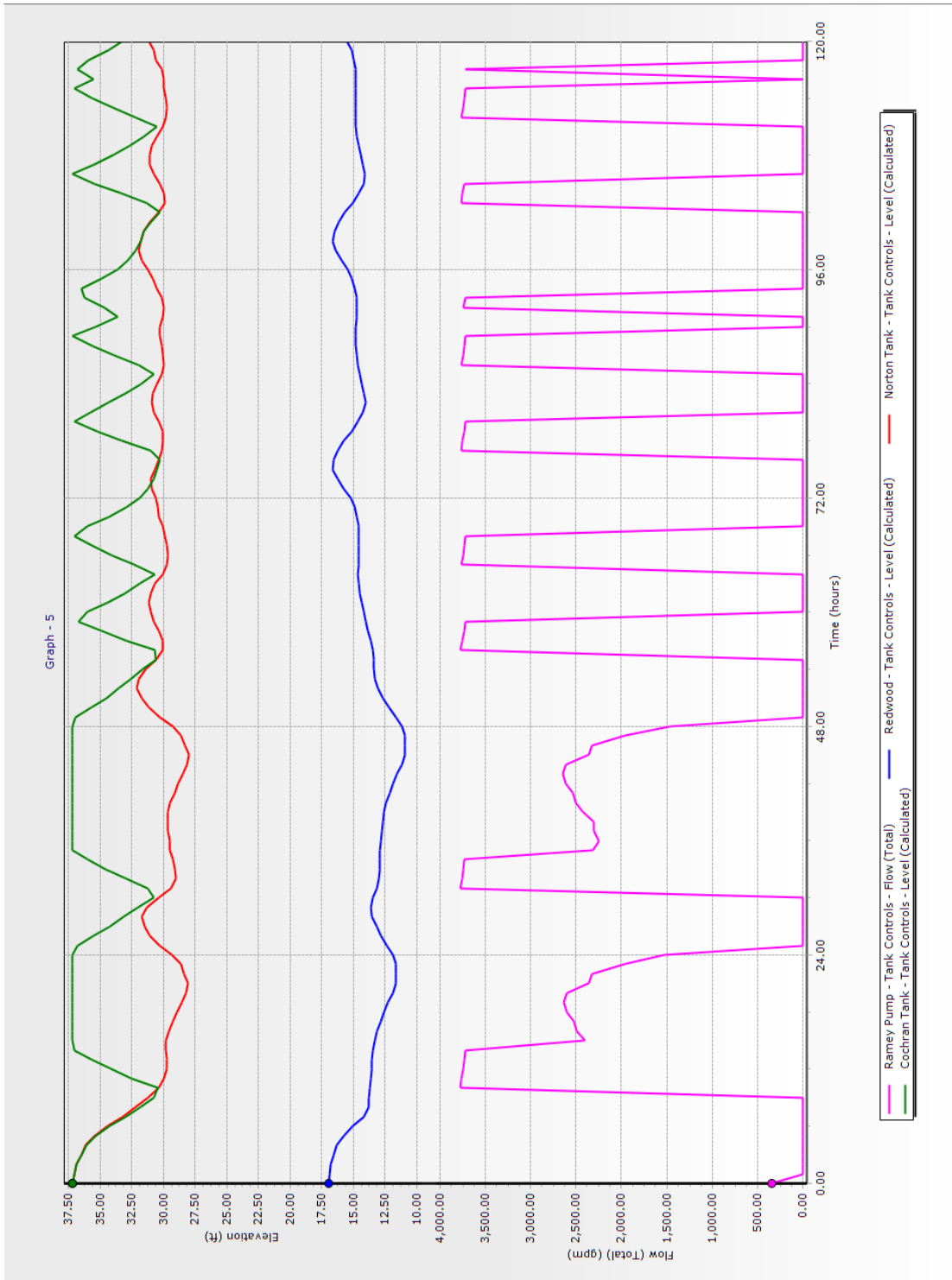
## **6.8 High Density Build-out Potential**

The potential for high density development was evaluated by placing additional demand nodes in undeveloped areas or areas available for future development within the McKinleyville service area. The additional projected usage of 457,200 gpd, as per the Humboldt County General Plan, was added to the additional and existing demand nodes.

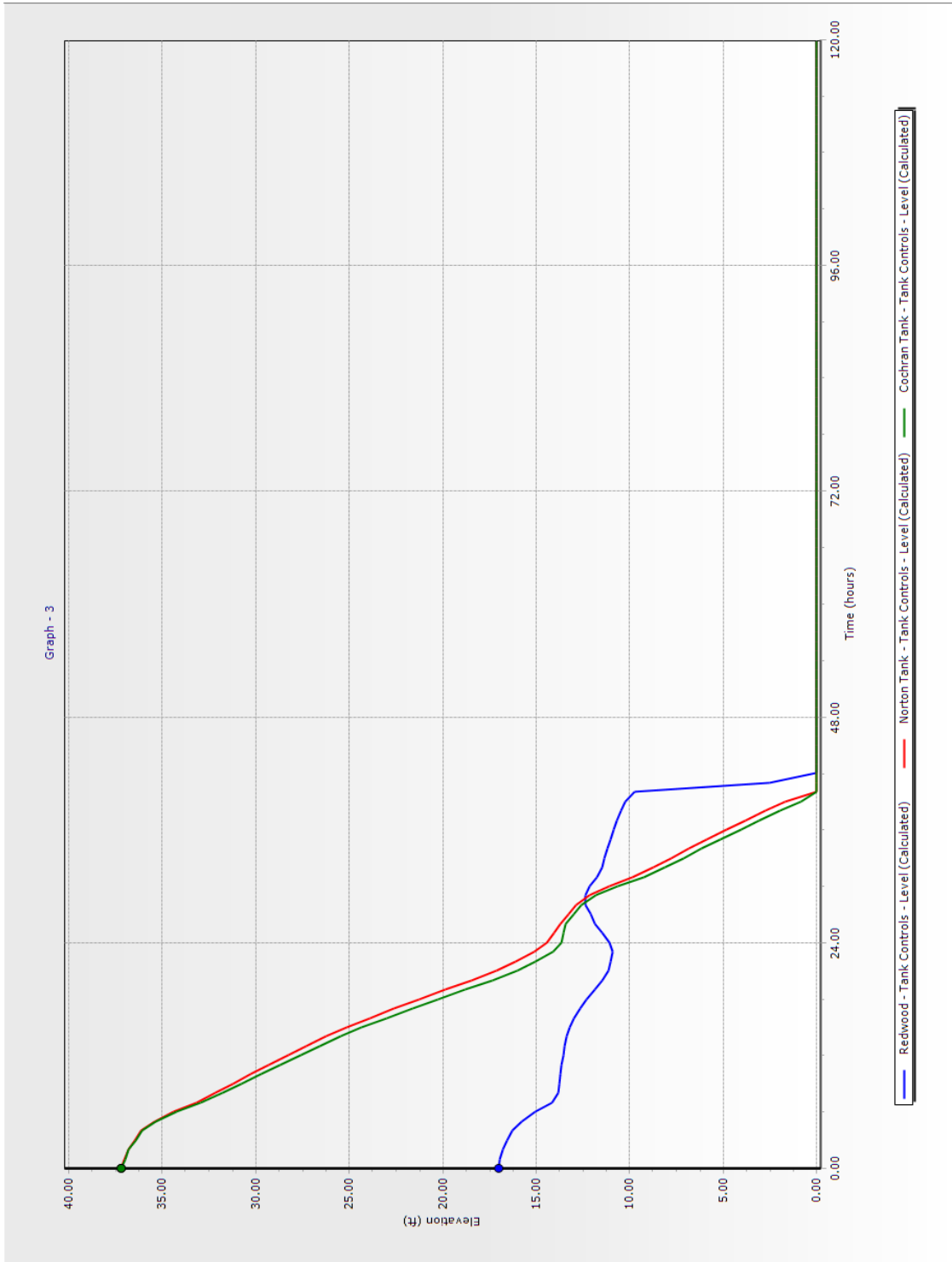
Under average daily demand plus the 457,200 gpd projected increase, no junction pressures fell below 20 psi and all pipe velocities were below 5ft/sec.

With the additional 457,200 gpd demand added to the current system there is not enough water available to satisfy the minimum storage criterion and the extenuating circumstance criterion. In addition, the projected demand increases pump frequency indicating a lack of storage (Figure 8).

With the additional 457,200 gpd added to the current state average daily demand the distribution system does not have the required 5 days of storage available. Under the current state high density build out scenario the system has approximately 1.5 days of water available from storage (Figure 9).



**Figure 8. 5 Day EPS ADD Current State (High Density Build-Out) tank levels, pumping schedule.**



**Figure 9.** 5 Day EPS ADD Current State (High Density Build-Out) minimum storage requirement.

## 7.0 New 4.5 MG Water Tank Scenario (Cochran Location)

To evaluate how the water system will respond to new growth a hypothetical 4.5 MG water tank was added to the model to test system responses to flows and pressures, pumping schedules and overall efficiency. The hypothetical 4.5 MG tank was placed just east of the existing Cochran Road tanks. The new circular tank has a base elevation of 280 ft and is 40 ft in height. This tank will be filled by Ramey pump station with an operating range of 20 ft – 37.2 ft. (Map 4)

### 7.1 Parameters / Controls

Average daily demand ADD (1.51 MG/day) and max daily demand MDD (3.39 MG/day) usages were used to evaluate pressures, flows, storage, pumping and overall reliability for both steady state and extended period simulations. The extended period analysis is controlled by a set of rule-based operations which control pump and tank activity over a period of time. The water model had a difficult time referencing Norton, Cochran and the new tank from one pump therefore a hybrid set of pump controls were created using both time steps and tank levels controlling Ramey pumps. Tank and pump controls for the new tank scenarios are outlined in (Table 14).

| <b>Table 14.</b>  |   |
|---|---|
| <b><u>Rule-Based Logic Controls For New 4.5 MG Tank Scenario 5 day EPS</u></b>  |   |
| Logical Control: LC1090<br>IF Redwood Hydraulic Grade <= 421.00 ft<br>THEN Cochran Pump Pump Status = On  | Logical Control: LC1091<br>IF Redwood Hydraulic Grade >= 423.70 ft<br>THEN Cochran Pump Pump Status = Off   |
| Logical Control: LC1224<br>IF Clock Time = 12:00 AM<br>THEN Ramey Pump Pump Status = On   | Logical Control: LC1247<br>IF Clock Time = 2:00 AM<br>THEN Ramey Pump Pump Status = Off   |
| Logical Control: LC1250<br>IF Clock Time > 9:00 PM<br>THEN Ramey Pump Pump Status = On  | Logical Control: LC1251<br>IF Norton Tank Hydraulic Grade <= 310.00 ft<br>THEN Ramey Pump Pump Status = On  |
| Logical Control: LC1262<br>IF New Tank Hydraulic Grade <= 310.00 ft Or<br>Cochran Tank Hydraulic Grade <= 310.00 ft<br>THEN Ramey Pump Pump Status = On | Logical Control: LC1263<br>IF New Tank Hydraulic Grade >= 317.20 ft<br>And Cochran Tank Hydraulic Grade >= 317.20<br>ft THEN Ramey Pump Pump Status = Off |

## **7.2 Steady State**

The additional 4.5 MG water tank scenario was examined under max daily demand plus a 2000 gpm fire on Central Avenue. Under MDD with the 2000 gpm fire on Central Ave. all junction pressures were above 20 psi and all flow velocities were below 5ft/sec. Junctions 42, 40, 371, had pressures exceeding 100 psi. All three junctions with pressures exceeding 100psi are located at the north east reach of the distribution system along Patrick Creek Drive and Little River Drive and were found to be at low elevations. Each of these junctions were analyzed individually and were found to be consistent with district field measurements.

## **7.3 Fire Flow**

Fire flow analyses were performed for both average daily demand and max daily demand on model nodes which represent system hydrants. MCSD's fire hydrant GIS layer was overlaid onto the model to select junctions close to actual hydrant locations. Small diameter mains, dead end nodes and nodes adjacent to tanks and mains which do not serve a hydrant were removed from the fire flow analysis. The hydraulic model was compiled with a minimum flow of 1000 gpm a maximum flow of 2000 gpm, and a minimum residual of 20 psi. Typical fire flow standards require 1000 gpm available for residential areas and 2000 gpm for commercial. Pumps were set to on and tank levels were set to normal operating levels.

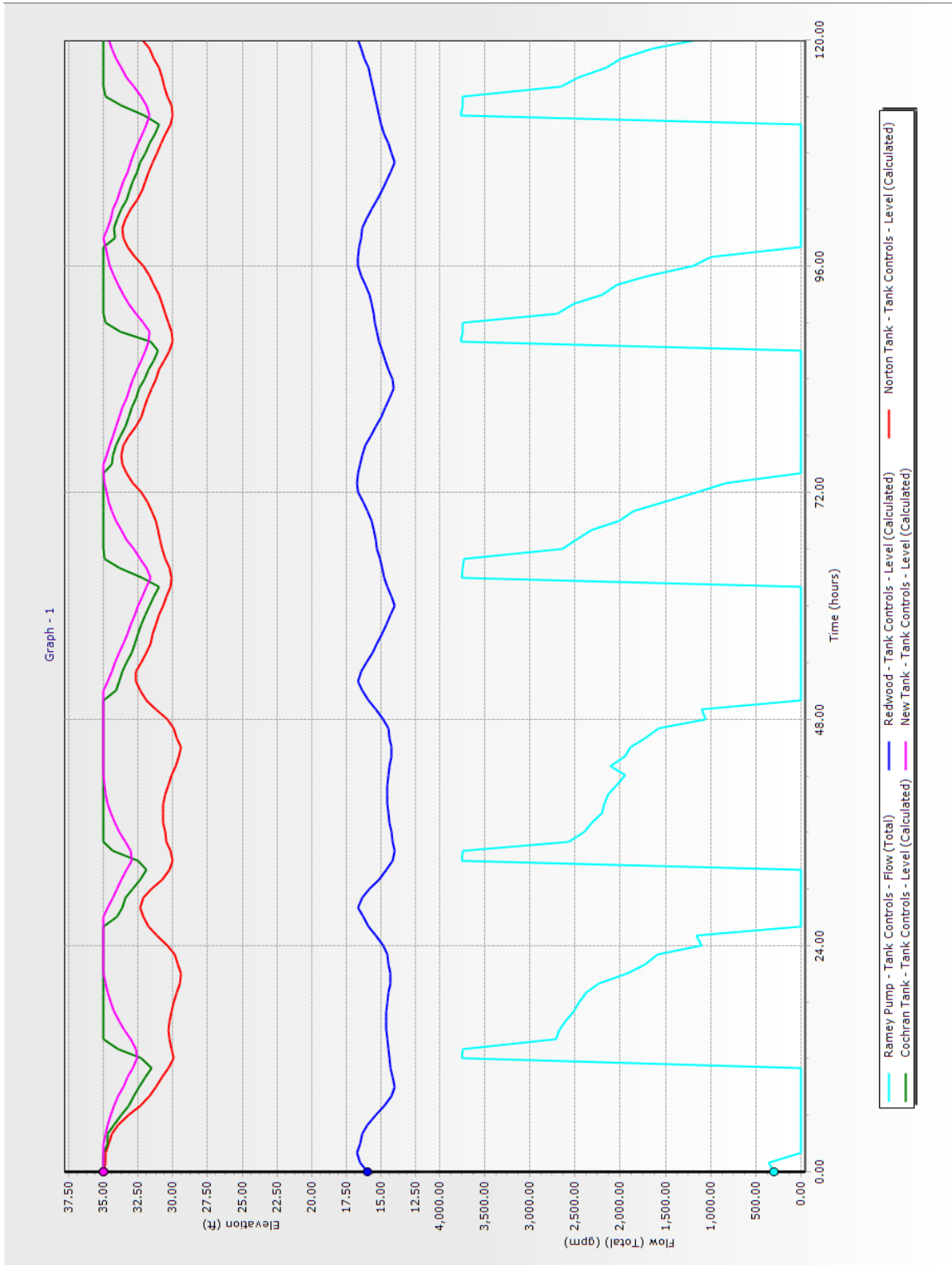
Under MDD 134 model junctions were tested for fire flow availability. Of the 134 junctions tested 7 failed to supply the required fire flow (Table 15). Junctions 30, 31, 35 and 43 are on the north eastern reach of the distribution system where elevations are high with large diameter mains and known low flow rates. This area of the system is older and when developed may have been in compliance with the fire protection levels at that time. Junctions 142, 334, and 382 all fall within the upper low-pressure zone and were expected to have lower flow. It is recommended that these junctions be field tested to ensure adequate fire flow is available.

The new 4.5 MG water tank improves both fire flow and residual pressures in the north eastern high elevation portions of the system but still does not provide the required minimum flow of 1000 gpm to all junctions.

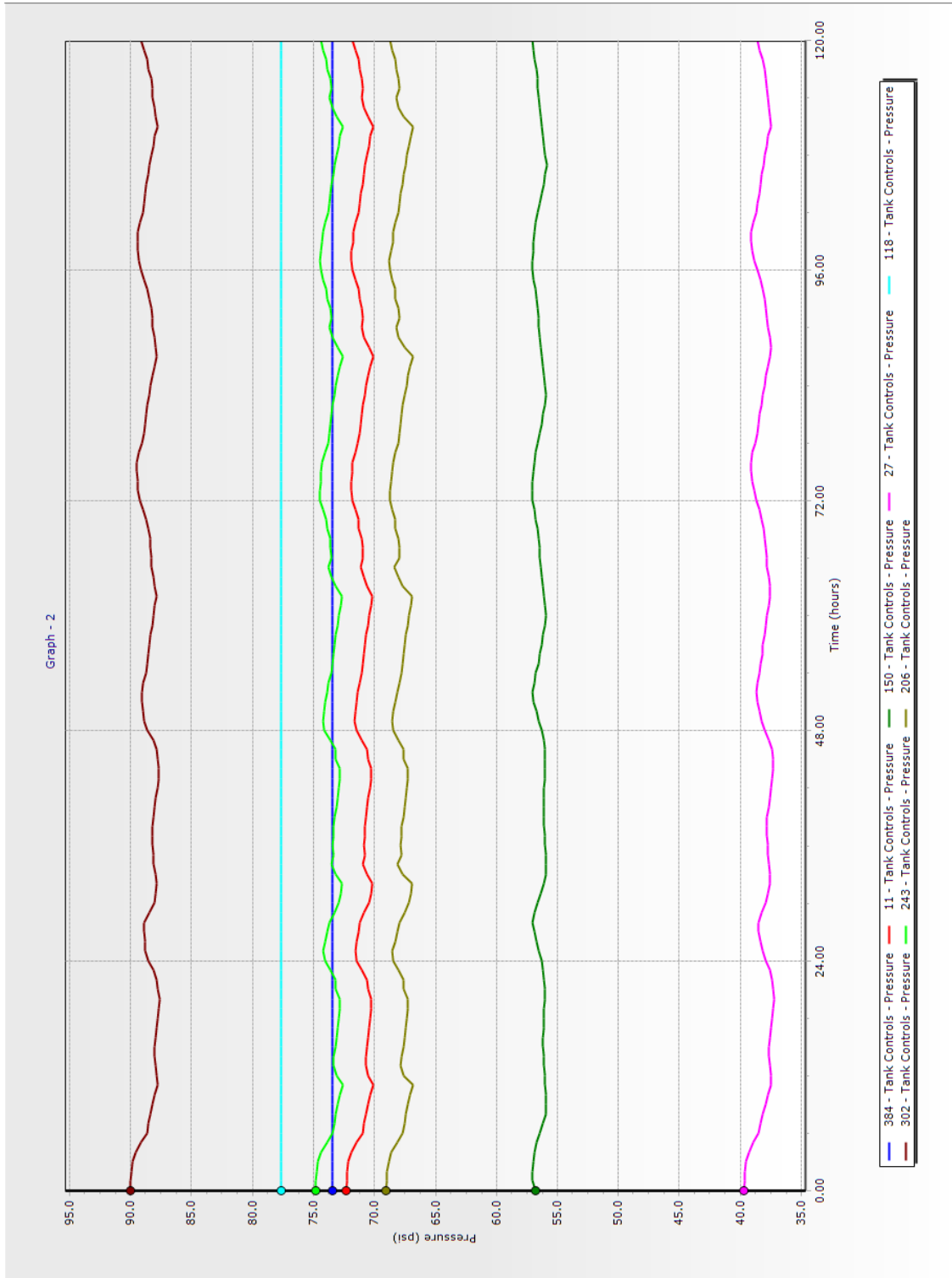
| <b>Junction #</b> | <b>Flow Available</b> | <b>Residual Pressure</b> | <b>Satisfies Fire Flow</b> | <b>Location</b>               |
|-------------------|-----------------------|--------------------------|----------------------------|-------------------------------|
| <b>44</b>         | 957.31                | 53.9                     | False                      | Central / Kjer Rd.            |
| <b>382</b>        | 924.54                | 45.1                     | False                      | End of Huntz Rd.              |
| <b>142</b>        | 924.54                | 31.0                     | False                      | Clay Rd / Leona Dr.           |
| <b>35</b>         | 659.63                | 24.1                     | False                      | Dows Prairie / Woody Rd.      |
| <b>43</b>         | 659.63                | 32.2                     | False                      | Dows Prairie / Clam Beach Rd. |
| <b>30</b>         | 651.44                | 21.8                     | False                      | Dows Prairie / Baird          |
| <b>31</b>         | 604.32                | 20.0                     | False                      | Baird Rd. / Chaffin Rd.       |

#### **7.4 Extended Period Simulation (EPS)**

System responses to the new tank scenario Under Average Daily Demand over a five day period are shown in (Figure 10). The figure shows tank elevations in relation to pumping schedules and corresponding pressures at 8 nodes (Figure 11) throughout the distribution system. With the new water tank Ramey pumps are expected to run less frequent for a longer period of time. Expected pumping times and flows are shown in (Figure 10).



**Figure 10.** 5 day EPS ADD 4.5 MG Tank Scenario tank elevations matched with pump speed and flow.

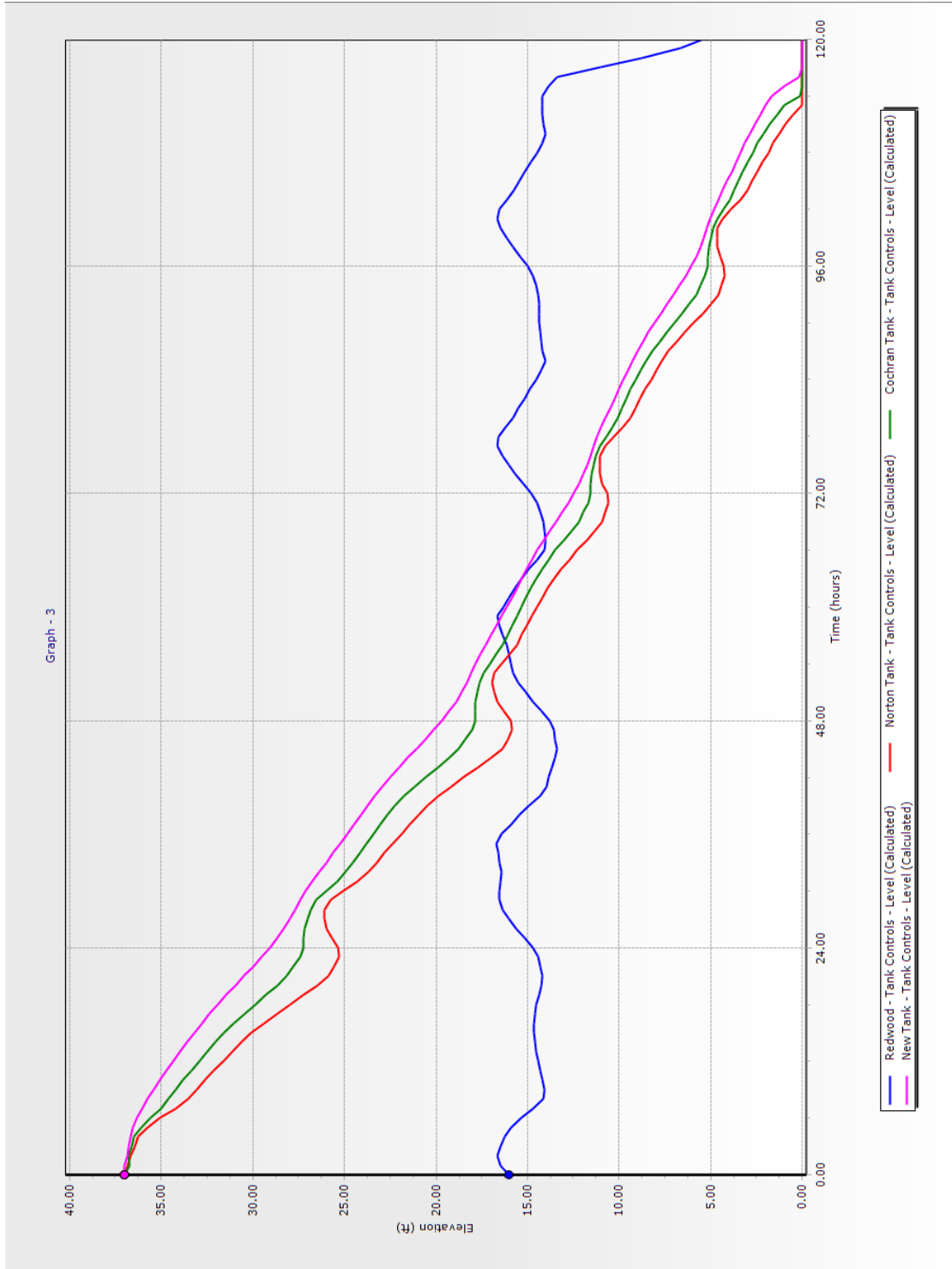


**Figure 11.** 5 day EPS ADD 4.5 MG Tank Scenario corresponding node pressures with tank levels and pumping schedule.

## **7.5 4.5 MG Tank Minimum Storage Criterion**

This criterion states that the MCSO water distribution system must have enough storage to sustain 5 days of ADD and fire flows. In order to simulate five days of storage the main transmission line from HBMWD was closed, tank levels were set to full, pumps were turned off and a 4 hour commercial fire was placed along Central Avenue during day two.

The addition of a 4.5 MG water tank at the Cochran tank site does not satisfy the minimum storage criterion set forth by MCSO. The new tank would provide approximately 4 days of water from storage only (Figure 12).

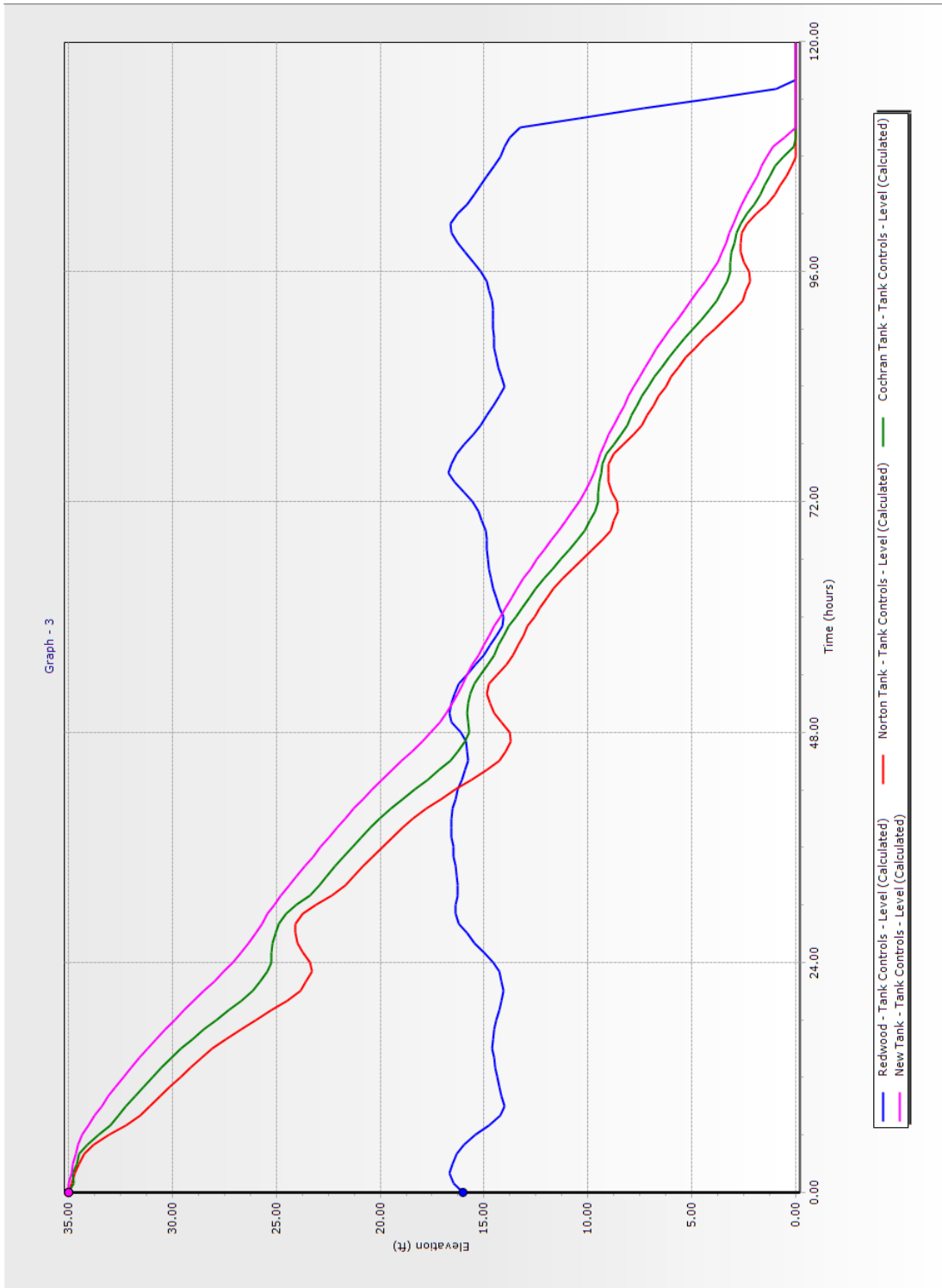


**Figure 12.** 5 Day EPS ADD 4.5 MG Tank Scenario water available from storage only. (Minimum Storage Criteria)

## **7.6 4.5 MG Tank Extenuating Circumstance (Earthquake Scenario)**

The “Earthquake Scenario” is a situation in which a natural disaster destroys the main transmission line and also causes fire within the MCSD service area. MCSD would need enough storage to provide the average person with water as well as fight multiple fires.

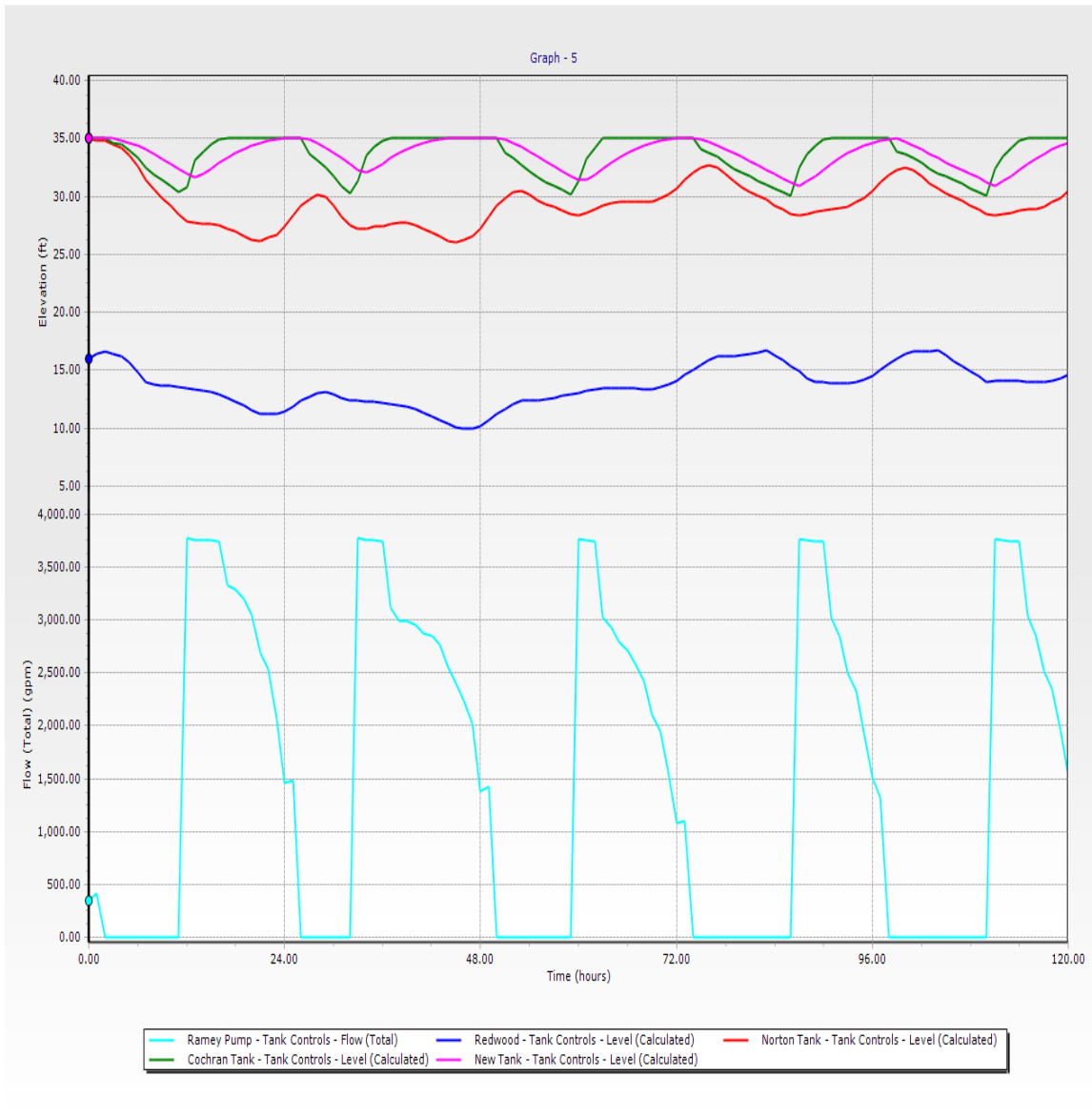
With the new 4.5 MG water tank under ADD and the earthquake scenario the system would have approximately 4 day of water (Figure 13).



**Figure 13.** 5 Day EPS ADD 4.5 MG Tank Scenario, water available from storage only (Earthquake Scenario).

### 7.7 High Density Build-out Potential

High Density build-out potential was evaluated by placing additional demand nodes in undeveloped areas or areas available for future development within the McKinleyville service area. The additional projected usage of 457,200 gpd, as per the Humboldt County General Plan, demand was then added to the additional and existing demand nodes.

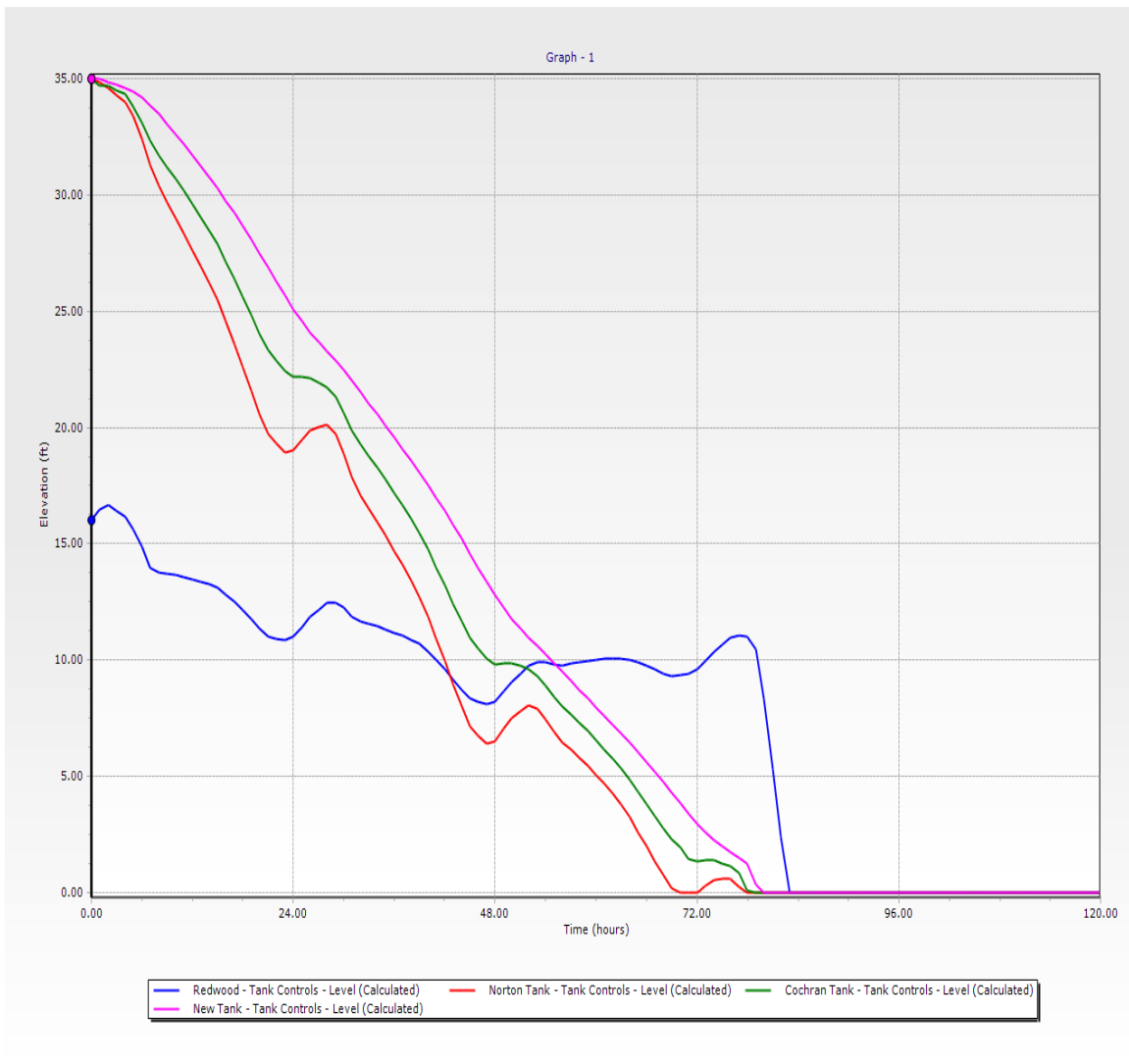


**Figure 14.** 4.5 MG Tank Build-out Potential 5 day EPS ADD tank levels and pump schedule.

Under average daily demand plus the 457,200 gpd projected increase, no junction pressures fell below 20psi and all pipe velocities were below 5ft/sec.

With the additional 457,200 gpd demand added to the 4.5 MG scenario the distribution system has approximately 2.75 days of water available (Figure 15)

With the additional 457,200 gpd demand added to the 4.5MG scenario there is not enough water available to satisfy neither the minimum storage criterion nor the extenuating circumstance criterion.



**Figure 15. 5 day EPS ADD 4.5 MG Water Tank Build-out Scenario (Minimum Storage Requirement).**

## 8.0 Additional 2.5 MG water tank added at the end of Mather Rd

This scenario will test the system’s ability to satisfy fire flow and low pressures in the northern high elevation areas of the system with the addition of 2.5 MG of storage. The hypothetical 2.5 MG tank was placed at the end of Mather Road and is in addition to the 4.5 MG previously analyzed. The new circular tank has a base elevation of 280ft and is 40ft in height. This tank will be filled by Ramey pump station with an operating range of 20ft – 37.2ft. (Map 5)

### 8.1 Parameters / Controls

Average daily demand ADD (1.51 MG/day) and max daily demand MDD (3.39 MG/day) usages were used to evaluate pressures, flows, storage, pumping and overall reliability for both steady state and extended period simulations. The extended period analysis is controlled by a set of rule-based operations which control pump and tank activity over a period of time. The water model had a difficult time referencing Norton, Cochran and the new tank from one pump therefore a hybrid set of pump controls were created using both time steps and tank levels controlling Ramey pumps. Tank and pump controls for the new tank scenarios are outlined in (Table 16).

| <b>Table 16.</b>  |   |
|---|---|
| <b><u>Rule-Based Logic Controls For New 2.5 MG Tank Scenario 5 day EPS</u></b>  |   |
| Logical Control: LC1090<br>IF Redwood Hydraulic Grade <= 421.00 ft<br>THEN Cochran Pump Pump Status = On  | Logical Control: LC1091<br>IF Redwood Hydraulic Grade >= 423.70 ft<br>THEN Cochran Pump Pump Status = Off   |
| Logical Control: LC1224<br>IF Clock Time = 12:00 AM<br>THEN Ramey Pump Pump Status = On   | Logical Control: LC1247<br>IF Clock Time = 2:00 AM<br>THEN Ramey Pump Pump Status = Off   |
| Logical Control: LC1250<br>IF Clock Time > 9:00 PM<br>THEN Ramey Pump Pump Status = On  | Logical Control: LC1251<br>IF Norton Tank Hydraulic Grade <= 310.00 ft<br>THEN Ramey Pump Pump Status = On  |
| Logical Control: LC1262<br>IF New Tank Hydraulic Grade <= 310.00 ft Or<br>Cochran Tank Hydraulic Grade <= 310.00 ft<br>THEN Ramey Pump Pump Status = On | Logical Control: LC1263<br>IF New Tank Hydraulic Grade >= 317.20 ft<br>And Cochran Tank Hydraulic Grade >= 317.20<br>ft THEN Ramey Pump Pump Status = Off |
| IF Mather tank Hydraulic Grade <= 310.00 ft<br>THEN Ramey Pump Pump Status = On   | IF Mather tank Hydraulic Grade >= 317.20 ft<br>THEN Ramey Pump Pump Status = Off  |

## 8.2 Steady State

For steady state analyses the additional 2.5 MG water tank scenario was examined under max daily demand plus a 2000 gpm fire on Central Avenue. Under MDD with the 2000 gpm fire on Central Avenue all junction pressures were above 20 psi and all flow velocities were below 5ft/sec. Junction 42, 40, 371, had pressures exceeding 100 psi. All three junctions with pressures exceeding 100 psi are located at the north east reach of the distribution system along Patrick Creek Dr. and Little River Dr. and were found to be at low elevations. Each of these junctions were analyzed and found to be consistent with district field measurements.

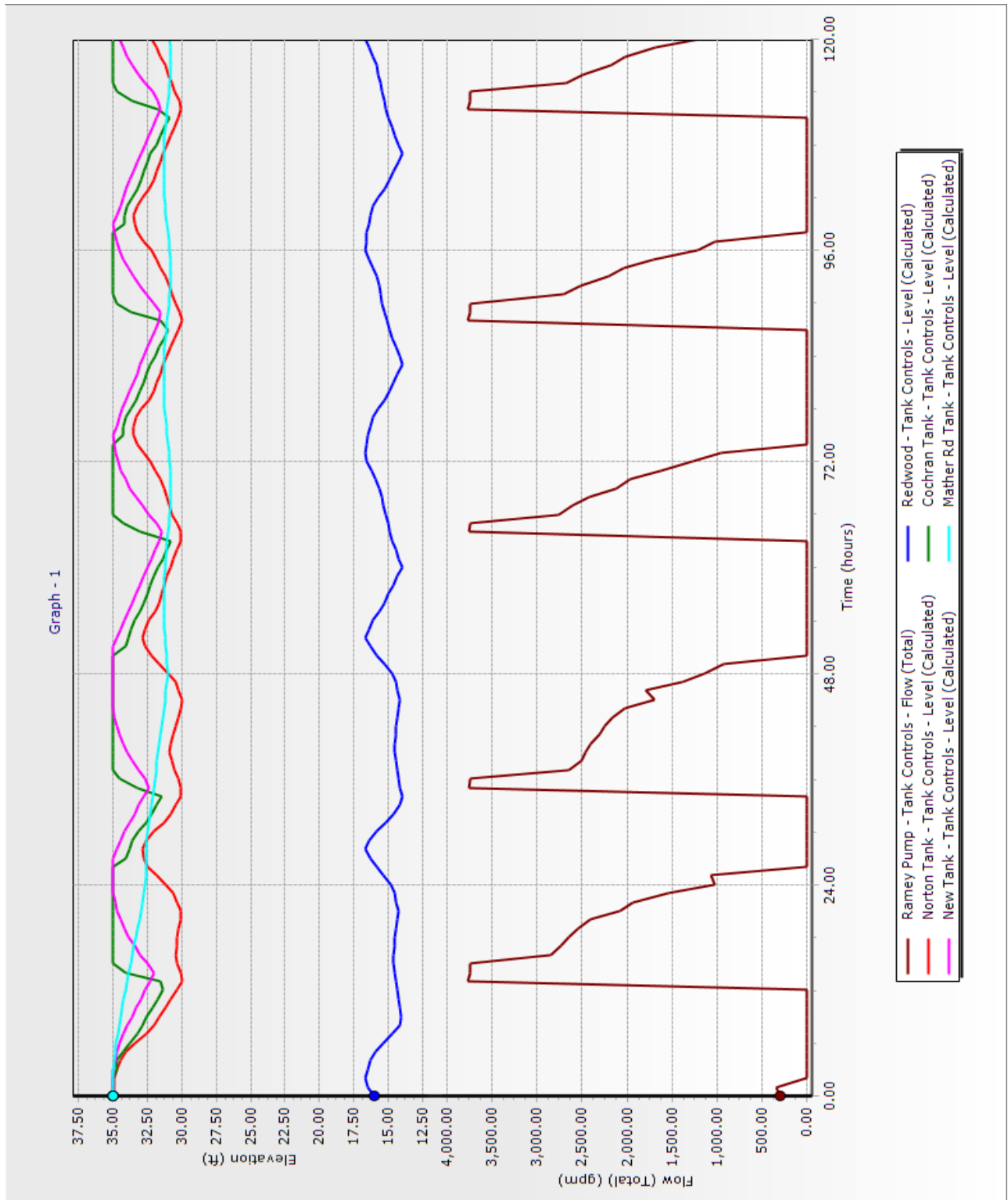
## 8.3 Fire Flow

A fire flow analysis was conducted with the addition of a 2.5 MG water tank at the end of Mather Rd. on top of the theoretical 4.5 MG tank at the Cochran site. With the addition of a 2.5 MG tank in the high elevation area of Dows Prairie all tested junctions passed the fire flow analysis. Table 15 shows the three junctions that had an available flow of less than 1000 gpm.

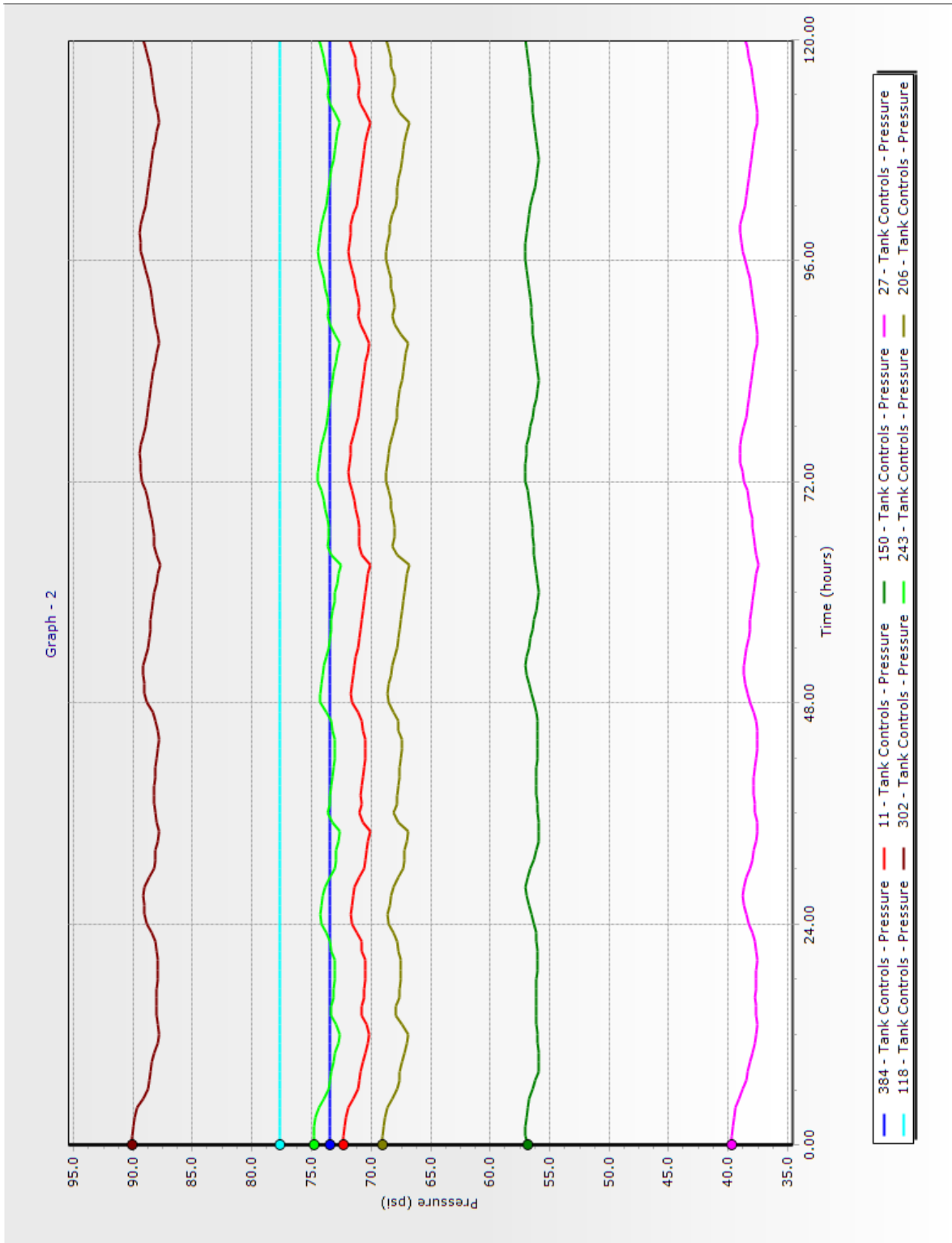
| Junction # | Flow Available | Residual Pressure | Satisfies Fire Flow | Location            |
|------------|----------------|-------------------|---------------------|---------------------|
| <b>334</b> | 961.92         | 20.0              | True                | Terra Vista Ct.     |
| <b>142</b> | 924.44         | 31.0              | True                | Clay Rd / Leona Dr. |
| <b>382</b> | 924.44         | 45.1              | True                | End of Huntz Rd.    |

## 8.4 Extended Period Simulation (EPS)

System responses to the new tank scenario Under average daily demand are shown in (Figure 16). The figure shows tank elevations in relation to pumping schedules and corresponding pressures at 8 nodes (Figure 17) throughout the distribution system. With the new water tank Ramey pumps are expected to run less frequent for a longer period of time. Expected pumping times and flows are shown in (Figure 16).



**Figure 16.** 5 day EPS ADD 4.5 MG plus 2.5 MG Tank Scenario tank elevations matched with pump speed and flow.

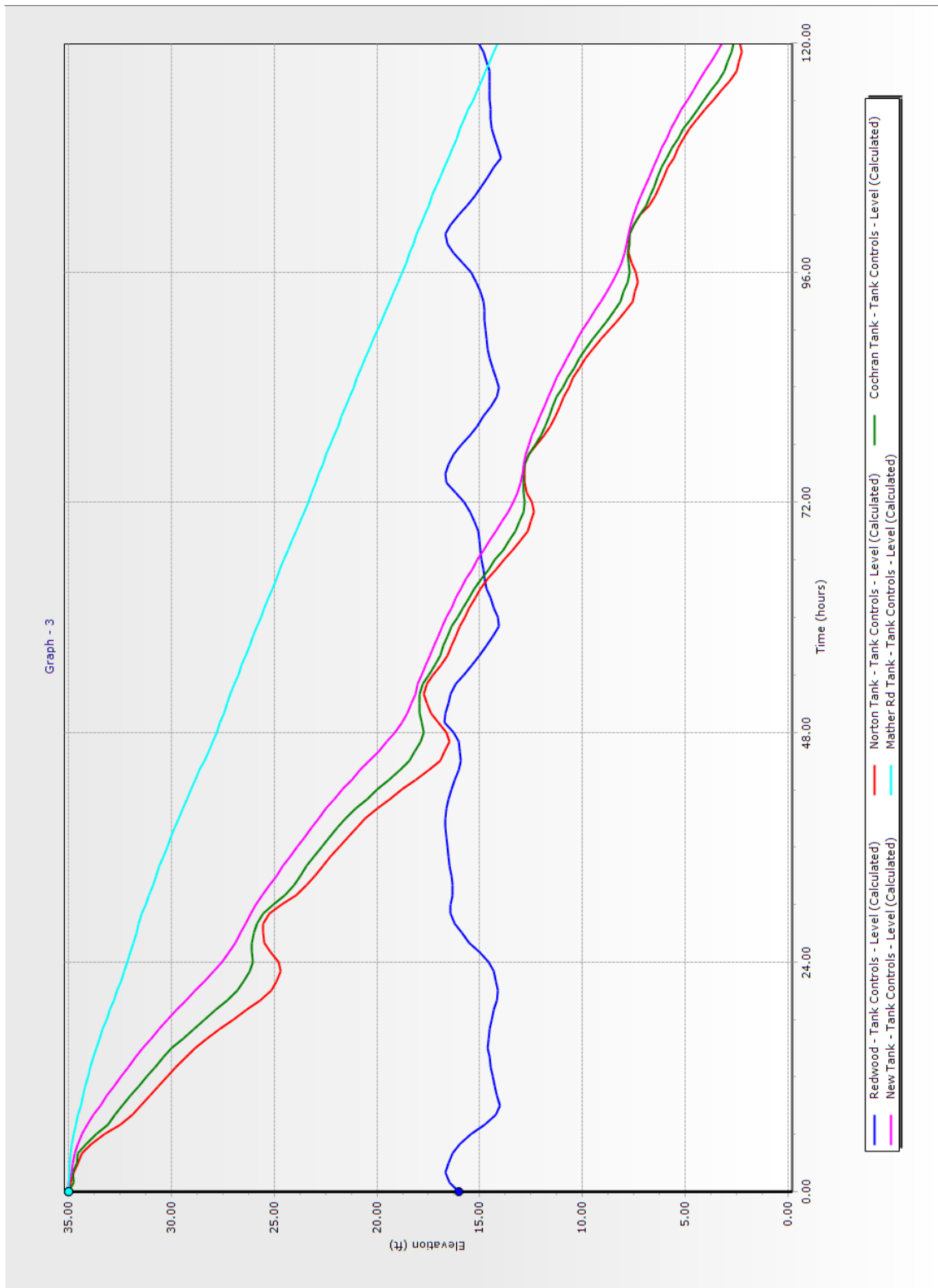


**Figure 17.** 4.5 MG plus 2.5 MG Tank Scenario 5 day EPS ADD corresponding node pressures with tank levels and pumping schedule.

## **8.5 Additional 2.5 MG Tank Minimum Storage Requirements**

This criterion states that the MCSO water distribution system must have enough storage to sustain 5 days of ADD and fire flows. In order to simulate five days of storage the main transmission line from HBMWD was closed, tank levels were set to full, pumps were turned off and a 4 hour commercial fire was placed along Central Avenue during day two.

The addition of a 2.5 MG tank on top of the hypothetical 4.5 MG water tank at the Cochran tank site satisfies the minimum storage criterion set by MCSO. The new tank would provide more than 5 days of water from storage only (Figure 18).

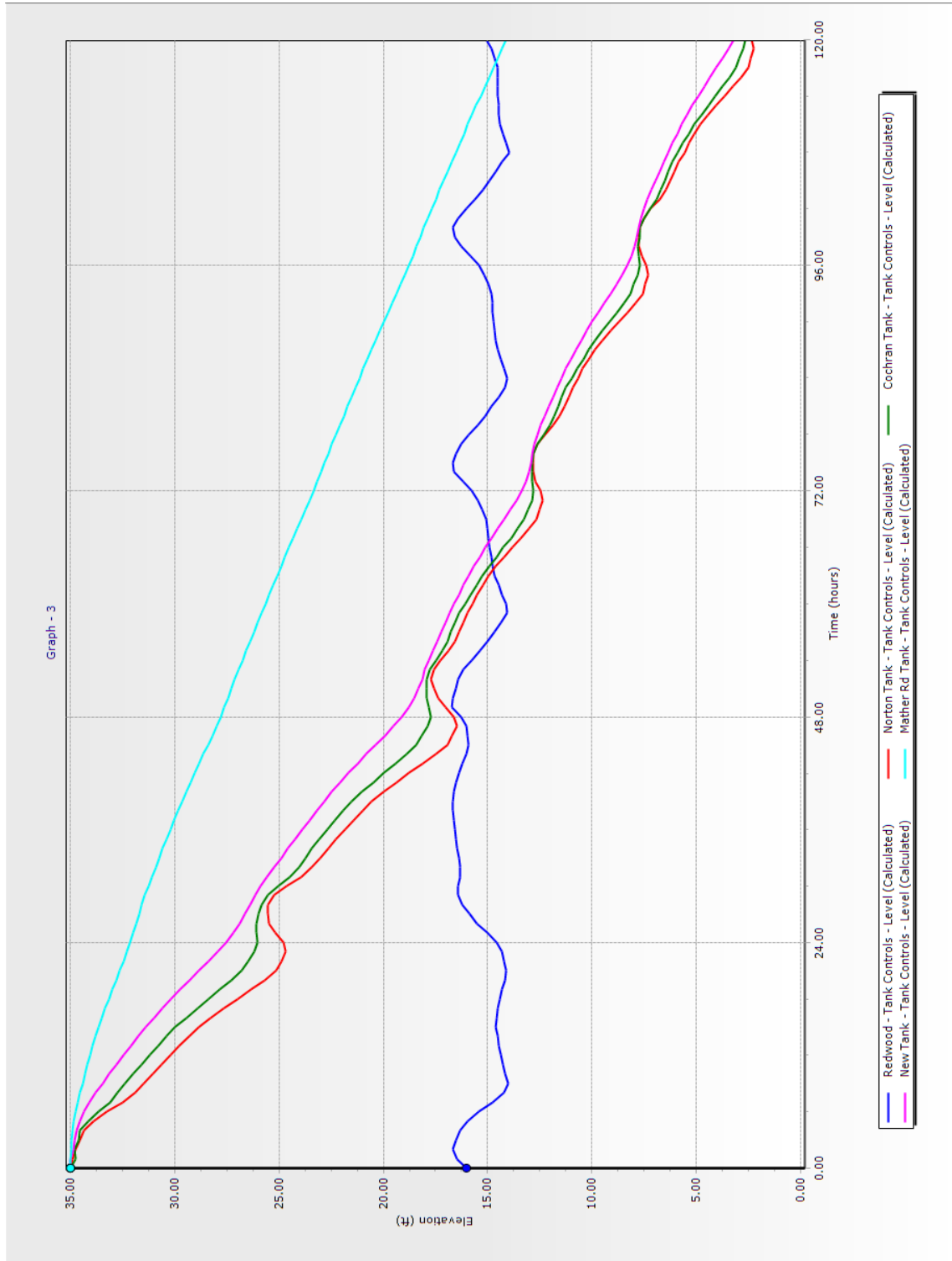


**Figure 18.** 4.5 MG plus 2.5 MG Tank Scenario 5 day EPS ADD water available from storage only. (Minimum Storage Criteria).

## **8.6 Additional 2.5MG Tank Extenuating Circumstances (Earthquake Scenario)**

The “Earthquake Scenario” is a situation in which a natural disaster destroys the main transmission line and also causes fire within the MCSD service area. MCSD would need enough storage to provide the average person with average daily demand of water as well as fight multiple fires.

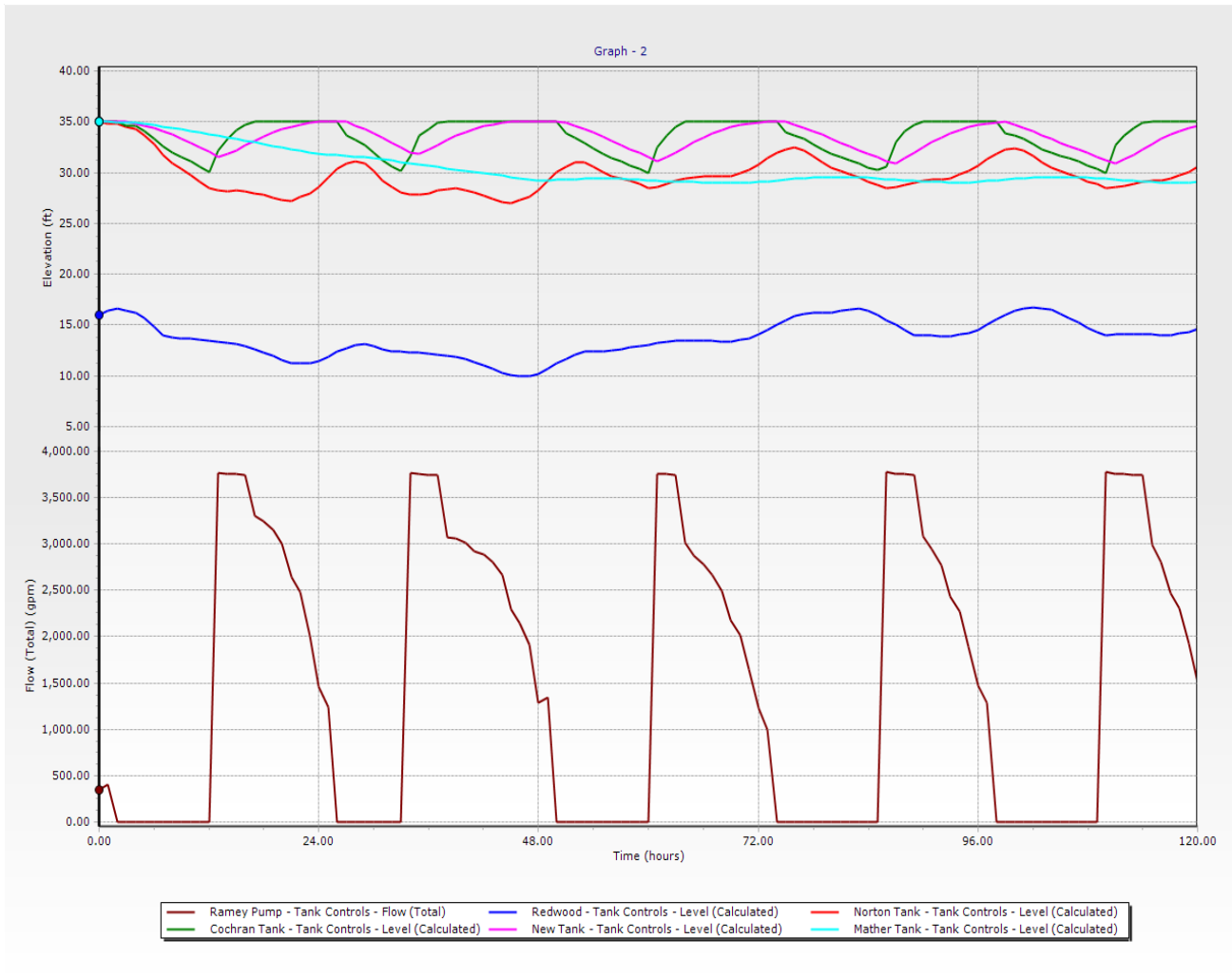
With the addition of 2.5MG water tank at the end of Mather Rd. on top of the theoretical 4.5MG tank at the Cochran site, under ADD and the earthquake scenario, the system would have a minimum of 5 days of water available from storage only (Figure 19).



**Figure 19.** 5 day EPS ADD 4.5 MG plus 2.5 MG Tank Scenario water available from storage only (Earthquake Scenario).

### 8.7 Additional 2.5 MG Tank High Density Build-out Potential

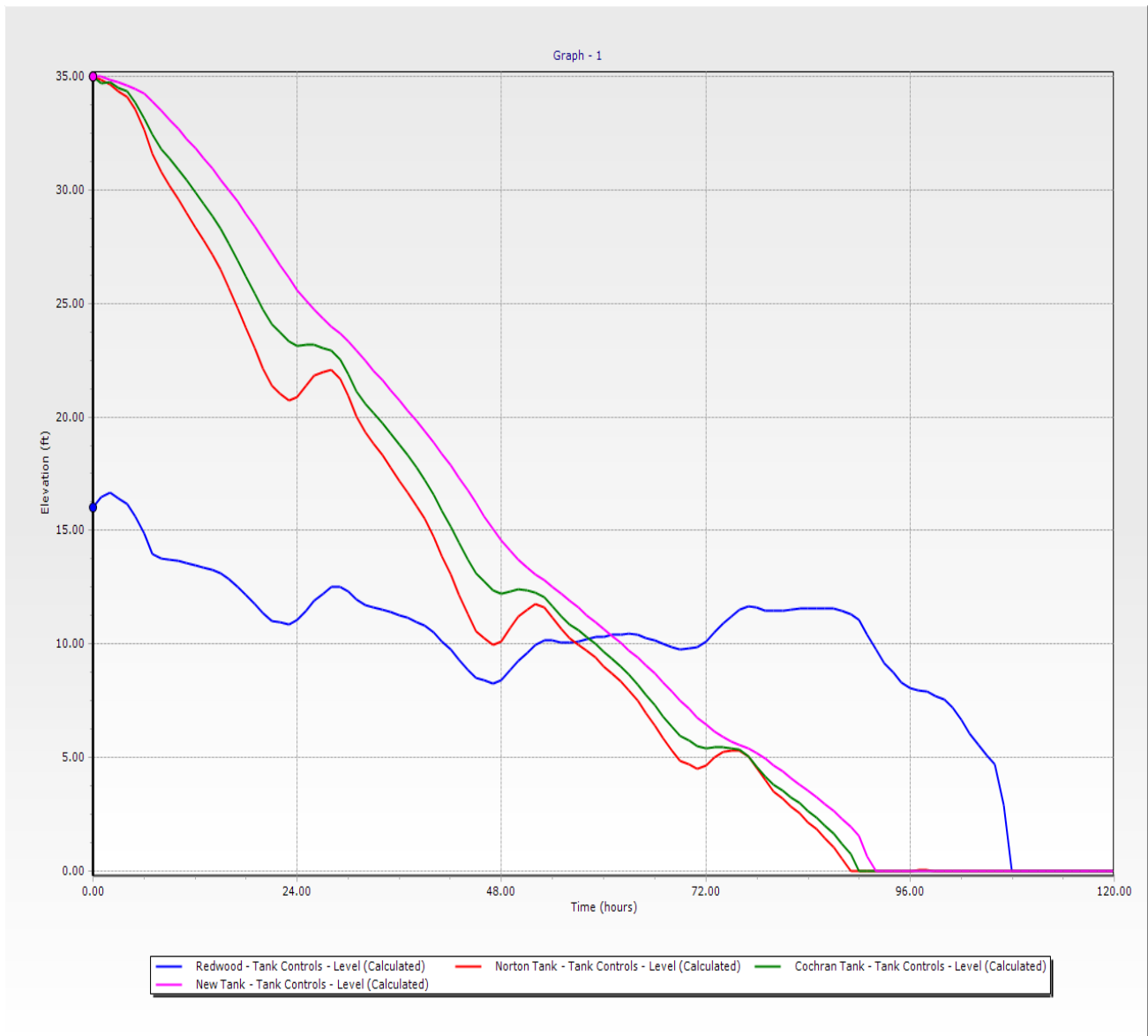
Build-out potential was evaluated by placing additional demand nodes in undeveloped areas or areas available for future development within the McKinleyville service area. The additional projected usage of 457,20 gpd, as per the Humboldt County General Plan, demand was then added to the additional and existing demand nodes.



**Figure 20.** 4.5 MG plus 2.5 MG Tank Scenario 5 day EPS High density Build-Out (Tank elevations matched with pump speed and flow).

Under average daily demand plus the 457,200 gpd projected increase, no junction pressures fell below 20 psi and all pipe velocities were below 5ft/sec. With the additional 457,200 gpd demand added to the 4.5 MG plus 2.5 MG scenario the distribution system has only 3 days of water available from storage not meeting the required 5 days set forth by MCSO (Figure 21)

With the additional 457,200 gpd demand added to the 4.5 MG plus 2.5 MG scenario there is not enough water available to satisfy neither the minimum storage criterion nor the extenuating circumstance criterion.



**Figure 21.** 4.5 MG plus 2.5 MG Tank Scenario 5 day EPS ADD Tank Build-out Scenario (Minimum Storage Requirement).

## 9.0 20 Year Growth Projections

This scenario will analyze the ability of the MCSD water distribution system to handle population growth over the next 20 years. According to the MCSD 20 Year Facilities Plan and Urban Water Management Plan the annual growth rate of McKinleyville since 1994 is 1.8%.

The annual growth rate of 1.8% was applied to the current average daily demand of 1.51MG and was calculated out for the years 2020 and 2030 (Table 16).

| <b>Table 16.</b>   |                   |            |            |
|--|-------------------|------------|------------|
| <b>20 year Projected Demands at 1.8% Annual Increase</b>                                       |                   |            |            |
| <b>Date</b>  | <b>% Increase</b> | <b>ADD</b> | <b>MDD</b> |
| <b>2010</b>  | 0 %               | 1.51 MGD   | 3.40 MGD   |
| <b>2020</b>  | 18 %              | 1.78 MGD   | 4.01 MGD   |
| <b>2030</b>  | 18 %              | 2.04 MGD   | 4.59 MGD   |
| 1. MGD = Million Gallons per Day<br>2. ADD = Average Daily Demand<br>3. MDD = Max Daily Demand |                   |            |            |

In order to analyze how the new growth will affect the system the proposed demand was allocated and evaluated two ways. The first, takes the projected increase in demand and averages it out to all existing nodes. This provides a quick look at how the system will respond to the increase in demand but will not give insight to areas of high density development. The second, places new nodes throughout the model where high density development is expected to occur. This will provide insight to pipe sizing and specific system deficiencies related to the increase in demand.

### 9.1 2020 Growth Projections

By the year 2020 the population of McKinleyville is expected to increase by approximately 18%. In order to analyze how the system will respond to the projected growth the water system was modeled with two new tanks, 4.5 MG at the Cochran tank site and 2.5 MG at the end of Mather Road. The system was analyzed for pressures, flow, fire flow availability, storage, and pumping efficiency.

### **9.1.1 2020 Steady State**

For steady state analyses the 2020 growth projections scenario was examined under max daily demand plus a 2000gpm fire on Central Avenue. Under MDD with the 2000 gpm fire on Central Ave. all junction pressures were above 20psi and all flow velocities were below 5ft/sec. Junction 42, 40, 371, had pressures exceeding 100 psi. All three junctions with pressures exceeding 100psi are located at the north east reach of the distribution system along Patrick Creek Dr. and Little River Dr. and were found to be at low elevations. Each of these junctions were analyzed and found to be consistent with district field measurements.

### **9.1.2 2020 Fire Flow**

A fire flow analysis was conducted under 2020 max daily demand. With the addition of a 2.5MG tank in the high elevation area of Dows Prairie all tested junctions passed the fire flow analysis.

### **9.1.3 2020 Extended Period Simulation (EPS)**

Pumping and storage levels for the 2020 growth scenario under ADD and MDD are shown in (Figure 22 & 23). Under average daily demand the pumps run once a day and are able to fill all five tanks efficiently (Figure 22). Under max daily demand the pumps are running for a longer duration and are unable to keep up with the increase in demand indicating a lack of storage (Figure 22).

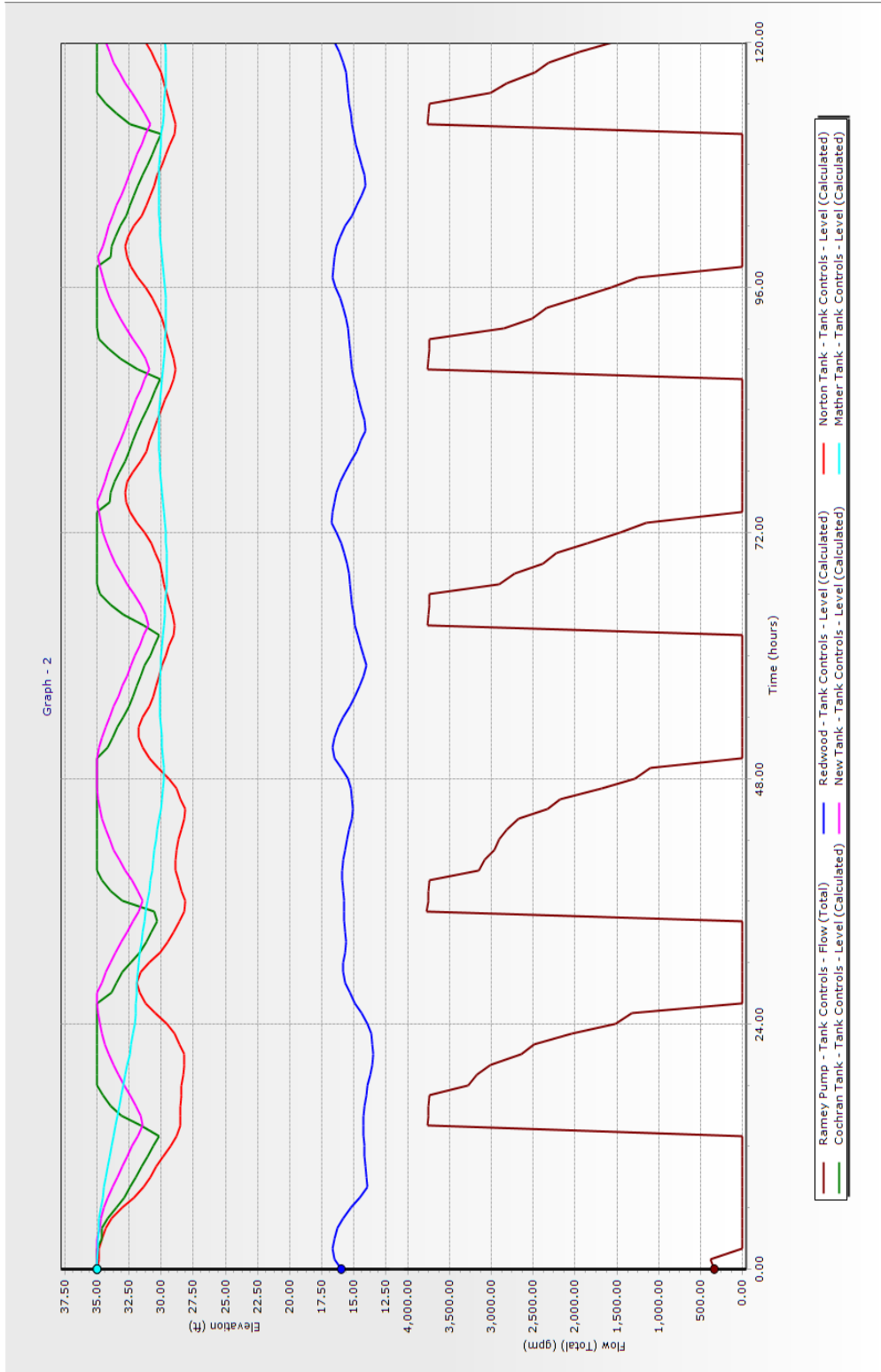
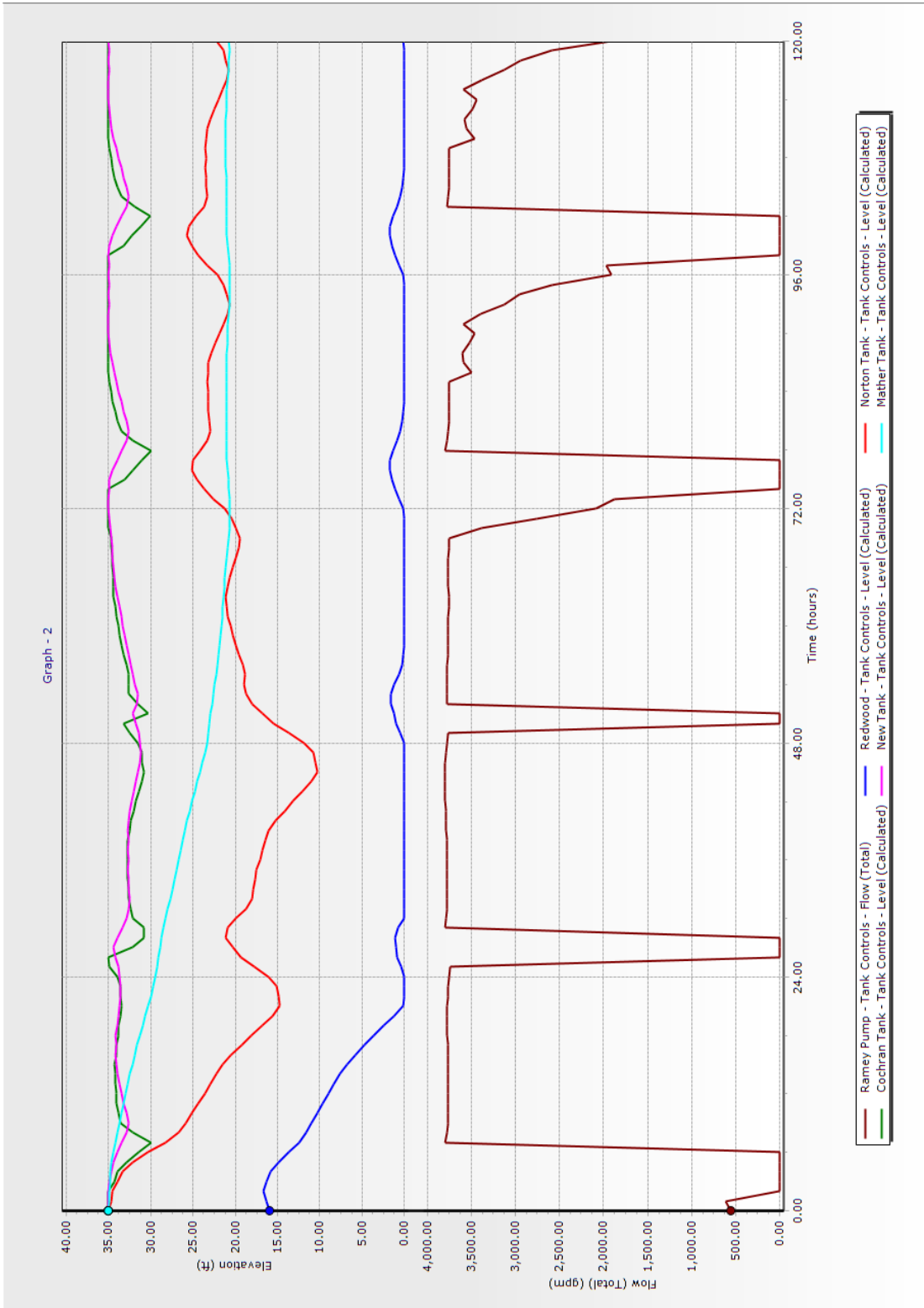


Figure 22. 2020 5 Day EPS ADD tank elevations matched with pump speed and flow.



**Figure 23. 2020 5 Day EPS MDD tank elevations matched with pump speed and flow.**

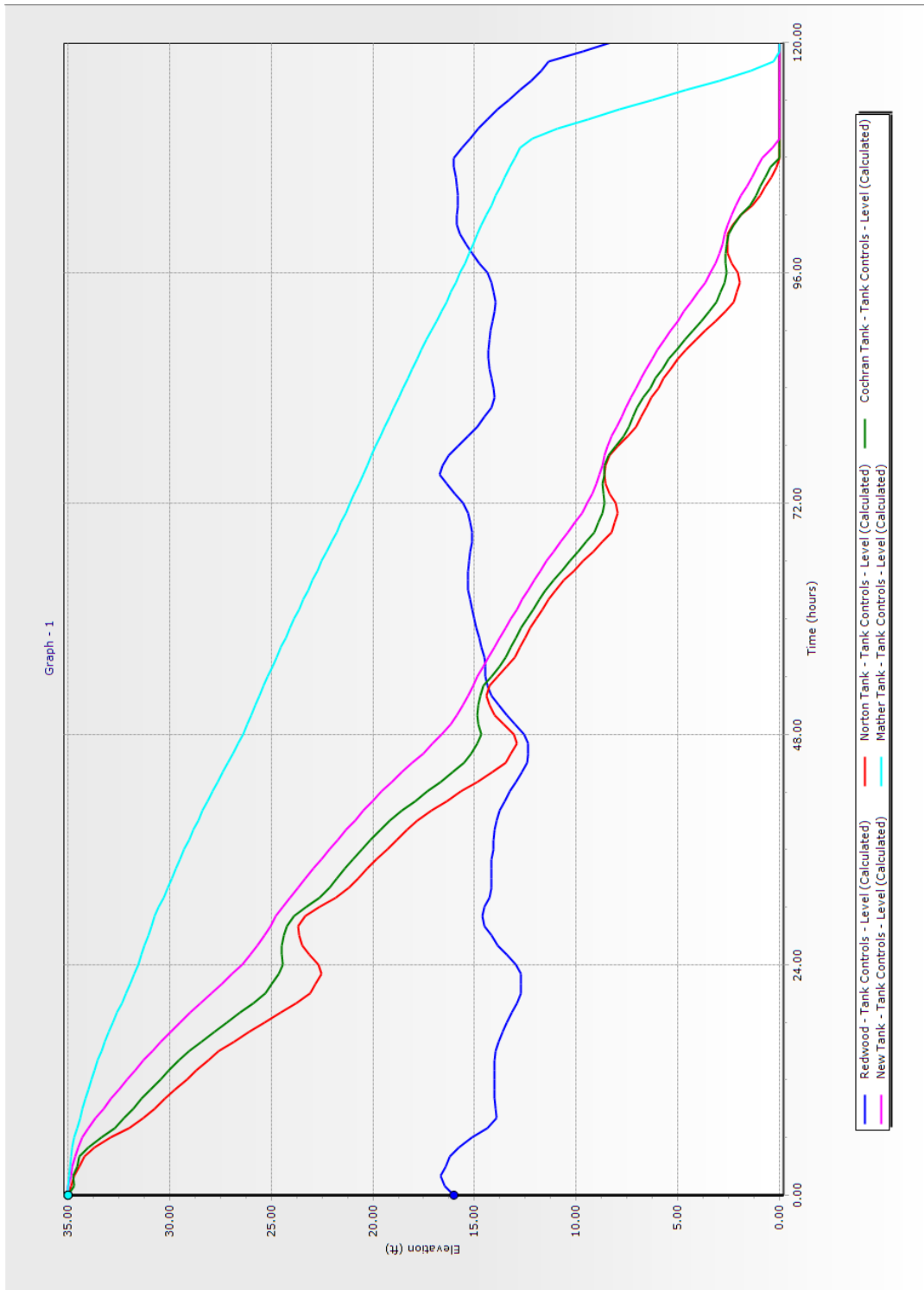
**9.1.4 2020 MCSD Minimum Storage Criterion**

This criterion states that the MCSD water distribution system must have enough storage to sustain 5 days of ADD and fire flows. In order to simulate five days of storage the main transmission line from HBMWD was closed, tank levels were set to full, pumps were turned off and a 4 hour commercial fire was placed along Central Avenue during day two.

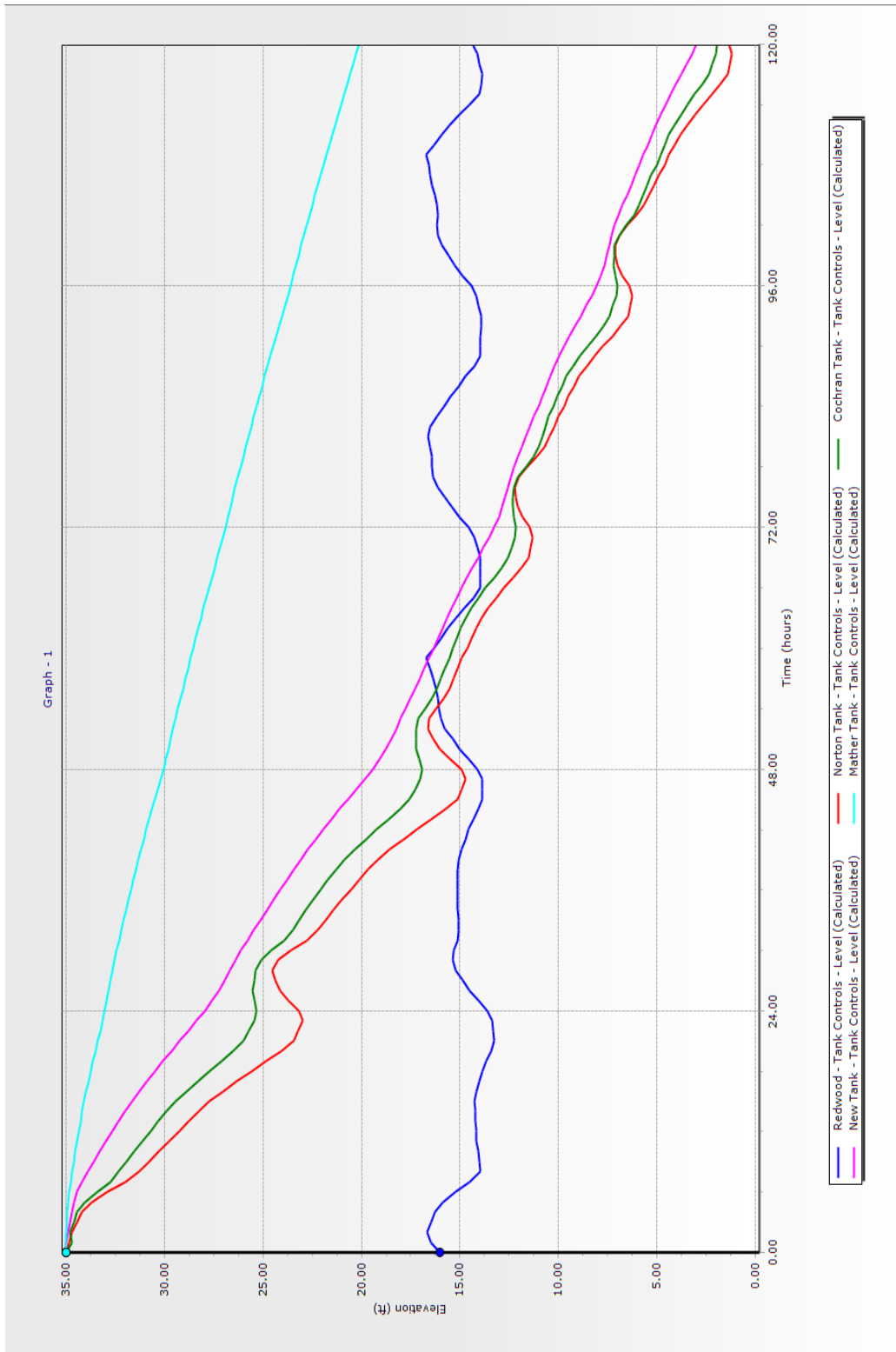
2020 minimum storage was analyzed under three scenarios (Table 18), 2.5 MG tank plus 4.5 MG tank, 4.5 MG tank plus a 4.5 MG tank and 4.5 MG tank plus a 6.0 MG tank.

By the year 2020 MCSD will need 10.5 MG of additional storage, from the current state, to meet the minimum storage requirement of 5 days ADD from storage only (Figure 25).

| <b>Table 18</b>  |                      |                       |   |
|--|----------------------|-----------------------|---|
| <b><u>2020 Tank Size required to meet MCSD 5 day minimum storage requirement</u></b> |                      |                       |   |
| <b>Year</b>  | <b>Tank Location</b> | <b>Tank Size (MG)</b> | <b># Days of Water Available from Storage</b> |
| 2020   | Mather Rd.           | 2.5                   | 4 Days Water from Storage Only                |
|  | Cochran Rd.          | 4.5                   |   |
| 2020   | Mather Rd.           | 4.5                   | 4.5 Days Water from Storage Only              |
|  | Cochran Rd.          | 4.5                   |   |
| 2020   | Mather Rd.           | 4.5                   | 5 Days Water from Storage Only                |
|  | Cochran Rd.          | 6.0                   |   |



**Figure 24.** 2020 5 Day EPS ADD **4.5MG** at Cochran and **2.5MG** at Mather Rd minimum storage requirement 5 days.



**Figure 25.** 2020 5 Day EPS **6.0MG** at Cochran and **4.5MG** at Mather minimum storage requirement 5 days.

## **9.2 2030 Growth Projections**

By the year 2030 the population of McKinleyville is expected to increase by approximately 18%. In order to analyze how the system will respond to the projected growth the water system was modeled with two new tanks, 4.5MG at the Cochran tank site and 2.5MG at the end of Mather Road. The system was analyzed for pressures, flow, fire flow availability, and storage and pumping efficiency.

### **9.2.1 2030 Steady State**

For steady state analyses the 2030 growth projections scenario was examined under max daily demand plus a 2000 gpm fire on Central Avenue. Under MDD with the 2000 gpm fire on Central Ave. all junction pressures were above 20 psi and all flow velocities were below 5ft/sec. Junction 42, 40, 371, had pressures exceeding 100 psi. All three junctions with pressures exceeding 100 psi are located at the north east reach of the distribution system along Patrick Creek Dr. and Little River Dr. and were found to be at low elevations. Each of these junctions were analyzed and found to be consistent with district field measurements.

### **9.2.2 2030 Fire Flow**

A fire flow analysis was conducted under 2020 max daily demand. With the addition of a 2.5 MG tank in the high elevation area of Dows Prairie all tested junctions passed the fire flow analysis.

### **9.2.3 2030 Extended Period Simulation (EPS)**

Pumping and storage levels for the 2030 growth scenario under average daily demand and max daily demand are shown in (Figure 26 & 27). Under average daily demand the pumps run once a day and are able to fill all five tanks (Figure 26). Under max daily demand the pumps are running for a longer duration and are unable to keep up with the increase in demand indicating a lack of storage (Figure 27).

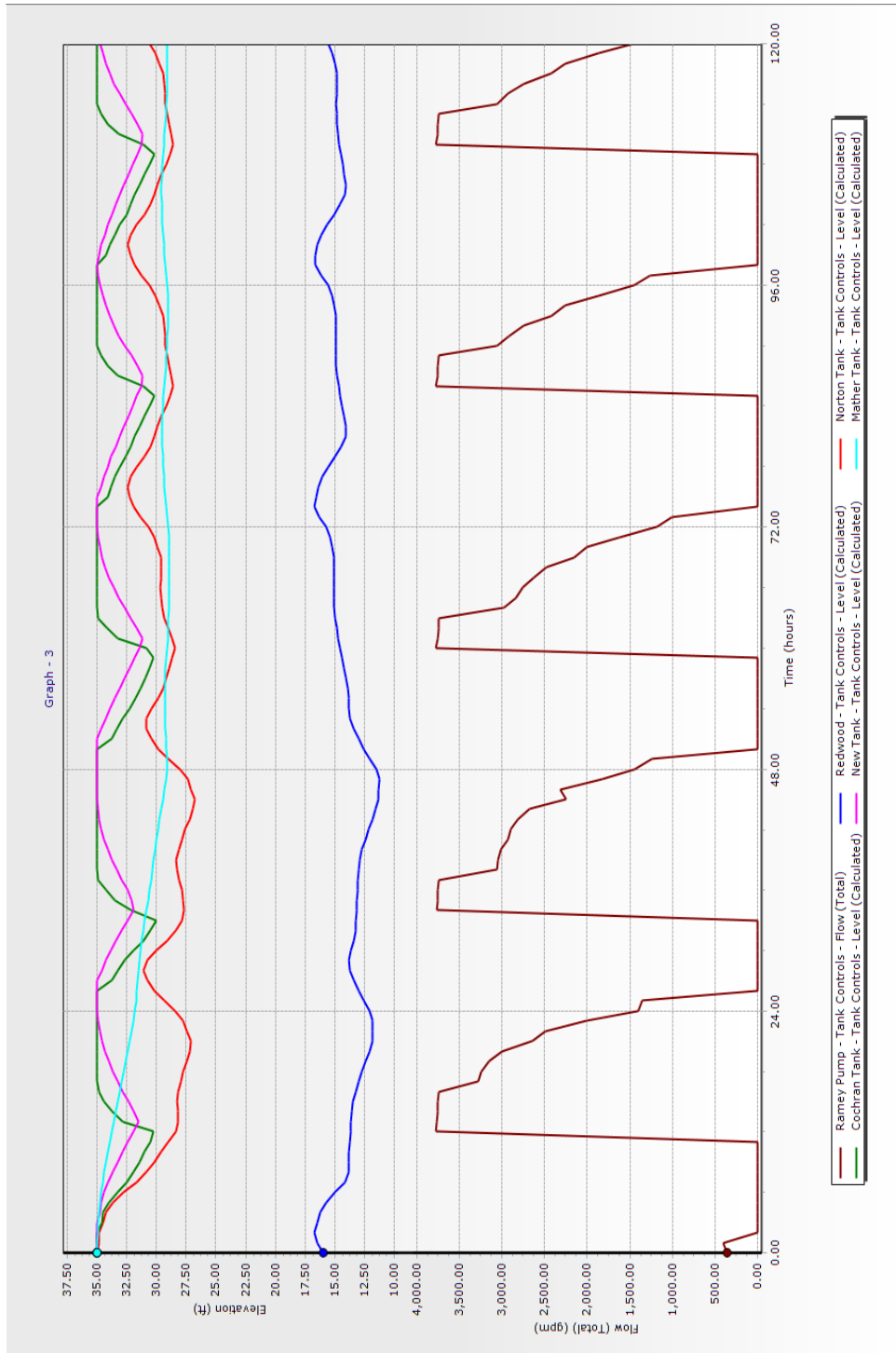
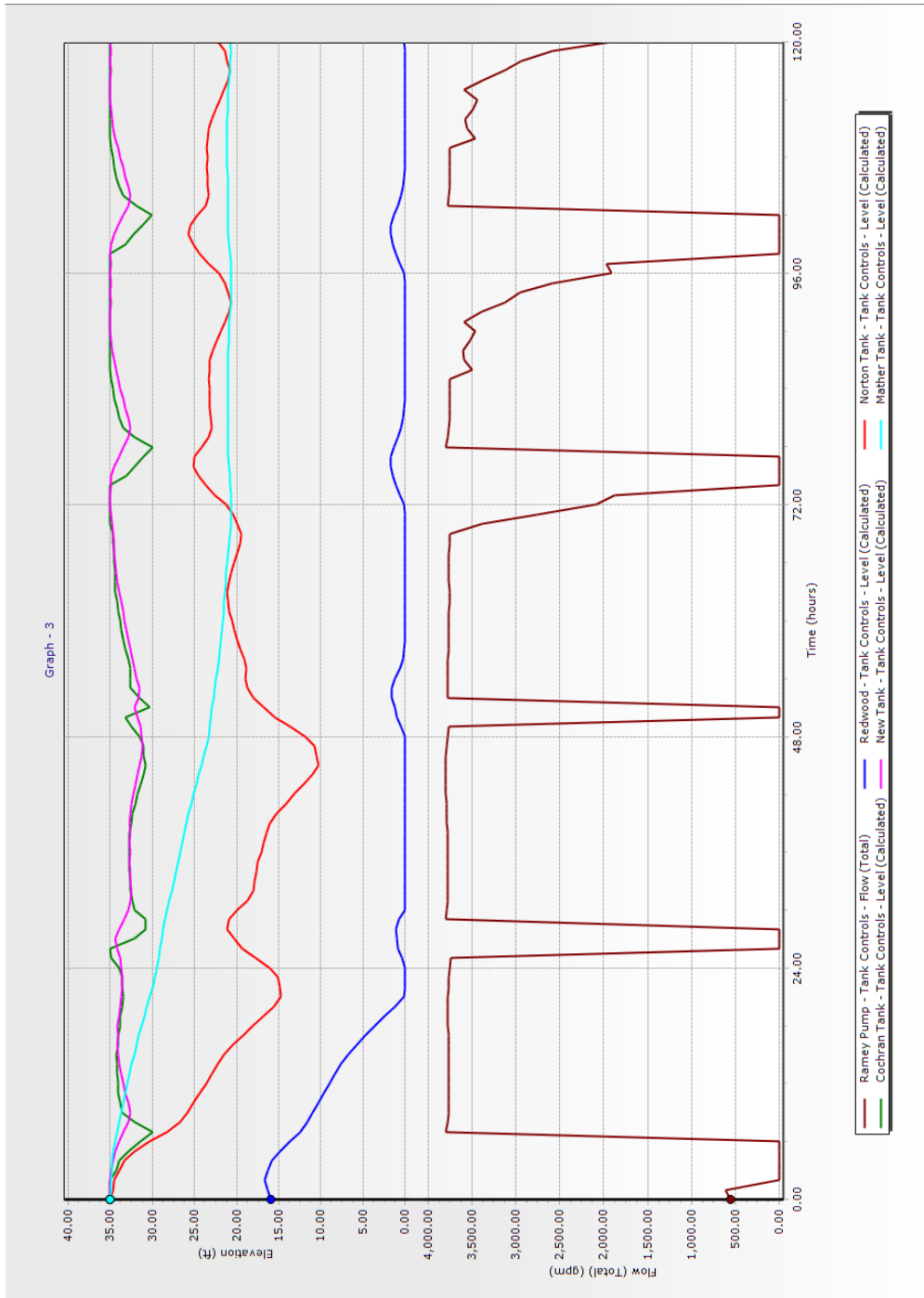


Figure 26. 2030 5 Day EPS ADD tank elevations matched with pump speed and flow.



**Figure 27.** 2030 5 Day EPS MDD tank elevations matched with pump speed and flow

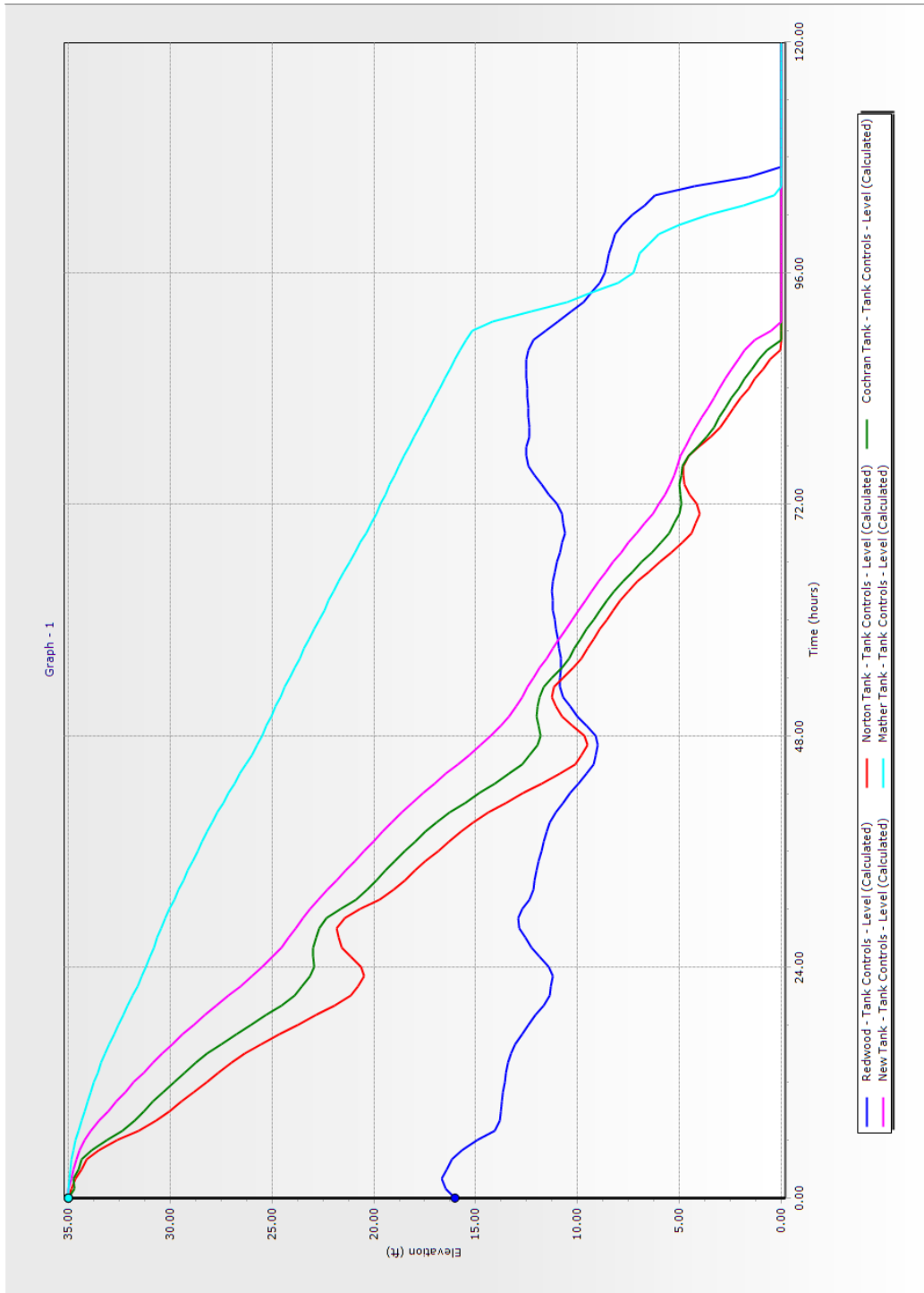
**9.2.4 2030 MCSD Minimum Storage Criterion**

This criterion states that the MCSD water distribution system must have enough storage to sustain 5 days of ADD and fire flows. In order to simulate five days of storage the main transmission line from HBMWD was closed, tank levels were set to full, pumps were turned off and a 4 hour commercial fire was placed along Central Avenue during day two. (Figure 28-29)

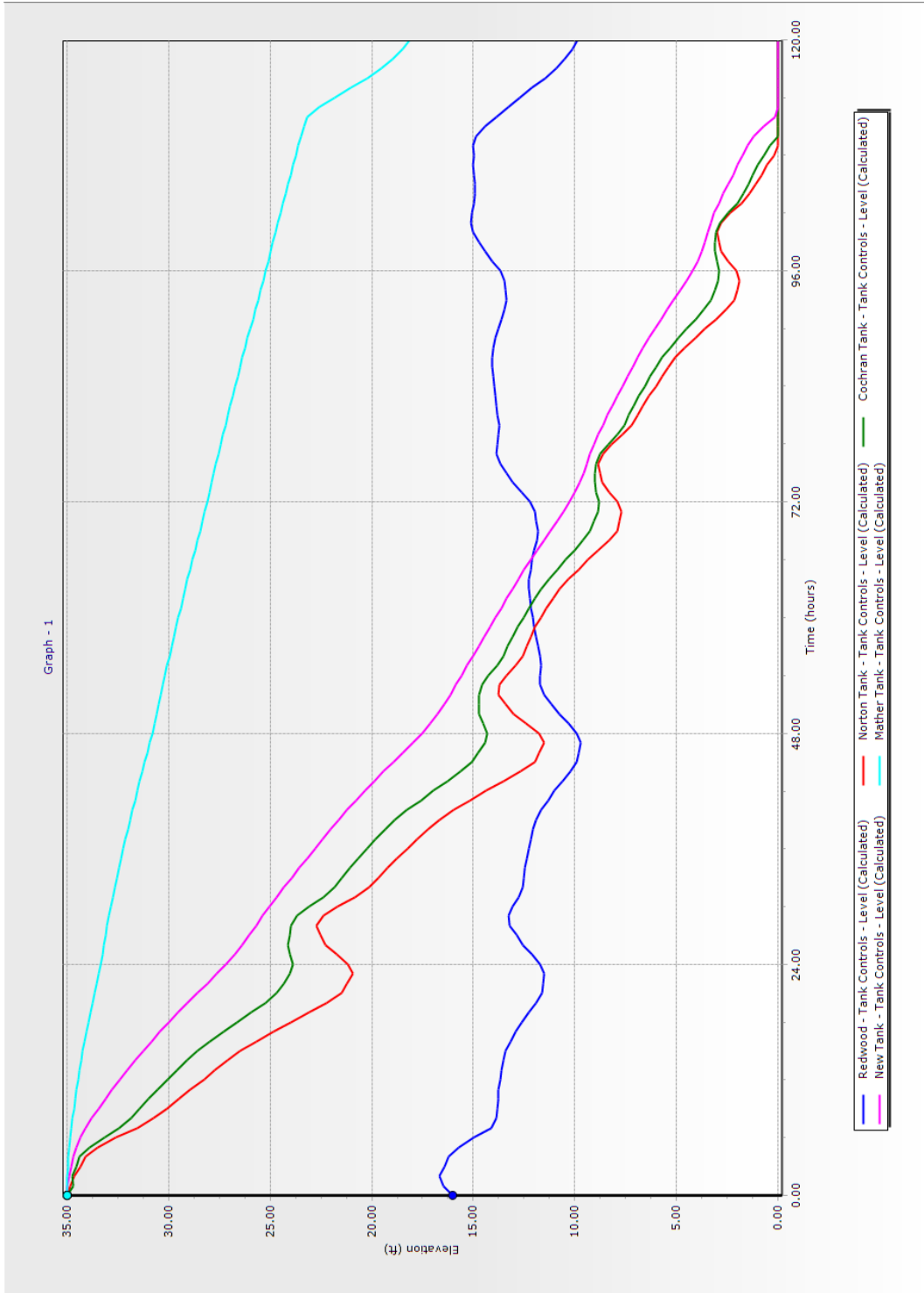
2030 minimum storage was analyzed under four scenarios (Table 19), 2.5 MG tank plus 4.5 MG tank, 4.5 MG tank plus a 4.5MG tank, 4.5 MG tank plus a 6.0 MG tank and 6.0 MG tank plus 6.0 MG tank.

By the year 2030 MCSD will need a minimum of 12 MG of additional storage, from the current state, to satisfy the MCSD minimum storage requirement of 5 day ADD from storage only.

| <b>Table 19</b>  |                      |                       |   |
|--|----------------------|-----------------------|---|
| <b>2030</b>  |                      |                       |   |
| <b><u>2030 Tank Size required to meet MCSD 5 day minimum storage requirement</u></b> |                      |                       |   |
| <b>Year</b>  | <b>Tank Location</b> | <b>Tank Size (MG)</b> | <b># Days of Water Available from Storage</b> |
| 2030   | Mather Rd.           | 2.5                   | 3 Days Water from Storage Only                |
|  | Cochran Rd.          | 4.5                   |   |
| 2030   | Mather Rd.           | 4.5                   | 3.5 Days Water from Storage Only              |
|  | Cochran Rd.          | 4.5                   |   |
| 2030   | Mather Rd.           | 4.5                   | 4 Days Water from Storage Only                |
|  | Cochran Rd.          | 6.0                   |   |
| 2030   | Mather Rd.           | 6.0                   | 4.5 Days Water from Storage Only              |
|  | Cochran Rd.          | 6.0                   |   |



**Figure 28.** 2030 5 Day EPS ADD **4.5MG** at Cochran and **2.5MG** at Mather minimum storage requirement 5 days.



**Figure 29.** 2030 5 Day EPS MDD **4.5MG** at Cochran and **2.5MG** at Mather minimum storage requirement 5 days.

## 10.0 Conclusion

The McKinleyville Community Services District water distribution system was modeled using WareCAD v8i (Select 3) water modeling software. The water system was analyzed for pressure, flow, fire flow availability, storage, pumping capacity, and overall reliability as per MCSD and CDPH minimum requirements, regulations, and standards. The model was developed to run Steady State and Extended Period Simulations. Steady State simulations create a “snap shot” of the modeled system and are used to determine flow rates and system wide pressures. Extended Period Simulations were employed to validate storage capacity of existing tanks to meet ADD (1.51 MG), MDD (3.41 MG), and PHD (MDD + .21 MG/hour) demands. Model results have been grouped into four scenarios and result sets: current state, 4.5 MG tank scenario, 2.5 MG tank scenario and 20 year growth scenario.

The model was calibrated by conducting six separate fire hydrant flow tests to collect static and residual pressures and flow rates. The model was then adjusted to match the recorded field values to within a 5% variation. System wide demands, ADD, MDD, and PHD were calculated using residential, commercial, and multi-family 2010 billing records and usages. Demands were then allocated throughout the model using the Thiessen Polygon Method.

For Extended Period Simulations Rule-Based logic controls and diurnal curves were set-up to simulate system activity over a period of time. Rule-Based controls are a set of statements that perform an action when a conditional statement is met (Ramey pump = on when Cochran tank falls below 30 ft AND Ramey Pump = OFF when Cochran tank is above 35 ft.). Residential and commercial diurnal multipliers and curves were established to allow the model to compute system demands over a pre-defined period of time. Both residential and commercial diurnal curves were established using SCADA data and through conversations with MCSD staff.

The current state scenario evaluates the distribution system under existing conditions and proved to have issues in regards to fire flow and minimum storage requirements. Under ADD 6 hydrants in the Dows Prairie and three hydrants in the McCluski Hill service areas failed to deliver the required 1000 gpm fire flow. The current system cannot satisfy the five days of average daily demand available from storage only, set forth by MCSD, there is approximately 2 days of water currently available from storage only. The current system cannot satisfy the high-density build out proposed by the Humboldt County General Plan update in regards to minimum storage.

The addition of 4.5 MG of storage improves fire flow availability but has a difficult time providing 1000 gpm to four hydrants in the high elevation Dow's Prairie area and three hydrants in the McCluski Hill service area. With the addition of 4.5 MG the system still cannot satisfy the five days of storage criterion under average daily demand, there is approximately 4 days of water available (from storage only). The addition of 4.5MG of storage cannot handle the Humboldt County proposed high-density build-out in regards to minimum storage requirements there would only be 2.5 days of water available.

The model was analyzed with 2.5 MG of additional storage (including the 4.5 MG at the Cochran tank site) located at the end of Mather Road in the Dow's Prairie area. The addition of 2.5MG in the Dows Prairie area provides the required 1000 gpm fire flow to all hydrants and satisfies the minimum storage requirement of five days average daily demand from storage only. The addition of 2.5 MG still does not handle the Humboldt County Proposed high-density build out in regards to minimum storage (3.5 days of water available).

By the year 2020 the average daily demand is expected to be 1.78 MG per day and 2.04 MG per day by 2030. In order to satisfy the MCSD minimum storage requirement by the year 2020, from the current state, 10.5 MG of additional storage will be required. For the year 2030 12 MG of additional storage will be required to satisfy the MCSD minimum storage requirement of five days average daily demand from storage only.

## 11.0 References

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