TWAIN HARTE COMMUNITY SERVICES DISTRICT
Water & Sewer Committee Meeting

Chair: *Eileen Mannix*
Co-Chair: *Richard Knudson*

VIDEO TELECONFERENCE
March 3, 2021 8:00 a.m.

IMPORTANT NOTICE:
To help slow the spread of COVID-19, the District offices are closed to the public. Under the Governor's Executive Order N-25-20, this meeting will be held remotely by teleconference using Zoom:

- Videoconference Link: https://us02web.zoom.us/j/84417060921
- Meeting ID: 844 1706 0921
- Telephone: (669) 900-6833

ANYONE CAN PARTICIPATE IN THIS MEETING: see details at the end of this agenda.

AGENDA

1. **Operations report.**
2. **Discuss water system hydraulic model results, fire flows and potential system modifications.**
3. **Review and discuss the Wastewater Collections System Condition Assessment report.**
4. **Review and discuss the Sherwood Forest Wastewater Collections System Evaluation Technical Memorandum.**
5. **Adjourn.**

HOW TO OBSERVE THIS MEETING:

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- **Computer**: Join the videoconference by clicking the videoconference link located at the top of this agenda or on our website. You may be prompted to enter your name and email. Your email will remain private and you may enter "anonymous" for your name.

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- **Telephone**: Listen to the meeting by calling Zoom at (4669) 900-6833. Enter the Meeting ID# listed at the top of this agenda, followed by the pound (#) key.

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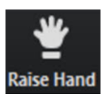
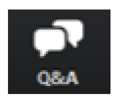
HOW TO SUBMIT PUBLIC COMMENTS:

The public will have an opportunity to comment before and after the meeting as follows:

- **Before the Meeting**: If you cannot attend the meeting, you may:
  - Email comments to ksilva@twainhartecsd.com, write "Public Comment" in the subject line. In the body of the email, include the agenda item number and title, as well as your comments.
  - Mail comments to THCSD Board Secretary: P.O. Box 649, Twain Harte, CA 95383
- **During the Meeting:** The public will have opportunity to provide comment before and after the meeting as follows:
  - Computer/Tablet/Smartphone: Click the "Raise Hand" icon and the host will unmute your audio when it is time to receive public comment. If you would rather make a comment in writing, you may click on the "Q&A" icon and type your comment. You may need to tap your screen or click on "View Participants" to make icons visible.

    Raise Hand Icon: 

 Q&A Icon: 

  - Telephone: The host will provide a time during each public comment period where telephone participants will be unmuted and enabled to share comments.

* NOTE: If you wish to speak on an item on the agenda, you are welcome to do so during consideration of the agenda item itself. If you wish to speak on a matter that does not appear on the agenda, you may do so during the Public Comment period. Persons speaking during the Public Comment will be limited to five minutes, or depending on the number of persons wishing to speak, it may be reduced to allow all members of the public the opportunity to address the Board. Except as otherwise provided by law, no action or discussion shall be taken/conducted on any item not appearing on the agenda. Public comments must be addressed to the board as a whole through the President. Comments to individuals or staff are not permitted.

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WRITTEN MEETING MATERIALS:

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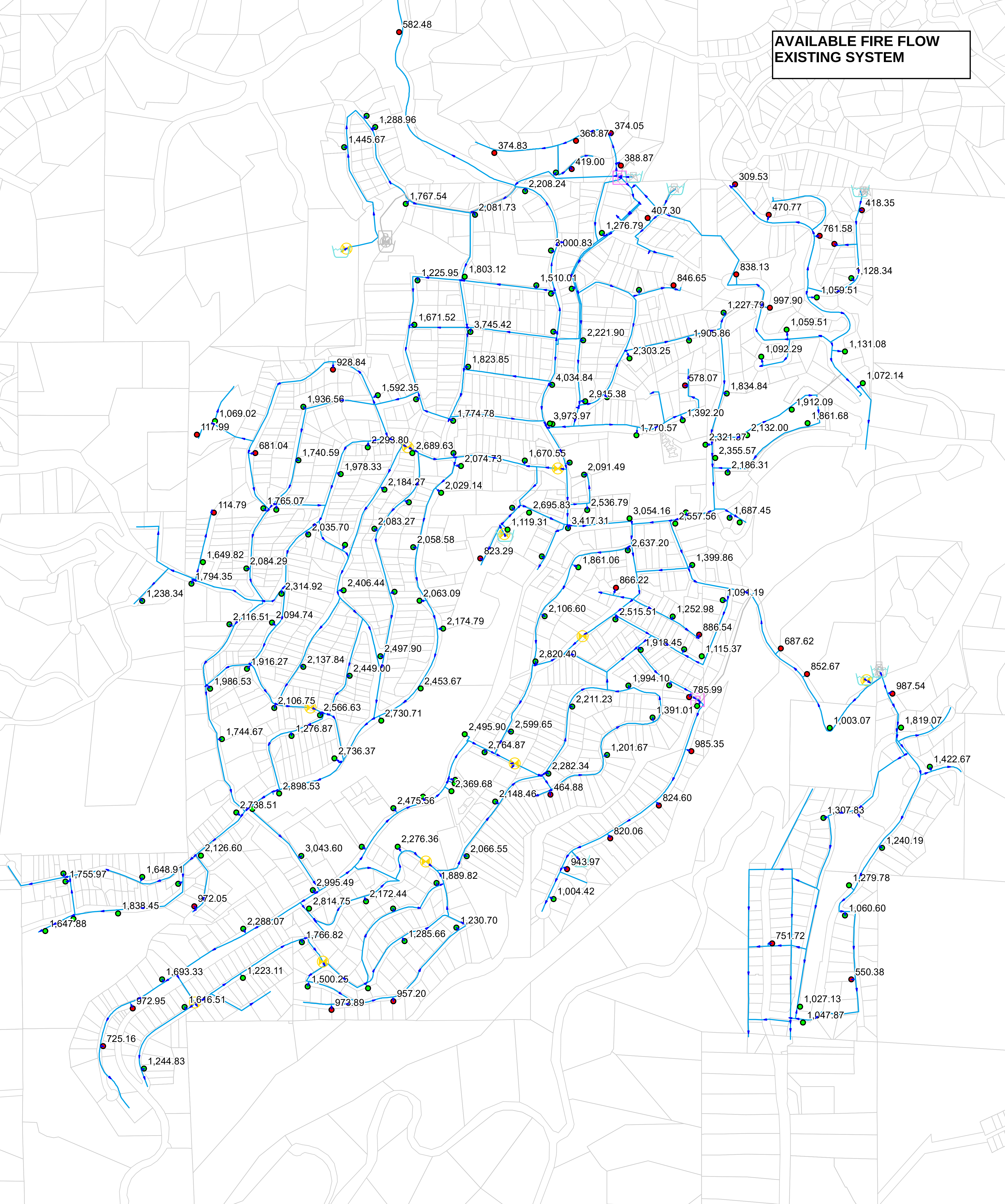
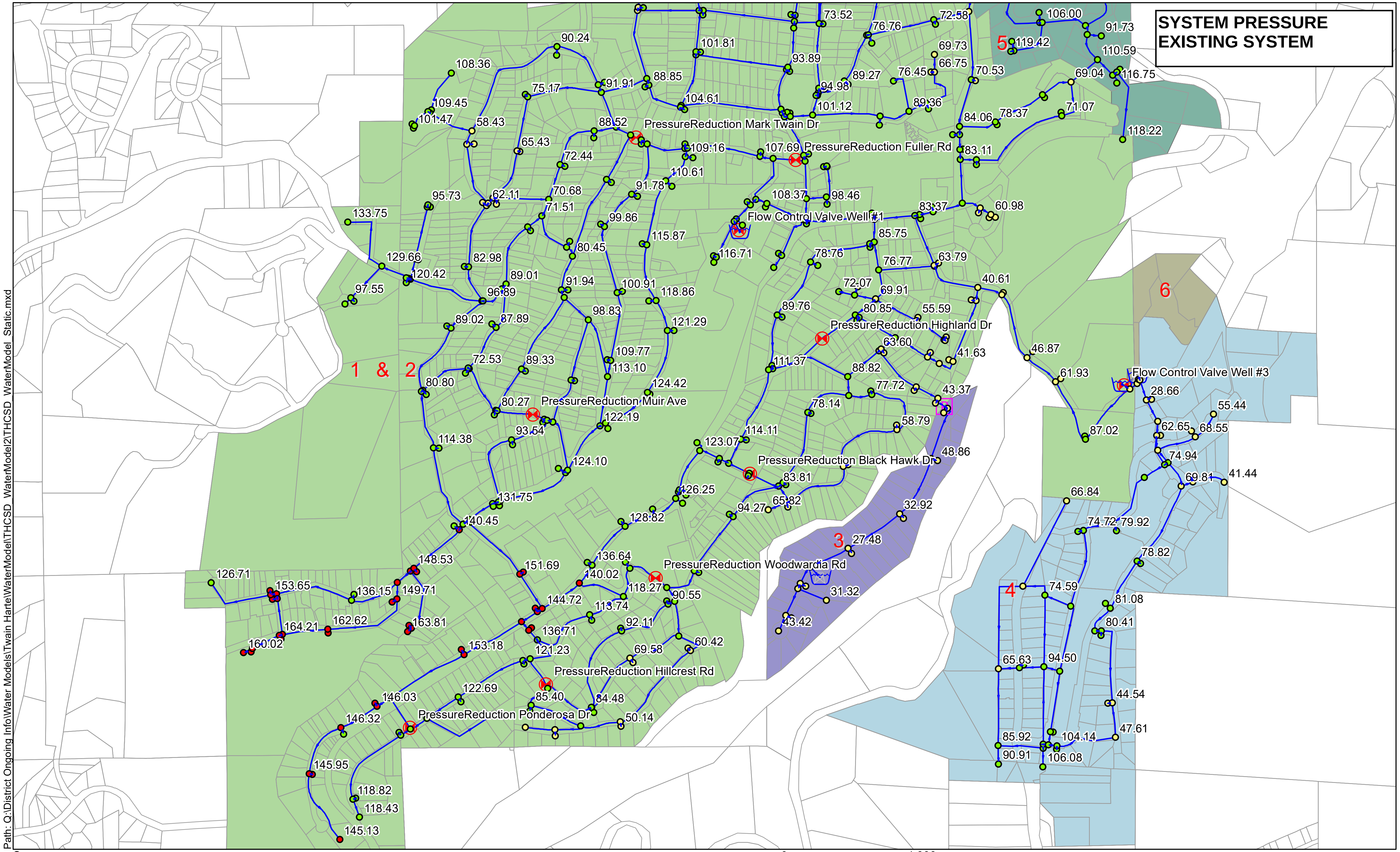
AVAILABLE FIRE FLOW EXISTING SYSTEM





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Source:

Legend

Junction

PRESSURE

- less than 70.00
- 70.00 ~ 140.00
- 140.00 ~ 164.65

Pressure_Zones

- <all other values>

PZ_Name

- 1 & 2
- 3
- 4
- 5
- 6

N

Kennedy/Jenks Consultants

TWAIN HARTE COMMUNITY SERVICES DISTRICT
WATER DISTRIBUTION SYSTEM
HYDRAULIC MODEL

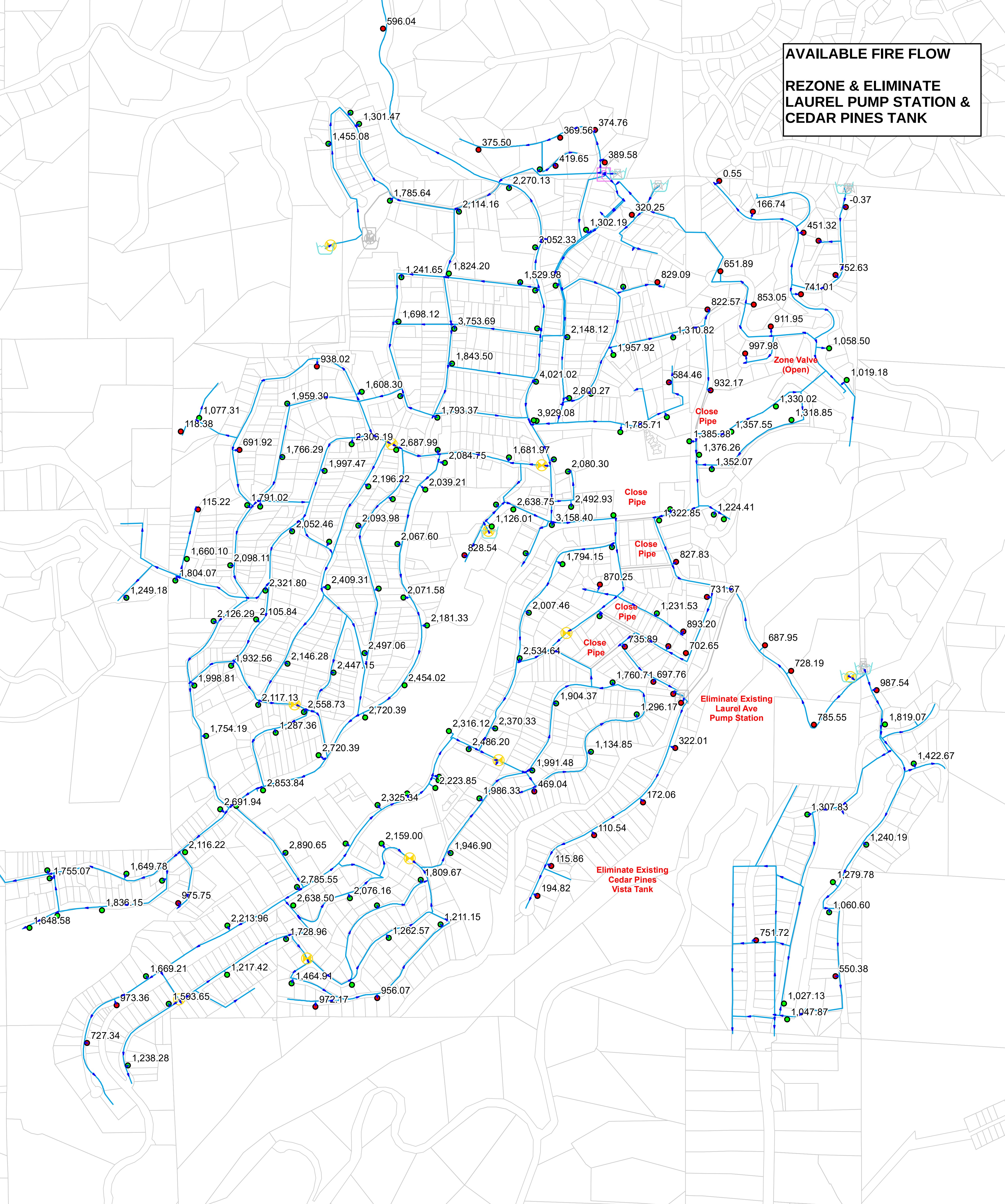
ZONE 1 & 2
PRV ANALYSIS
PEAK HOUR DEMAND

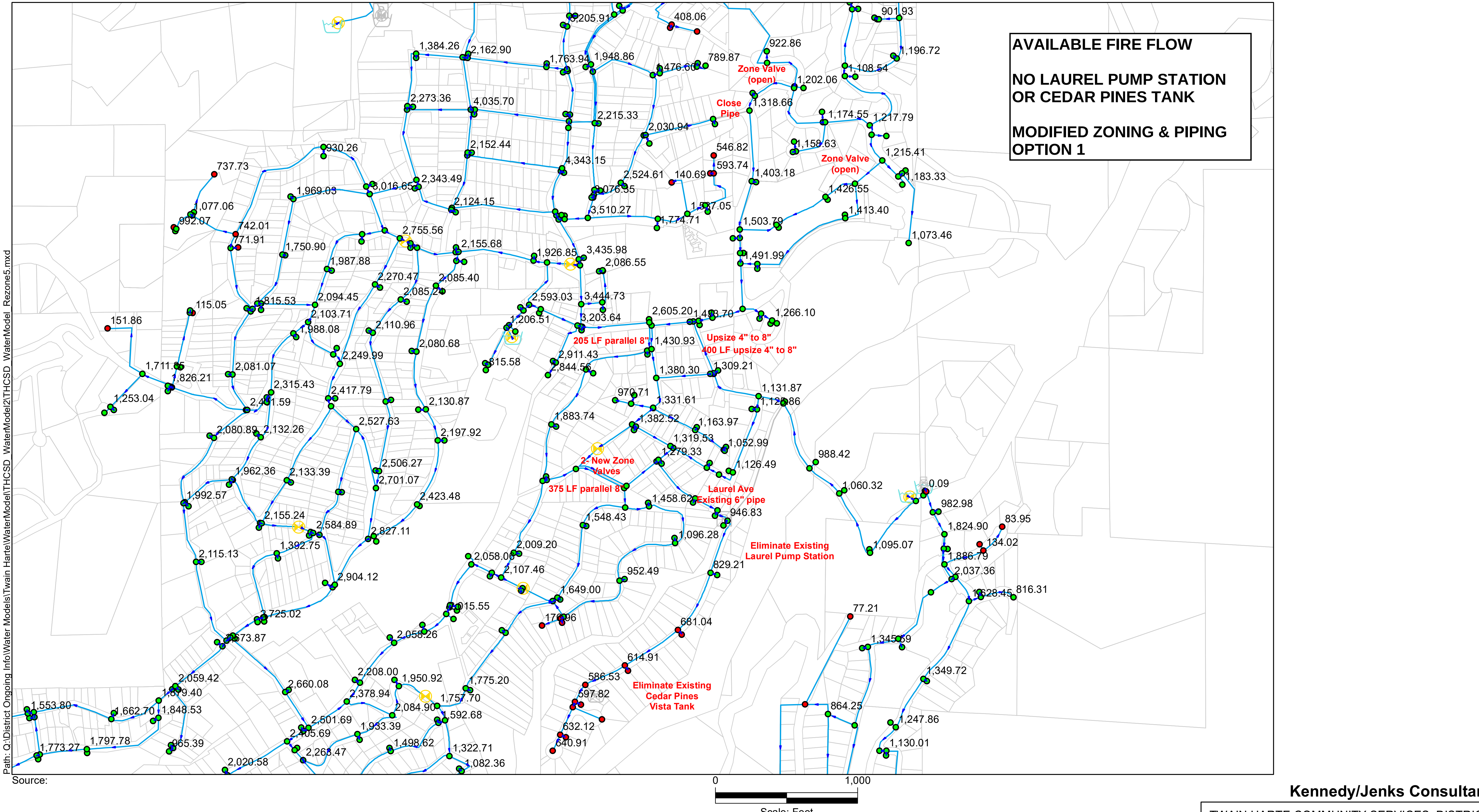
1870003

SCENARIO 1
FIGURE 2

AVAILABLE FIRE FLOW

REZONE & ELIMINATE LAUREL PUMP STATION & CEDAR PINES TANK





Source:

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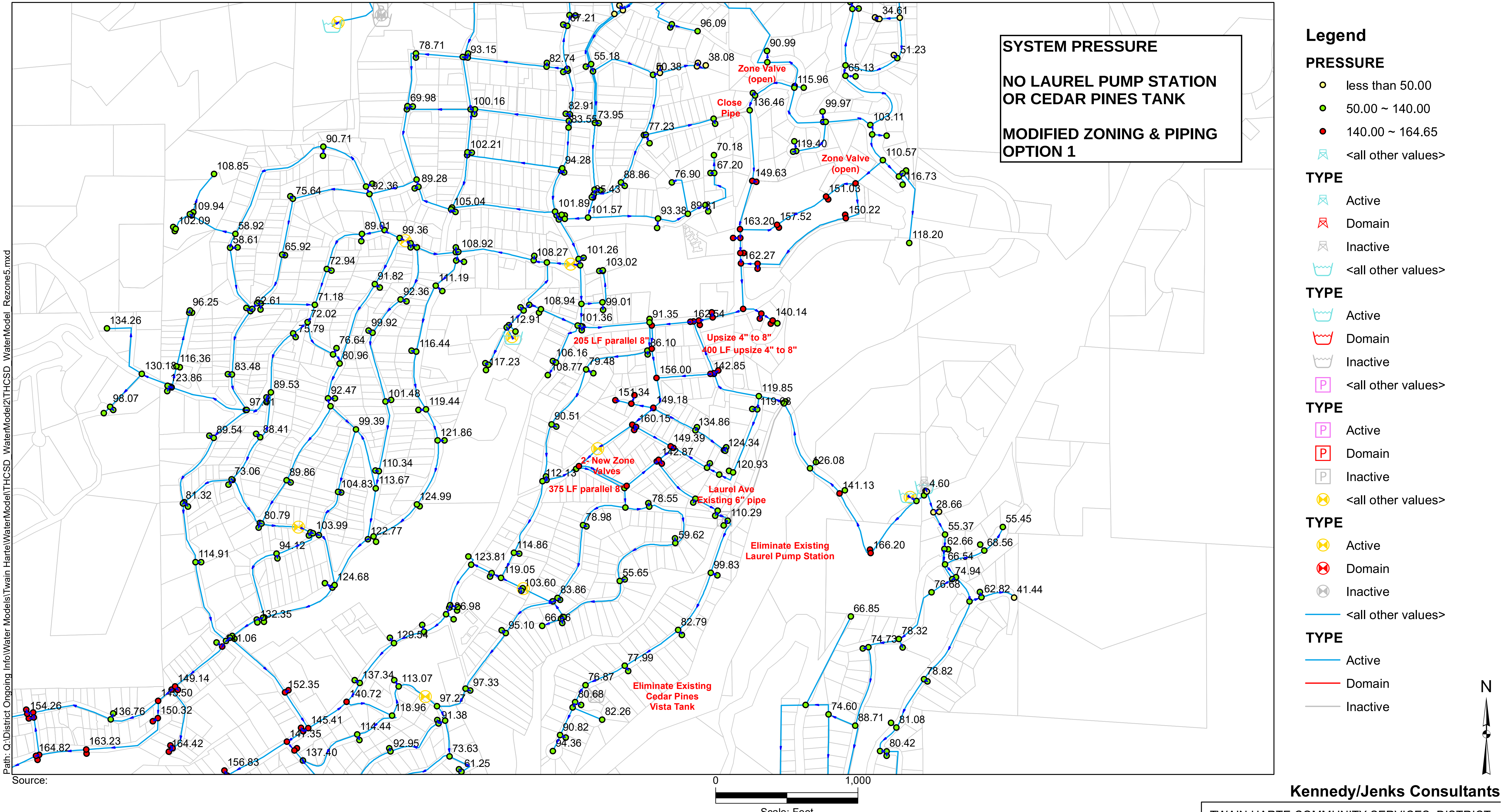
TWAIN HARTE COMMUNITY SERVICES DISTRICT
WATER DISTRIBUTION SYSTEM
HYDRAULIC MODEL

Max Day Demand with Available Fire Flow at 20 psi Lauel Ave. Existing 6" Waterline Exhibit

1870003
February 2021



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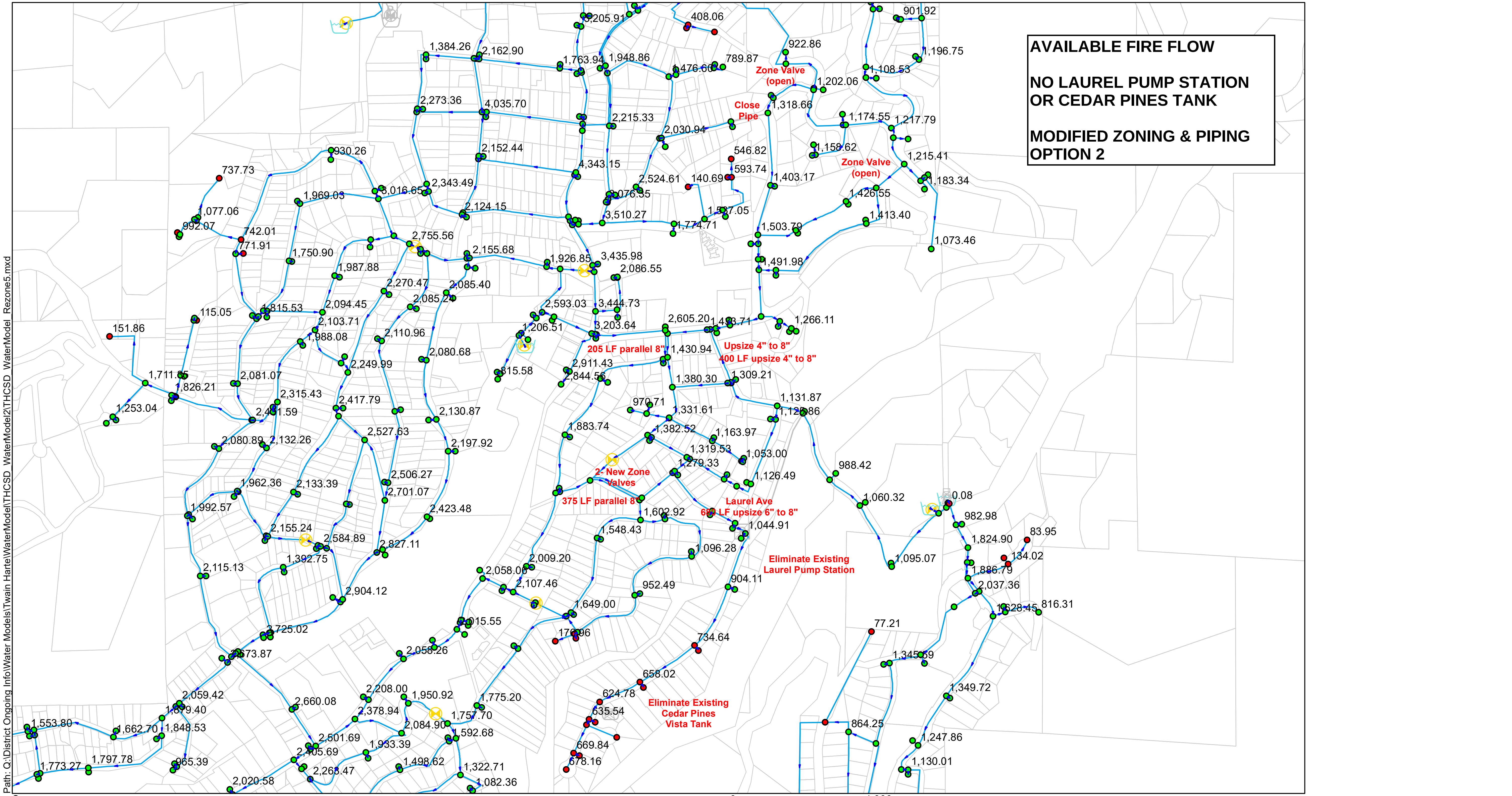
Kennedy/Jenks Consultants

TWAIN HARTE COMMUNITY SERVICES DISTRICT
WATER DISTRIBUTION SYSTEM
HYDRAULIC MODEL

Max Day Demand
Lauel Ave. Existing 6" Waterline
Pressure Exhibit

1870003
February 2021



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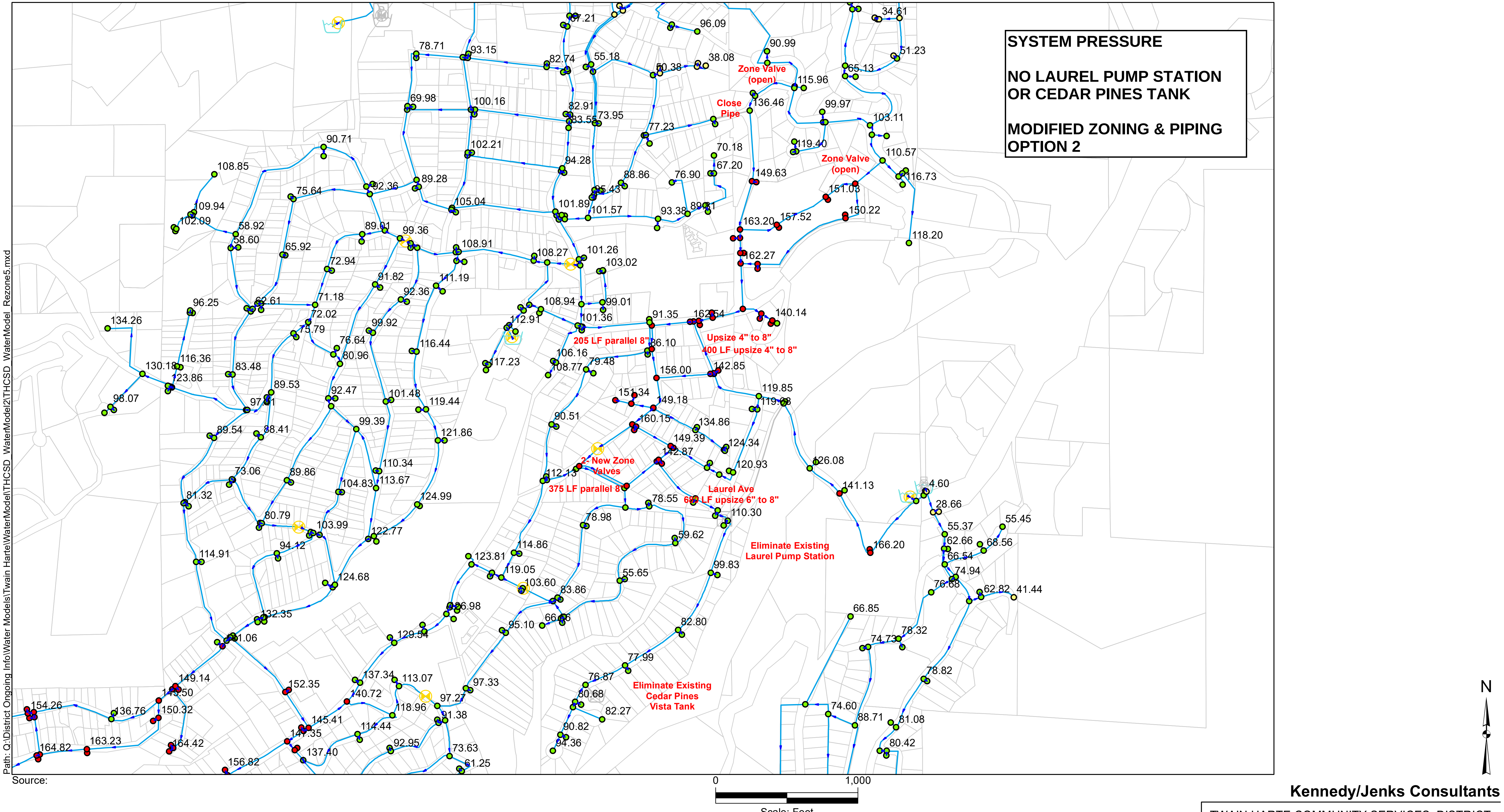
Scale: Feet

Kennedy/Jenks Consultants

TWAIN HARTE COMMUNITY SERVICES DISTRICT
WATER DISTRIBUTION SYSTEM
HYDRAULIC MODEL
Max Day Demand with
Available Fire Flow at 20 psi
Lauel Ave. Upsize 8" Waterline
Exhibit

1870003
February 2021



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Source:

Kennedy/Jenks Consultants

TWAIN HARTE COMMUNITY SERVICES DISTRICT
WATER DISTRIBUTION SYSTEM
HYDRAULIC MODEL

Max Day Demand with Lauel Ave. Upsize 8" Waterline Pressure Exhibit

1870003
February 2021

To: Tom Trott, P.E., Twain Harte Community Services District
Lewis Giambruno, Twain Harte Community Services District

From: Jeff Black, P.E., Black Water Consulting Engineers
Tyler Lee, E.I.T., Black Water Consulting Engineers

Subject: Twain Harte Community Services District
Condition Assessment Summary

Date: February 24, 2021

INTRODUCTION

As part of the Scope of Work for the Inflow/Infiltration Identification and Reduction Planning Project No. C-06-8408-110, Black Water Consulting Engineers, Inc. (Black Water) assisted with the solicitation of proposals to perform a Closed-Circuit Television (CCTV) survey of the Twain Harte Community Services District (THCSD) sanitary sewer collection system. Concurrent with the CCTV survey, manhole (MH) surveys were performed. This technical memorandum (TM) provides an overview of the CCTV and MH surveys and describes the methodology used to analyze the data. The results of the analysis will be used to assist with the development of criteria for a risk model that will be used to refine and prioritize capital projects for a long-term Capital Improvement Plan to reduce Inflow and Infiltration (I&I).

Funding for this project has been provided in full or in part through an agreement with the SWRCB. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

REFERENCES

Engineering reports and documents reviewed and referenced in this TM include the following:

[1] Planning Project No. C-06-8408-110 Attachment 1 Plan of Study, October 2018.

INVENTORY DATABASE

The first step in a condition assessment is the review of existing data. The existing data provided is comprised of notes prepared by operations staff, geographical information, flow monitoring, and as-built records. A review of the existing information is used for and followed by prioritizing the CCTV inspections.

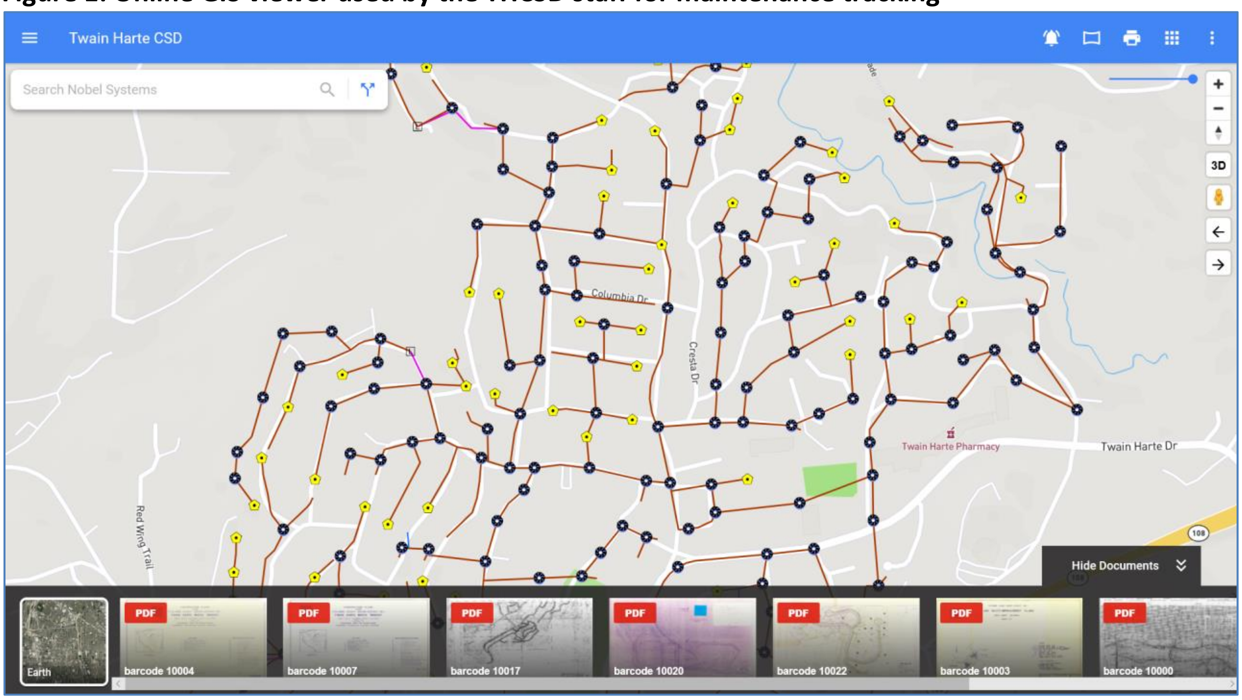
THCSD uses Geoviewer, an online Geographic Information System (GIS) based operations management program, to record regular maintenance and operations activities conducted by THCSD staff (See **Figure 1**). Horizontal and vertical data based on survey conducted in 2004 by Northstar Engineering Group had been entered into the program and was reviewed by Black Water. THCSD had also entered detailed information on construction projects into the program since the survey.

In addition to the physical data, the experiences from the staff at THCSD have provided abundant guidance on problematic areas/collection lines. Unlike many collection systems in the Central Valley, THCSD has steep reaches and resides in a highly forested area. As a result of the steep reaches, solids can separate from the wastewater stream and deposit in the collection system. The dense trees and brush throughout THCSD cause frequent root intrusion to both MHs and pipelines. The staff at THCSD aided in identifying lines that require frequent cleaning and maintenance.

THCSD has an established MH naming system for their collection system. MH's are identified as D-manhole (DMH), manhole (MH) or standpipe (SP) followed by the respective numbering. Lampholes and cleanouts are labeled as LH with the respective numbering system.

About two-thirds of the pipes in the sewer collection system had previously been numbered. Starting from the existing system, the remaining pipes were numbered.

Figure 1: Online GIS viewer used by the THCSD staff for maintenance tracking



PRIORITIZING ASSETS FOR INSPECTION

To ensure the budget afforded by the State for this task was optimized, the existing infrastructure was prioritized based on the following criteria:

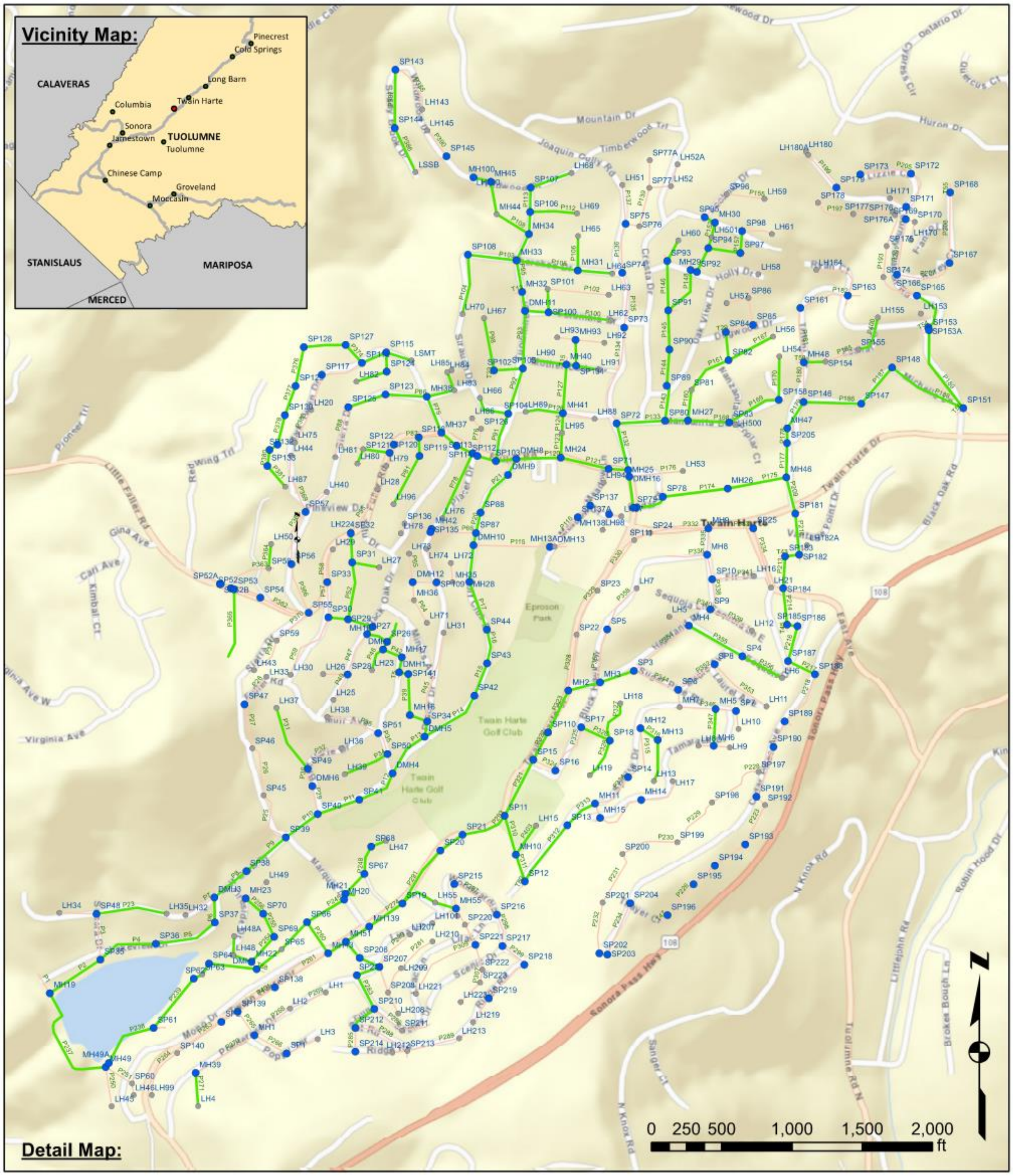
- High quantity of flow (The flow is proportional to the number of equivalent single-family residences [ESFRs] affected by a failure)
- Excessive or frequent maintenance issues (Issues may indicate existing and/or potential future defects in the pipe)
- Close proximity to waterways
- Reverse Slopes (Sags and reverse slopes accumulate solids and can cause plugged lines and exfiltration)
- MH with difficult accessibility (These MHs receive infrequent maintenance)

The system was divided into two categories based on the aforementioned priorities. The first category is comprised of lines with high priority. The second category was not CCTV'd and represents a low priority.

Figure 2 displays the extent of the CCTV. The total amount of linear ft CCTV'd was 48,364 ft (CCTV is shown as green in **Figure 2**).

CCTV MH surveys were performed for sections. Where time allowed additional manholes outside of the CCTV scope of work were also surveyed. Lastly, MH's not surveyed in roadways were evaluated using Google Earth for their location relative to drainage swales and ephemeral streams. All MHs that were identified and included in the study either through Google Earth or MH survey are shown in blue in **Figure 2**. The total number of MHs identified and evaluated using these methods is 127 MH Surveys, 92 Google Earth surveys, and 23 where only CCTV imaging was available. All combined, this accounts for 85% of the MHs in the THCSD system.

Figure 2: Categorization of the existing CCTV infrastructure before the inspection



PIPELINE INSPECTIONS

THCSD received bids for the CCTV inspection and the contract was awarded to Liberty Pipelines in December 2019. A preliminary meeting to discuss the scope of the project was conducted with staff from THCSD on January 10th, 2020 at the THCSD office. At this meeting, it was decided that THCSD personnel would perform jetting services in front of the Liberty Pipeline inspection team. Following the commencement of inspections on January 27, 2020, several lines were cleaned by THCSD and then inspected by Liberty Pipelines. On or around February 12, 2020, the camera used by Liberty Pipelines required repair. During this repair period, no CCTV inspections were performed. Liberty Pipelines was able to commence the inspection on March 24, 2020. Upon commencement of the inspection, the novel coronavirus had reached the United States and there was a statewide stay-at-home order in place. Concerns over the spread of coronavirus limited THCSD staff ability to perform only flushing services as opposed to the original jetting. As a result of the different cleaning methods, several lines that were simply flushed had observations of root intrusions and root balls. As a result of less than optimal cleaning methods, small and medium root intrusions were disregarded. The final deliverable was completed on November 4, 2020.

The CCTV inspections were performed following the National Association of Sewer Service Companies Pipeline Assessment Certification Program (NASSCO PACP) methodology. The NASSCO PACP method allows for the identification and scaling of defects based on priority. PACP by NASSCO is separated into two sections: the first being structural observations, and the second being operations and maintenance (O&M) observations. Structural observations are items that require repair or replacement. Structural defects would include collapsed pipes, cracked pipes, joint offsets, deformed pipes. O&M observations indicate actions that can be resolved through additional cleaning or flushing of the collection system. O&M conditions include root deposits, vermin, and grease buildup among a list of other observations. Additional information on the PACP methodology can be found in **Attachment H**.

Each of the observations, both structural and O&M, was assigned a grade. **Table 1** describes each grade category. The collection of grades on each line are combined into an index for each pipe section. The index takes the sum of all the grades per pipe and divides it by the number of observations per pipe. The pipe segment indexes are then used as a numerical method to prioritize repairs and maintenance schedules based on CCTV observations.

Table 1: Condition grade categories used in PACP

Grade	Description
5	Defects requiring immediate attention
4	Severe defects that will become Grade 5 defects within the foreseeable future
3	Moderate defects that will continue to deteriorate
2	Defects that have not begun to deteriorate
1	Minor Defects

Two images were provided of each condition and the CCTV files were provided to THCSD as a Microsoft Access Database on a portable hard drive. Three reports were generated which included the inspection summary, pipe run reports, and observations reports. Attached to this report (**Attachment F**) is the pipe run report with photos.

The CCTV data was combined and sorted using ArcMap 10.5.1. ArcMap allows for the amalgamation of the photographic, tabular, and geospatial data. The data were analyzed using four scoring systems. The PACP structural index, O&M index, and overall Index. The fourth scoring system used to evaluate the CCTV inspections was the likelihood of failure (LOF).

The structural index ranges from 1 to 5 with 1 being a pipe with minor defects (a score of zero indicates no structural defects detected). A high structural index indicates frequent observations such as pipe collapse, cracks, deformed pipes, holes in pipes, and joint offsets. In determining sources of infiltration, all of these structural defects are potential sources.

The O&M index ranges from 1 to 5 with 1 being minor observations (a score of zero indicates no O&M defects detected). A high O&M index may indicate frequent maintenance issues and includes such observations as root intrusion, infiltration, obstacles, sediment in the pipe, and vermin. While not every item in O&M will result in infiltration, the frequent observation throughout THCSD is that pipes with root intrusion and in close proximity to surface waterways can generate infiltration.

The third index is the overall index which ranges from 1 to 5 with 1 being minor defects. This index combines the two observation methods of structural and O&M. The sum of all the defects is divided by the number of defects.

LOF is based on the Quick Rating System and shows the priority of repairs. The Quick Rating System can get complex and a detailed description is outlined in **Attachment H-PACP methodology**. The LOF builds on the Quick Rating System. LOF ranges from 1 to 6 with 6 needing immediate repairs. Any collection lines with a grade 3 or higher rating were evaluated. In short, LOF takes the first two numbers of the Quick Rating and divides it by 10. The LOF has some additional parameters that build on it that guarantee that the value will always range from 1.0 to 6.0.

Finally, while the PACP rating method works well, there are many cases where a defect receives a lower grade or no grade proportional to the problem it presents (for example, bends or obstructions preventing CCTV often receive no rank). Items that were previously identified as needing immediate repair were also determined regardless of assigned ratings or indexes.

Each of these scores has limitations but a combined use of the three indexes and the LOF allows for the isolation of problematic lines. A map of the televised lines using each of these review strategies can be found in the following attachments:

- Attachment A – Structural Index
- Attachment B – O&M Index
- Attachment C – Overall Index
- Attachment D – LOF

MANHOLE INSPECTIONS

The MH inspection was performed by THCSD and Black Water staff to assess the structures condition and identify potential sources of I&I. Manhole inspections were performed in two periods: November 24 – 26 and February 4 – 5. Notes from the MH Inspection can be found in **Attachment G** of this TM.

MH Inspections evaluate MH type, condition, observations on I&I, location relative to roadway or surface water, flow path, depth of flow, and additional observations.

THCSD makes use of inflow dishes under MH lids to reduce inflow through vent holes and between the lid and frame. Inflow dishes have been demonstrated to reduce surface inflow but do not provide a completely watertight seal. A significant surface inflow during storm events is estimated to occur in manholes located in drainage swales and ephemeral streams. Manholes without dishes or that are located in areas subject to submergence or sheet flow will have significant inflow.

Figure 3 demonstrates the importance of location relative to surface runoff. Both images show surface runoff from either the street or drainage swale. In both cases, surface runoff can be seen entering manholes.

Figure 3: Surface runoff entering manholes in poor locations

Groundwater in and around THCSD typically has high concentrations of iron and manganese. The concentrations of iron will cause a rust color to appear on the concrete at locations that experience I&I. Locations that showed this rust coloring on the interior concrete walls are a telltale sign of infiltration. The majority of manholes in the THCSD collection system are shallow and constructed of irrigation standpipe or two-foot inside diameter (ID) concrete pipe. Although these pipes are easy to install and have continued in operation, the sidewalls, bench, and frame are connected through cold joints. These cold joints are sources of I&I during storm events. (See **Figure 4**). Cracks or breaks in pipe connections to manholes are also potential sources of I&I. The MH inspection evaluated THCSD's manholes to best determine and rate these sources of I&I.

Figure 4: L buildup of iron deposits from frequent infiltration at a cold joint. R cracked MH lid.

DATA ANALYSIS

Manhole Inspection Results

Figure 5 shows the MHs surveyed with their priority rating. Since this evaluation aims to identify sources of I&I, high priority (red) MHs either have defects in need of immediate repair or high inflow. Medium priority items (orange) are MH's with a significant amount of inflow and in need of repairs. Low priority (yellow) represents either minor inflow and or minor repairs.

Table 2 presents a list of MHs that were identified as potential sources of high I&I or in need of immediate repair. Repair options are listed in the table along with location and a description of the observation. Additional manholes with lower I&I sources and lower priority are included as part of **Attachment G**.

Figure 5: MH's showing urgency of repair. Red is a high priority, Orange medium priority, yellow low priority, and green no defects observed (See Attachment__).

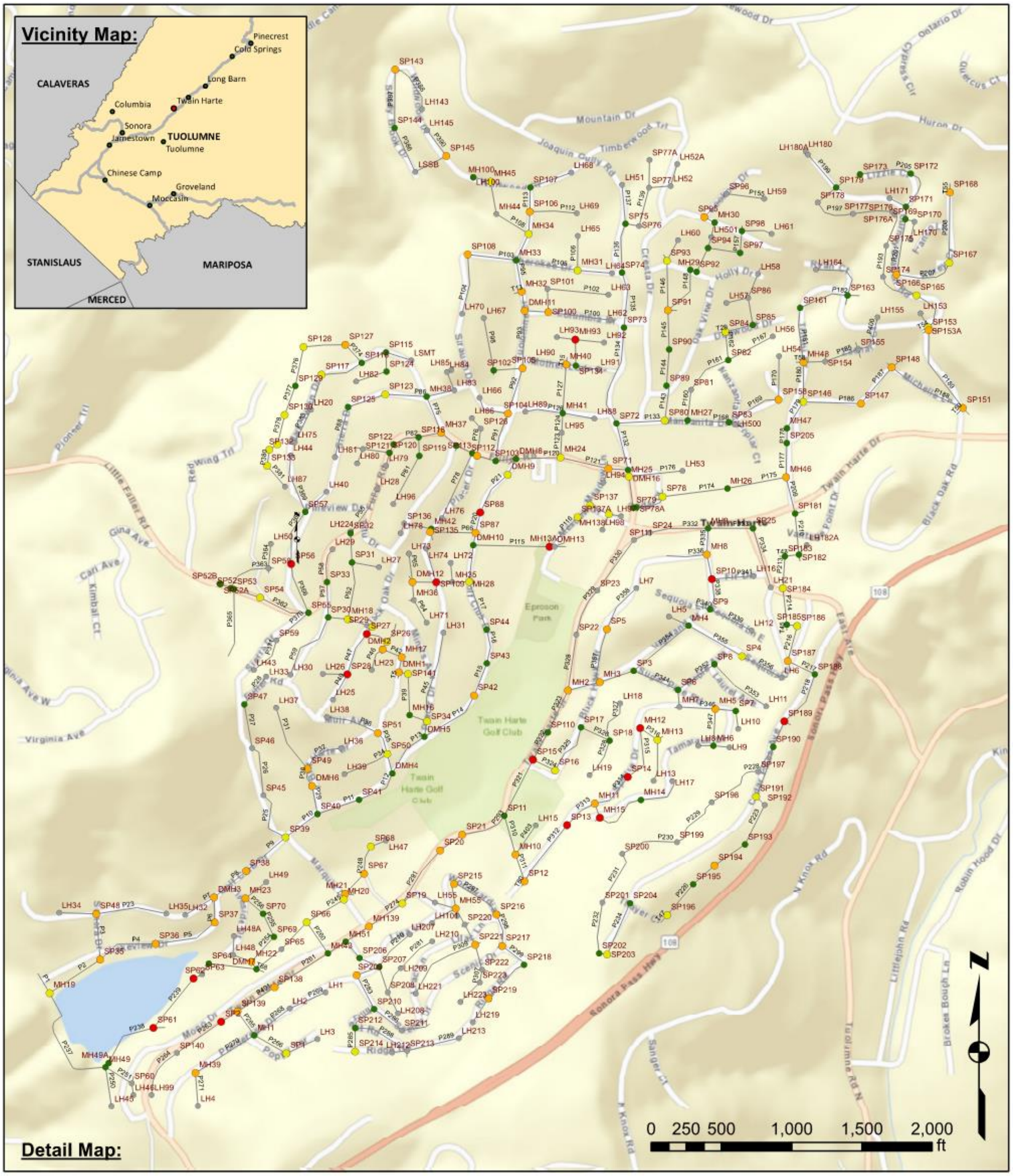


Table 2: Summary of MH's potentially contributing to I&I

MH #	Location	I&I Rating (1-5)	Description of observation	Possible solutions	Timeline
MH12	Uphill of driveway 22727	4	In drainage swale, bad location significant root intrusions on inlet channel. Raise MH 3" switch to eccentric cone and reconstruct inlet	Replace concentric cone w/ eccentric cone to move rim out of swale and up the embankment. Raise MH	High Priority
MH13A		1	MH raised, barrel and bench condition, the rim is loose	Replace Frame and Rim	High Priority
MH15		5	MH is in the low spot of the cul de sac. The drainage channel appears higher than the MH elevation.	Lower drainage channel. Remove berm	High Priority
MH93		1	The broken section in the lower barrel. A potential source for infiltration.	Damaged MH, Replace	High Priority
SP10	Intersection of Fir and Highland	3	Ring and MH lid fused. The ring came up when pulling the lid. No inspection performed	Replace MH ring and Lid	High Priority
SP109		5	Bad location in drainage swale at low point	Bolt Lid, relocate MH	High Priority
SP13	Uphill of Driveway 22623 Spruce Dr	5	Inflow from drainage swale.	Relocate Mh or add SD channel	High Priority
SP14	22695 Spruce Dr (Across street to the mailbox of address 22678 Spruce Dr)	5	Bad location significant inflow, the manhole is standpipe w/ cracked vcp as the channel	Move Manhole uphill to the driveway of 22695 spruce. Can raise Mh and no damage of plow	High Priority
SP15		5	Bad location. CCTV photo show possible rust from infiltration	Raise relocate or bolt. Possibly construct SD channel	High Priority
SP189		5	Significant puddle around MH. Ring slightly elevated. Switch to eccentric cone	Switch to eccentric to get MH away from the low point. Adjust asphalt. Bolt MH or relocate	High Priority
SP2		5	MH in a drainage swale	Move MH construct SD channel or Bolt lid	High Priority
SP27			MH not located during Inspection. Visible from Google Earth. MH was submerged under a puddle at the time of inspection. Significant Inflow was observed downstream of this MH.	Raise MH. Replace with Eccentric Cone to remove from the roadway. Or add an SD culvert under the roadway to remove the puddle.	High Priority
SP28		5	MH in drainage swale.	Relocate raise or bolt MH	High Priority
SP56		5	MH is in drainage swale in the lowest point	Construct culvert under the driveway or relocate or bolt MH	High Priority
SP61	Along Path by Lake	1	Heavy I&I observed at connections	Replace Manhole, not in the roadway	High Priority
SP62	22410 Mono Dr	1	Frame broken raise and repair	Replace Frame and Raise, not in the roadway	High Priority
SP88	22982 Golf Club Dr	3	Large Rust Buildup after lowest joint in the barrel.	Grout or Replace MH to eliminate I&I	High Priority

Pipeline Inspection Results

The lines requiring repair/replacement based on the aforementioned criteria can be seen in **Attachments A** through **D**. These findings are summarized in **Table 3**. The CCTV inspections for the pipes identified in **Tables 3, 4 and 5** can be seen in **Attachment E**.

Table 3: Pipes Recommended for Repair/Replacement

Pipe #	Struc Index	O&M Index	Overall Index	LOF	Priority	Length	Size
		Structural					
P161	**5.00**	1.00	2.33	**5.1**	High	350’	6”
P249	**3.50**	1.69	1.93	**5.1**	High	113’	6”
		Overall					
Pipe #	**Struc Index**	**O&M Index**	**Overall Index**	**LOF**	**Priority**	**Length**	**Size**
P109	0.00	**4.00**	**4.00**	0	High	269’	6”
P108	2.00	**4.00**	**4.00**	2.1	High	235’	6”
P177	0.00	**4.00**	**4.00**	1	High	243’	6”
P189	1.00	**4.00**	**4.00**	1.2	High	636’	6”
P209	0.00	**4.00**	**4.00**	1	High	269’	8”
P214	0.00	**4.00**	**4.00**	1	High	261’	8”
P216	0.00	**4.00**	**4.00**	1	High	258’	8”
P238	0.00	**4.00**	**4.00**	1	High	440’	10”
P239	0.00	**4.00**	**4.00**	1	High	452’	10”
P241	0.00	**4.00**	**4.00**	1	High	92’	10”
P242	0.00	**4.00**	**4.00**	1	High	341’	10”
		Operations and Maintenance					
Pipe #	**Struc Index**	**O&M Index**	**Overall Index**	**LOF**	**Priority**	**Length**	**Size**
P178	1	**4**	2.5	1.1	High	106’	6”
		Likelihood of Failure					
Pipe #	**Struc Index**	**O&M Index**	**Overall Index**	**LOF**	**Priority**	**Length**	**Size**
P4	2.50	1.00	1.19	**3.1**	Medium	427’	10”
P150	3.00	1.60	1.73	**3.1**	Medium	193’	6”
P157	2.33	1.40	1.52	**4.1**	High	152’	6”

Several structural defects are recommended for immediate repair regardless of the scores. A list of these items are as follows:

- Infiltration
- Joint Offset Large
- Pipe Collapse
- Missing Wall
- Inaccessible Pipes

A list of the pipes requiring replacement based on singular observations is shown in **Table 4**.

Tables 3 and **4** Provide a summary of pipes in need of repair or replacement. In addition to these pipes, the pipes shown in **Table 5** need repair or improvement projects, but their priority is lower than the pipes from **Tables 3** and **4**. Many of the lines shown in **Table 5** have bends that make portions of the pipe segment inaccessible to CCTV or maintenance.

Table 4: Pipes with Major Structural Defects

Pipe #	Immediate Repair Required Description	Priority	Length	Size
P107	Collapsed Pipe	High	206’	6”
P112	Crack Circumferential	High	334’	6”
P147	Crack Circumferential	High	168’	6”
P365	Crack x2	High	488’	6”
P9	Cracks top of Pipe missing	High	374’	10”
P85	Cracks x2	High	201’	6”
P310	Cracks x2	High	288’	6”
P132	Infiltration Observed	High	352’	8”
P245	Infiltration Observed	High	309’	6”
P291	Infiltration Observed	High	472’	10”
P175	Joint Offset Large x2	High	425’	8”
P312	Joint Offset Large x2	High	501’	6”
P375	Roots Ball Unknown by Lift Station	High	297’	6”
P8	Joint Offset Large	High	295’	10”
P54	Joint Offset Large	High	207’	6”
P87	Joint Offset Large	High	279’	6”
P127	Joint Offset Large	High	350’	6”
P143	Joint Offset Large	High	258’	6”
P145	Joint Offset Large	High	278’	6”
P148	Joint Offset Large	High	359’	6”
P152	Joint Offset Large	High	108’	6”
P167	Joint Offset Large	High	359’	6”
P260	Joint Offset Large	High	267’	10”
P313	Joint Offset Large	High	353’	6”
P356	Joint Offset Large	High	319’	6”
P396	Joint Offset Large	High	246’	6”
T39	Joint Offset Large	High	52’	
P321	Joint Offset Medium x2	High	447’	8”
P52	Minor Crack	High	411’	6”

Table 5: Lower Priority Pipe Improvement Recommendations

Pipe #	Minor Repairs/Replacement Description	Priority	Length	Size
P170	Joint Offset Large or Bend	Medium	310’	6”
P80	Bend (pipe inaccessible)	Medium	132’	6”
P124	Bend (pipe inaccessible)	Medium	140’	6”
P144	Bend (pipe inaccessible)	Medium	259’	6”
P156	Bend (pipe inaccessible)	Medium	231’	6”
P164	Bend (pipe inaccessible)	Medium	194’	6”
P237	Bend (pipe inaccessible)	Medium	853’	10”
P284	Bend (pipe inaccessible)	Medium	199’	6”
P294	Bend (pipe inaccessible)	Medium	282’	6”
P328	Bend (pipe inaccessible)	Medium	288’	8”
P385	Bend (pipe inaccessible)	Medium	227’	6”
P386	Bend (pipe inaccessible)	Medium	346’	6”

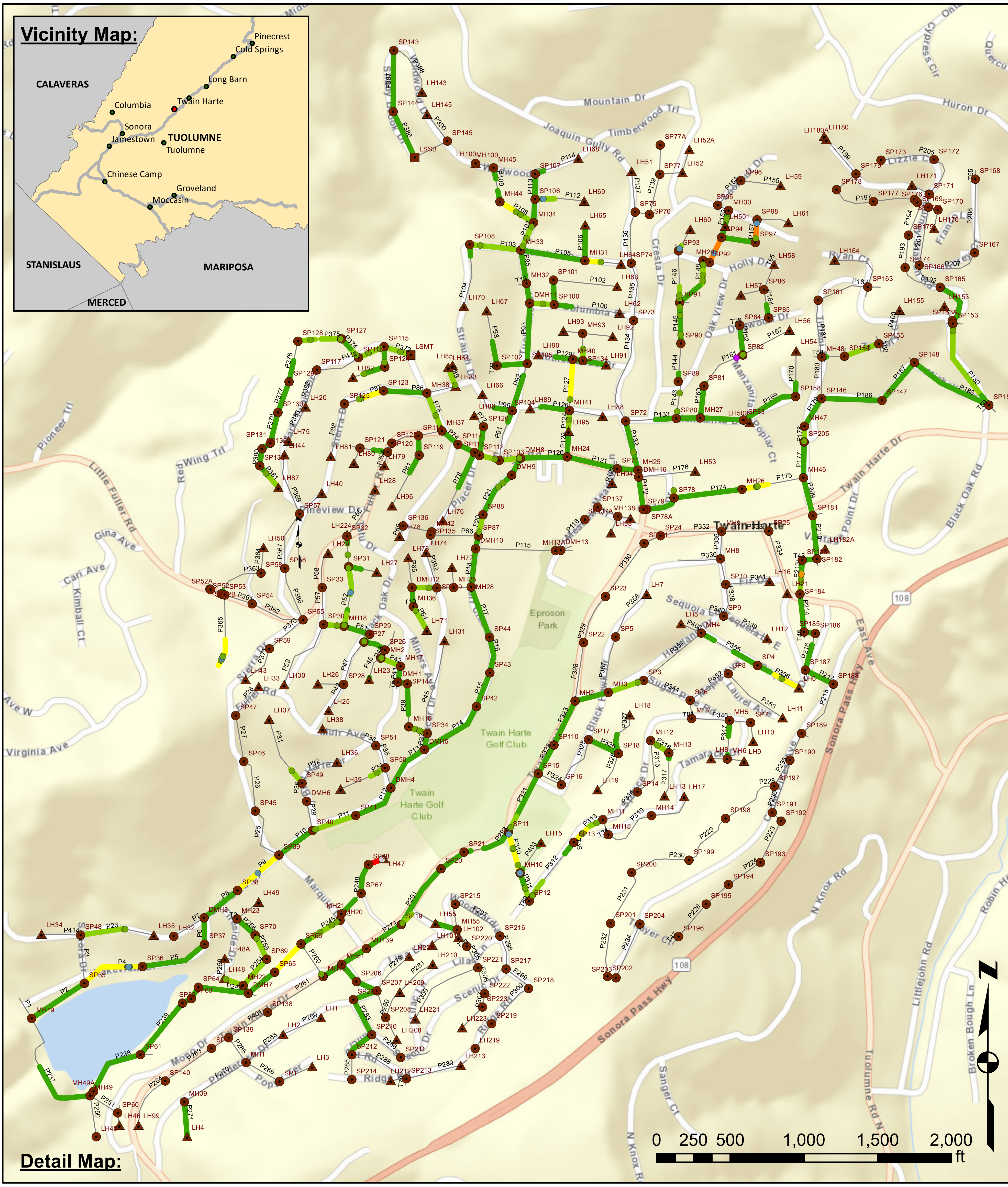
In addition to the previously discussed CCTV and MH Inspection results, the creek crossing between MH22 and DMH7 was observed to have erosion on the north side of the concrete encasement. River crossings are extensive, and it is recommended that this erosion be further evaluated in the Project Engineering Report.

Additionally, several sewer pipes are adjacent to Twain Harte Lake. It is recommended that pipes adjacent to bodies of water currently constructed of Vitrified Clay Pipe be replaced with PVC, HDPE, or ductile iron to limit infiltration from the perennial high groundwater.

SUMMARY

A CCTV and manhole survey were completed for portions of the THCSD sanitary sewer collection system. The data collected were analyzed to assess the condition of the system and identify deficiencies. The most common pipeline deficiencies identified included large joint offsets, cracks, infiltration, and root balls. Defects in several manholes included cracks, joint gaps, and locations where I&I is probable. The results of this condition assessment will be integrated into a risk model that will assist with developing a long-term Capital Improvement Plan which will be detailed in a Project Engineering Report.

ATTACHMENT A - CCTV STRUCTURAL INDEX RESULTS



Condition Observations

- Collapsed Pipe
- Cracked Pipe
- Deformed Pipe
- Hole in Pipe
- Joint Offset/Separation

Structural Index

- 0.00
- 0.01 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 5.00
- Not Inspected

Sewer Structures

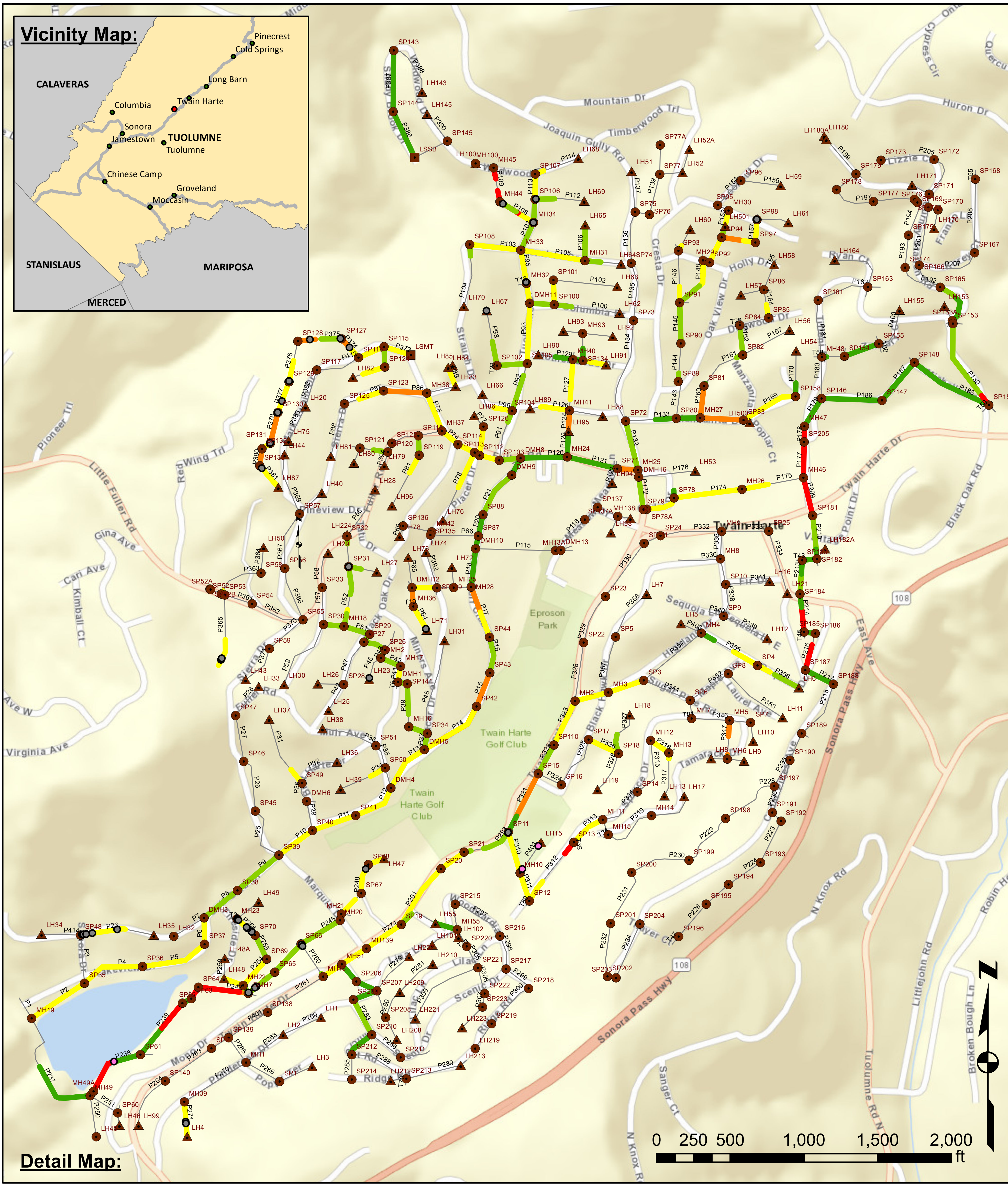
- LAMPHOLE
- LIFT STATION
- MANHOLE

TWAIN HARTE PARKS & RECREATION FIRE WATER SEWER COMMUNITY SERVICES DISTRICT

BLACKWATER CONSULTING ENGINEERS, INC.

I&I Identification Reduction Project
CCTV Structural Index

ATTACHMENT B - CCTV OPERATIONS AND MAINTENANCE



Condition Category

- Grout Test and Seal
- Vermin
- Deposits in Pipe
- Infiltration
- Obstacle

OM Index

- 0.00
- 0.01 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 5.00
- Not Inspected

Sewer Structures

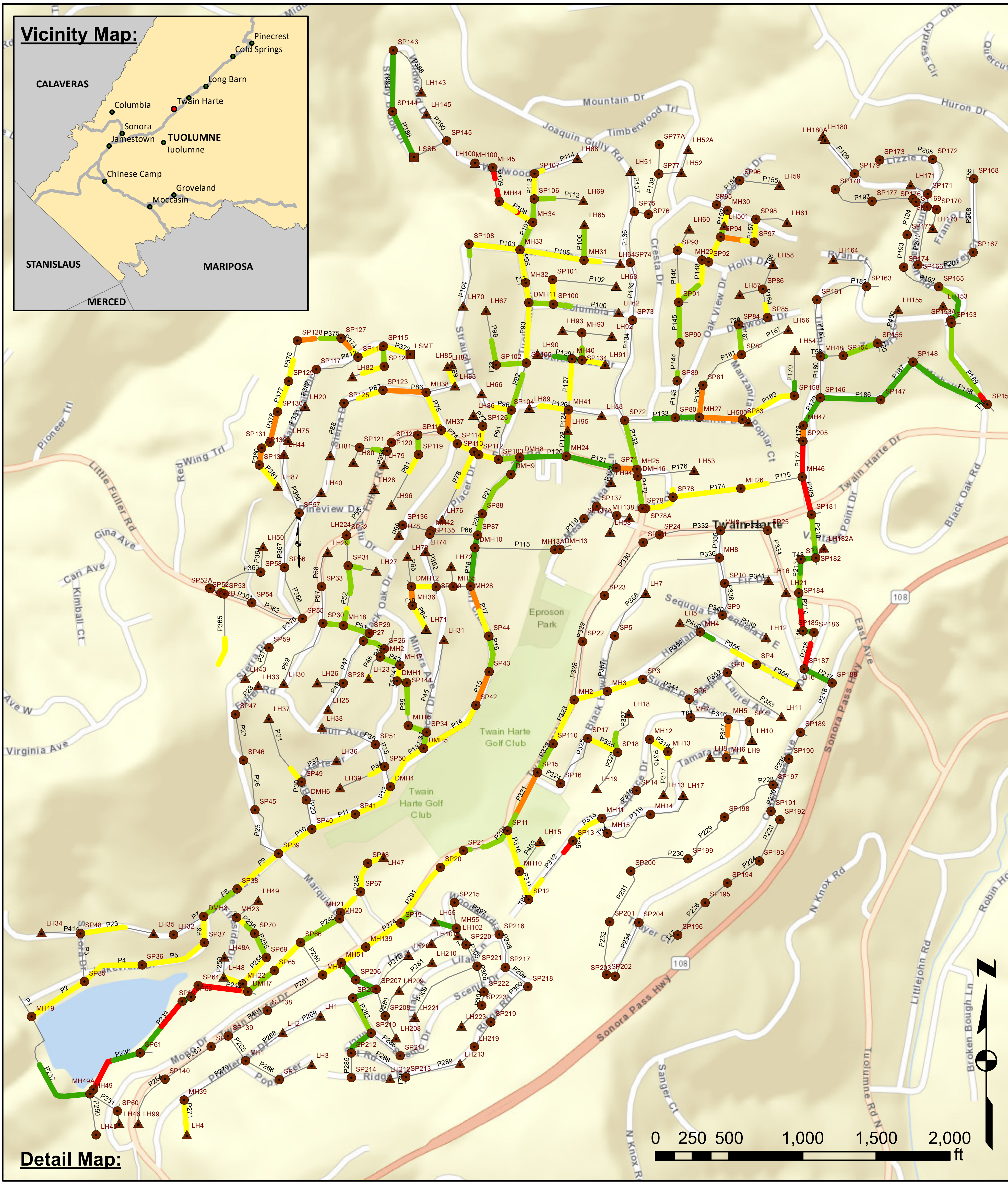
- LAMPHOLE
- LIFT STATION
- MANHOLE

TWAIN HARTE PARKS & RECREATION FIRE WATER SEWER COMMUNITY SERVICES DISTRICT

BLACKWATER CONSULTING ENGINEERS, INC.

I&I Identification Reduction Project Operations and Maintenance Index

ATTACHMENT C - CCTV OVERALL INDEX



Overall Index

- 0.00
- 0.01 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 5.00
- Not Inspected

Sewer Structures

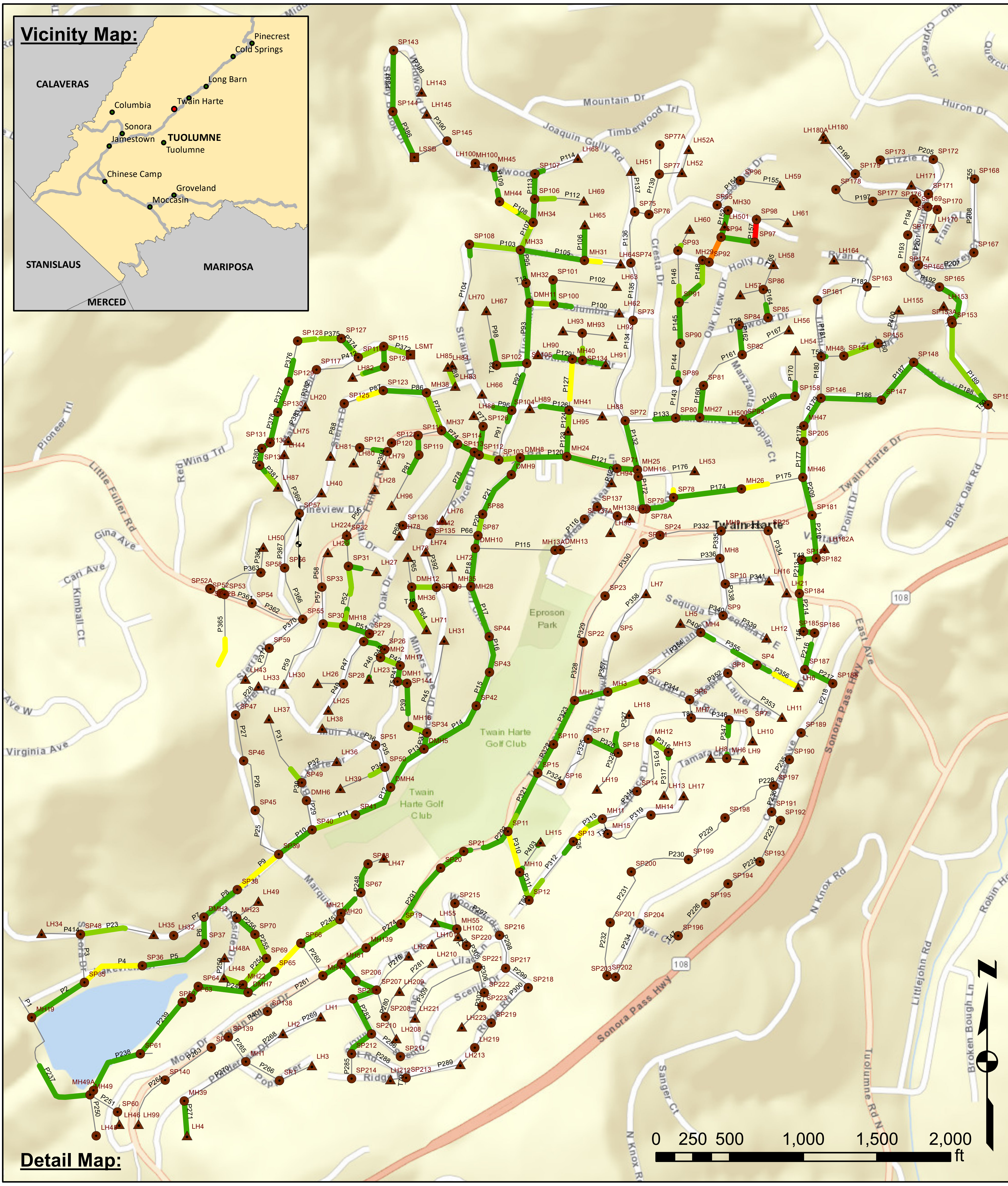
- LAMPHOLE
- LIFT STATION
- MANHOLE

TWAIN HARTE
PARKS & RECREATION
FIRE
WATER
SEWER
COMMUNITY SERVICES DISTRICT

BLACKWATER
CONSULTING ENGINEERS, INC.

I&I Identification Reduction Project
Overall Index

ATTACHMENT D - LIKELIHOOD OF FAILURE



LOF

- 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.001 - 4.00
- 4.01 - 5.00
- Not Inspected

Sewer Structures

- LAMPHOLE
- LIFT STATION
- MANHOLE

TWAIN HARTE PARKS & RECREATION FIRE WATER SEWER COMMUNITY SERVICES DISTRICT

BLACKWATER CONSULTING ENGINEERS, INC.

I&I Identification Reduction Project
Likelihood of Failure

To: Cheng Vue, State Water Resources Control Board (SENT VIA: EMAIL)

From: Jeff Black, P.E., Black Water Consulting Engineers, Inc.
Tyler Lee, E.I.T., Black Water Consulting Engineers, Inc.

Subject: **FINAL Twain Harte Community Services District**
(Planning Project No. C-06-8408-110)
Sherwood Forest Evaluation

Date: February 24, 2021

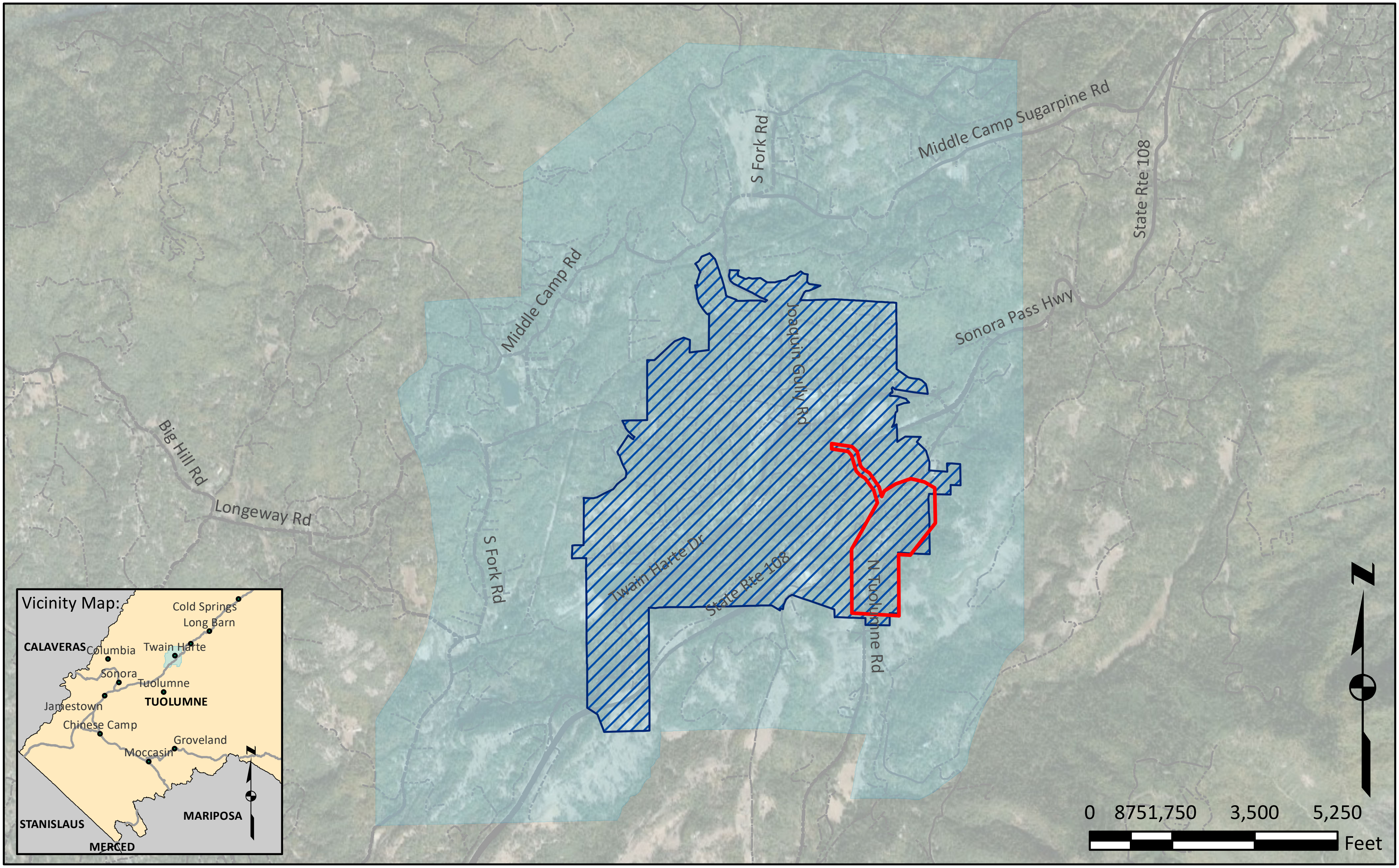
INTRODUCTION

This technical memorandum (memo) has been prepared as part of the Sherwood Forest Evaluation (Task 5) of the Twain Harte Community Services District (THCSD) Inflow/Infiltration Identification and Reduction Planning Project No. C-06-8408-110. This memo will describe the history and the limitations of the current on-site wastewater treatment systems (OWTS) at the Sherwood Forest community. Following the historical background is an evaluation of the potential for a gravity collection system connecting to the THCSD sewer. The evaluation will be based on maintenance requirements, design constraints, potential environmental impacts, and estimated construction costs. This memo will also present the project constraints and a recommended alternative.

BACKGROUND

Sherwood Forest is located southwest of Twain Harte in the county of Tuolumne, CA as shown in **Figure 1**. The Sherwood Forest development was constructed in 1964 and included Cedar Springs Road, King Arthurs Court, Little John Road, Broken Bough Lane, Robin Hood Drive, and Fallen Leaf Lane. After the initial development was constructed, additional houses were built along N. Tuolumne Rd. In this memo, the entire area will be referred to as Sherwood Forest or the Development. At the center of the Development, between Robin Hood Drive and Little John Road, is Turnback Creek with a perennial reservoir. The Development area is shown in **Figure 2**.

As a condition of the Development, each lot line has a 5-ft public utility easement (PUE). Each of the lots was constructed with independent OWTS. Since its approval and initial construction phase, the Development has continued to build-out as planned with each property owner independently maintaining an OWTS. As shown in **Figure 1**, Sherwood Forest is within the THCSD service area and has the potential to connect to the public sewer system. This technical memorandum will evaluate the potential of abandoning the individual OWTS in Sherwood Forest and connecting to the public sewer system.



TWAIN HARTE PARKS & RECREATION FIRE WATER SEWER COMMUNITY SERVICES DISTRICT

Figure1: Sherwood Forest Conceptual Collection System - Location Map

Author: Tyler Lee

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Project Area

THCSD Boundary

THCSD Sphere of Influence

Roads

Major Roadways

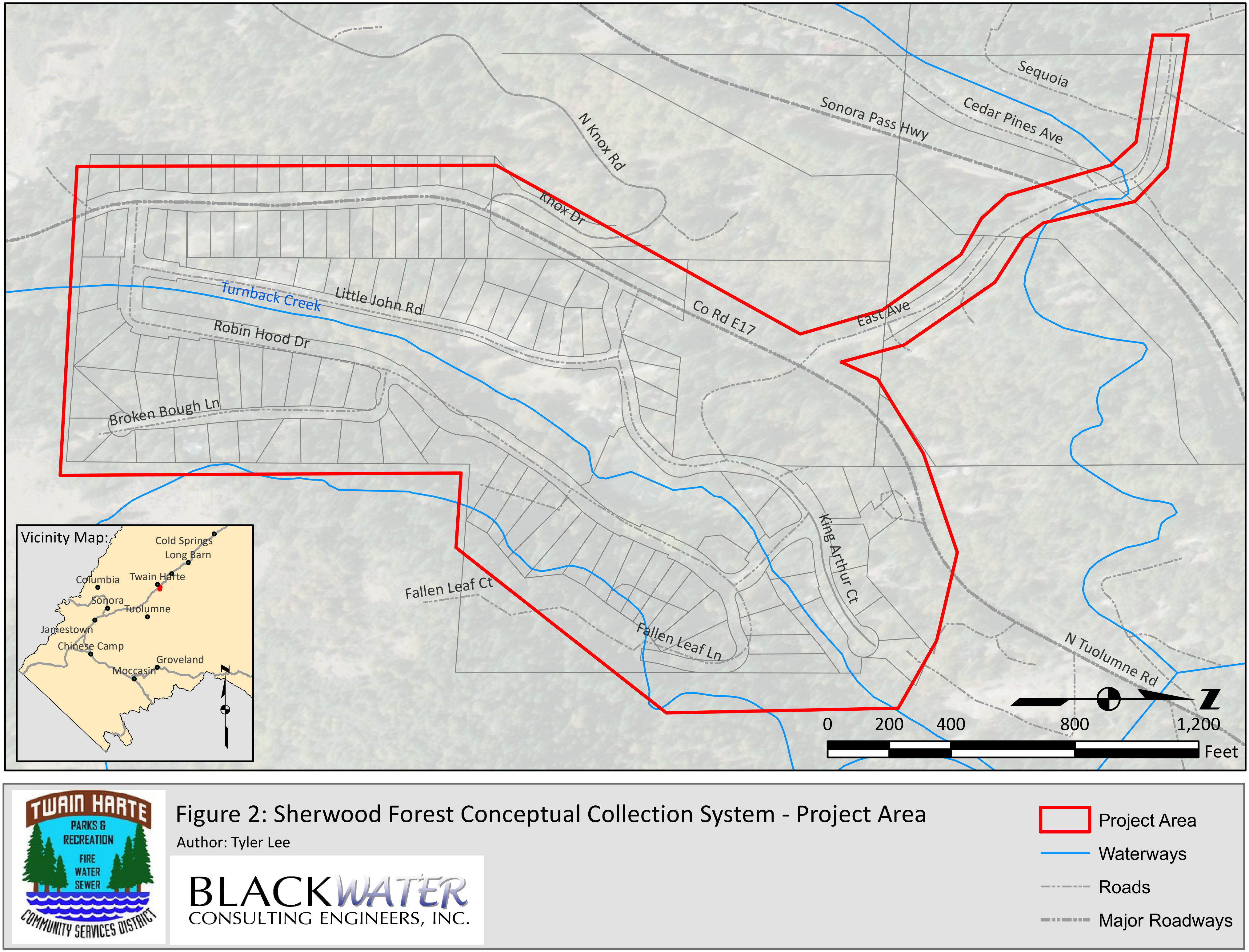


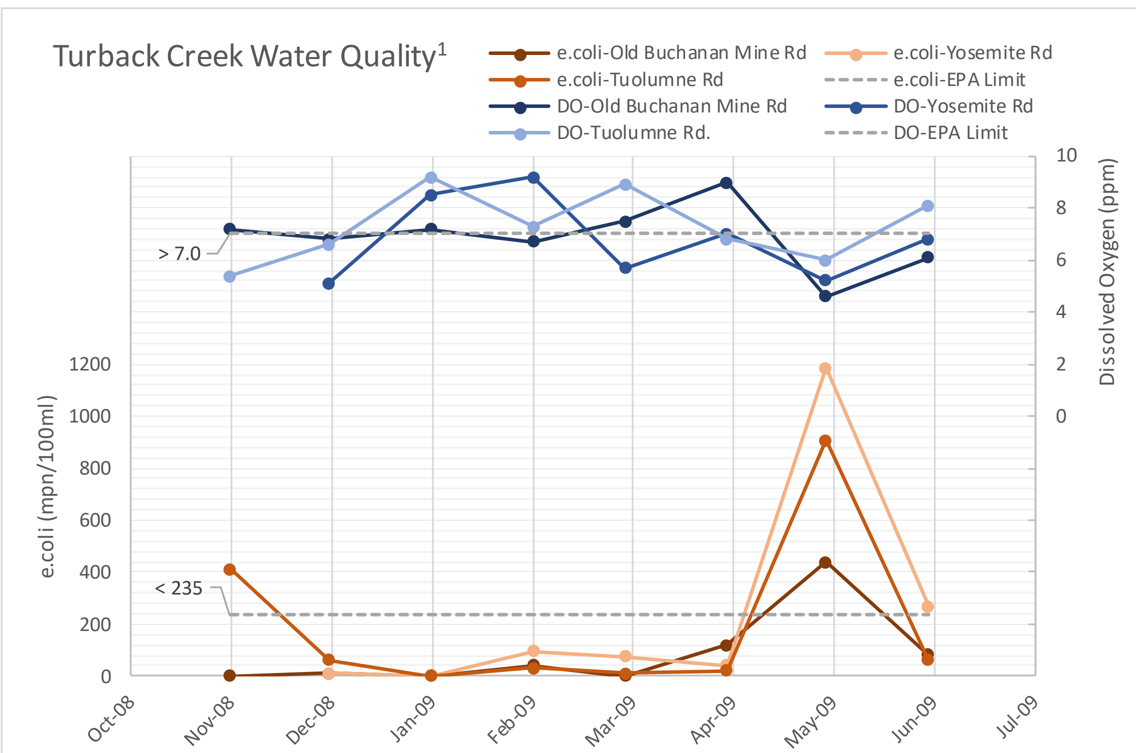
Figure 2: Sherwood Forest Conceptual Collection System - Project Area

Author: Tyler Lee

Sherwood Forest originally received water from the Waterfall Lodge Improvement Company. The water system operated from groundwater well(s). When the water system failed drinking water standards the well was abandoned and the distribution piping was consolidated with the Twain Harte Community Services District water system.

In 2016, the Central Valley Regional Board recommended that Turnback Creek be added to the 303(d) list for impaired surface water. This recommendation was based on water quality samples taken from the creek from 2007 to 2009. The samples collected evaluated pH, turbidity, dissolved oxygen (DO), and the indicator bacteria, E. coli. Of the 19 samples tested for E. coli from 2007 to 2009, five samples exceeded the Environmental Protection Agency (EPA) recreational limits. Of the 46 samples tested for dissolved oxygen, 20 were below the EPA recreational minimums. As a result, the Central Valley Regional Board recommended that Turnback Creek be added to the State's list of impaired surface water. The recommendation was received by the State as part of a multi-county submission in 2016. The State has not ruled on the various recommendations from 2016 and its decision is pending. The values for DO and E. coli reported to the Central Valley Regional Board from November 2008 to June 2009 are shown in **Figure 3.**

Figure 3 - Turnback Creek Impacted Surface Water Recordings for Dissolved Oxygen and E. coli



[1]Tuolumne County Stream Team water Quality Monitoring Report 2008-09, Tuolumne County Resource Conservation District

With the construction of a sewer collection system, all existing OWTS could be removed from service. This would alleviate the possibility of the OWTS impacting the water quality in Turnback Creek.

If the State designates Turnback Creek as an impaired water body as a result of the recorded decline in water quality, then the setbacks for OWTS will increase. The current setbacks are 50 ft for sewer lines, 50 ft for septic tanks, and 100 ft for leach fields. Should the State move forward and designate Turnback Creek as an impaired creek, the new setback requirements for future development at Sherwood Forest would be 50 ft for sewer lines, 600 ft for septic tanks, and 600 ft for leach fields. Since many areas are incapable of meeting these setbacks, future growth in the area would be curbed by the setback requirements of an impaired water source. With the installation of a collection system for the area, development could continue in the area regardless of updated OWTS setbacks.

PURPOSE

The purpose of this memo is to provide preliminary analysis, justification, and design information to the State Water Resources Control Board (SWRCB) for approving the development of design documents for a proposed collection system and sewer lift station in Sherwood Forest and connection to the existing THCSD sewer system. The following sections will provide a detailed evaluation of the Sherwood Forest Development regarding sanitary sewer collection.

DESIGN CONSTRAINTS

The design of the collection system will be based on a design flow derived using the THCSD standards. This design flow accounts for base sanitary flow, inflow, infiltration, and peaking flow. The pump station will also be designed to meet the design flow.

Since the area surrounding Twain Harte is heavily wooded, the collection system has frequent issues with root intrusion. While it is not economical to construct a collection system that prevents all root intrusion, it can be minimized by locating the collection system in the public right-of-way with limited use of utility easements. Where the collection system cannot be installed in the public right-of-way, root intrusion can be minimized with the use of seamless pipe such as high-density polyethylene (HDPE).

The elevations across the Sherwood Forest Development vary from 3557.6 ft to 3752.0 ft above mean sea level (AMSL). The variability in elevation has the potential to result in sewer lines with uncharacteristically steep slopes. If this is the case, then the layout of the collection system will match the topography where possible.

There are two locations where topography will preclude using public rights-of-way. The first location is along the east side of N. Tuolumne Road where the houses are 15-20 ft below the road. The options for this location are presented in Options 1 and 2 described later in this memo. The second location is along Broken Bough Lane. Broken Bough Lane is a dead-end road that starts at Robin Hood Drive. The lane rises from its origin to a high point of ±3,695 AMSL then dips back down to ±3,680 AMSL. Several homes on the end of this road are lower than the high point and would not be able to gravity flow to a public sewer main in the roadway. The options for sewering homes on Broken Bough Lane are presented in Options 1 and 3 of this memo.

SHERWOOD FOREST WASTEWATER FLOWS

In calculating the design flow of the collection system, it is assumed that every parcel is one household equivalent (HE). There are 124 parcels in the Development. Despite a few of the parcels being undeveloped, all vacant lots will also be assigned one HE. This assumption has minimal effect on flow rates and creates a margin of safety in the design. THCSD standards specify a waste generation rate of 437 gpd/HE. Multiplying the generation rate by 124 HE's in the Development, the average flow for the Development is estimated at 54,188 gpd. THCSD standards also specify a peaking factor of 3.0 and 500 gpd/(in·mile) for inflow and infiltration. Assuming 2.19 miles of 8-in pipe, the inflow and infiltration is estimated to be 8,750 gpd. This equates to an estimated design flow of 171,316 gpd. A detailed analysis of the proposed collection system pipeline alignments is provided in **Attachment A**.

Tuolumne Utilities District (TUD) has confirmed capacity at their Sonora Regional WWTP to accept and treat the anticipated flow from 124 HEs at Sherwood Forest.

For a detailed discussion on additional flows from Sherwood Forest using the District's collection system, a system hydraulic model has been developed under Task 6 of the Planning Project No. C-06-8408-110. District standards limit the depth-to-diameter ratio (d/D) to 0.70. The maximum flow recorded annually is referred to as the Peak Wet Weather Flow (PWWF). The PWWF accounts for groundwater infiltration and inflow from surface runoff and peak generation rates from the service connections. It is estimated that under the PWWF flow for the year of 2018, the current number of undersized lines from Sherwood Forest to the TUD collection point is three (3). If the District received additional wastewater flows from Sherwood Forest, the number of undersized lines along this path increases to seven (7). Assuming the three lines will be updated regardless of this project, four additional pipelines would need to be upgraded in the existing collection system to effectively convey flows from Sherwood Forest. The pipelines to be replaced are located between these manholes:

- SP35 to MH19
- SP38 to DMH3
- MH25 to SP71
- DMH16 to MH25

THCSD sewer design standards call for:

- A minimum pipe slope of 0.0033 ft/ft for an 8-inch diameter pipe
- A minimum pipe slope of 0.0049 ft/ft for a 6-inch diameter pipe for top of line sewers less than 400 ft in length

The minimum slope ensures that flows in gravity collection achieve a scouring velocity of 2.0 ft/s at full or half-full pipe. While THCSD does not provide a maximum slope, it is generally recommended that the velocity of gravity sewers not exceed 10.0 ft/s. Using the minimum pipe size permitted by THCSD design standards (8-in), the maximum depth of flow in a pipe at the minimum slope would be approximately 3.4 inches or 0.43 d/D.

THCSD does not have design standards for sewer lift stations but it is recommended that the District utilize the design criteria in **Tables 1** and **2**. Applying these criteria, the wet well requires an active volume of at least 300 gallons (**Attachment B**) and pumps capable of operating with a total dynamic head of 270 ft. The pump station will operate with three (3) submersible pumps (two duty and one standby). THCSD will require an on-site emergency generator with 3,000 gallons of overflow storage. The overflow storage can be provided with either off- or on-line storage as necessary.

Table 1 – Pump System Design

Description	Criteria
System Design	
Flow Rate	120 gpm
Static Head	219 ft
Pump Design	
Number of Active	2
Number of Stand-By	1
Power	10 hp
Pump Type	Submersible
Minimum TDH	270 ft
Maximum Cycles per Hour	
Submersible Pump	6 cycles/hr
Wet Well Design	
Wet Well Depth	72 in
Wet Well Active Volume	300 gal
Design Velocity	
Minimum design velocity	3 ft/s
Maximum design velocity	10 ft/s
Force Main	
Force Main Diameter	4 in
Force Main Length	4140 ft
Material	Ductile Iron
Generator	
Power	14.92 kW
Overflow Storage	
Inline storage	3,000 gal

Table 2 – Design Standards

Element	Design Standard
Pumps	Enclosures must be explosion-proof
	Pump NPSH'r must be met with safety allowances
	Minimum submergence per pump mfr or Froude submergence values, whichever is greater
Redundancy	Emergency Generator capable of meeting peak operating limits
	Pump station shall meet PWWF w/ largest pump out of service
	Bypass pumping locations (suction and discharge)
	2-hour in-line emergency storge
Security and Access	The site shall be designed above the 10-year flood line
	The site shall divert all stormwater away from the wet well
	The site shall be accessible with a 12 ft access gate
	The site shall have 1 hr freeboard with alarm at average flow
	The collection system shall have 2 hours of inline storage at design flow
	The site shall have odor control measures
Control Design	Force main shall have a flow meter rated for the design velocities
	Wet well liquid level shall be reported locally and remotely to the District

<u>OPTION 1</u>

This option uses public rights-of-way and existing PUEs along the common lot lines running parallel to N. Tuolumne Road and Little John Road. The topography along these shared lot lines naturally slopes down from the north to south. THCSD currently has a water main in the PUEs. The water main is difficult for THCSD staff to access and maintain and has been damaged by property owners. As a result of the maintenance issues and to provide separation from the proposed sewer, the water line should be relocated to N. Tuolumne Road and a gravity sewer line installed in its place. The gravity sewer line will be HDPE and backfilled with controlled low strength material (CLSM). The fused joints of the HDPE will minimize root intrusion, and the slurry backfill will protect the sewer main from damage by property owners. The total length of the PUE segment is approximately 1,100 ft. In addition to the 1,100 ft gravity sewer in the PUE, another PUE would be utilized for the sewer pipe segment from Little John Road to two lots on the east side of N. Tuolumne Road.

The residences at the end of Broken Bough Lane would be served by a gravity line within the roadway. This would require either a bore through the hill between two proposed manholes on Broken Bough Lane or a trench having a depth of approximately 15-ft (**Figure 4**). These sub-options have high costs but would allow for a gravity line to reach the end of the street.

The advantage of this option is the limited use of PUEs. When PUEs are required, the sewer pipe will be encased and jointless. The disadvantage of this option is additional coordination during construction. The associated cost estimate for this project is shown in **Table 3**.

Table 3 – Cost Estimate of Option 1

Item	Unit	Quantity	Unit Cost, $	Total Unit Cost, $
Collection System (Option 1)				
Mobilization	ls	1	$ 8,000	$ 8,000
Connections to existing piping	ls	1	$ 1,600	$ 1,600
Collection System Piping	lf	11550	$ 173	$ 1,998,000
6" Lateral Connections	ea	124	$ 1,200	$ 148,800
SS Manhole	ea	46	$ 4,359	$ 200,500
Pump Station/Force Main				
Civil Site Improvements	ls	1	$ 50,000	$ 50,000
Wet Well	ls	1	$ 40,000	$ 40,000
Submersible Pumps	ea	3	$ 16,000	$ 48,000
Force Main Pipe	lf	4200	$ 161	$ 676,650
Electrical and Instrumentation	ls	1	$ 120,000	$ 120,000
Site Piping and Appurtenances	ls	1	$ 150,000	$ 150,000
20 kW Generator	ls	1	$ 60,000	$ 60,000
			Estimated Construction Cost	$ 3,501,550
			40% construction contingency	$ 1,400,620
Engineering, Construction Services, and Administration			Preparation of bid documents	$ 250,000
			Consultant assistance during bidding	$ 9,000
			Engineering services during construction	$ 25,000
			Construction management	$ 150,000
			Estimated Project Cost	$ 5,336,170

[1] Engineering News Record, Construction Cost Index for 2/8/2021=$ 11,698.80

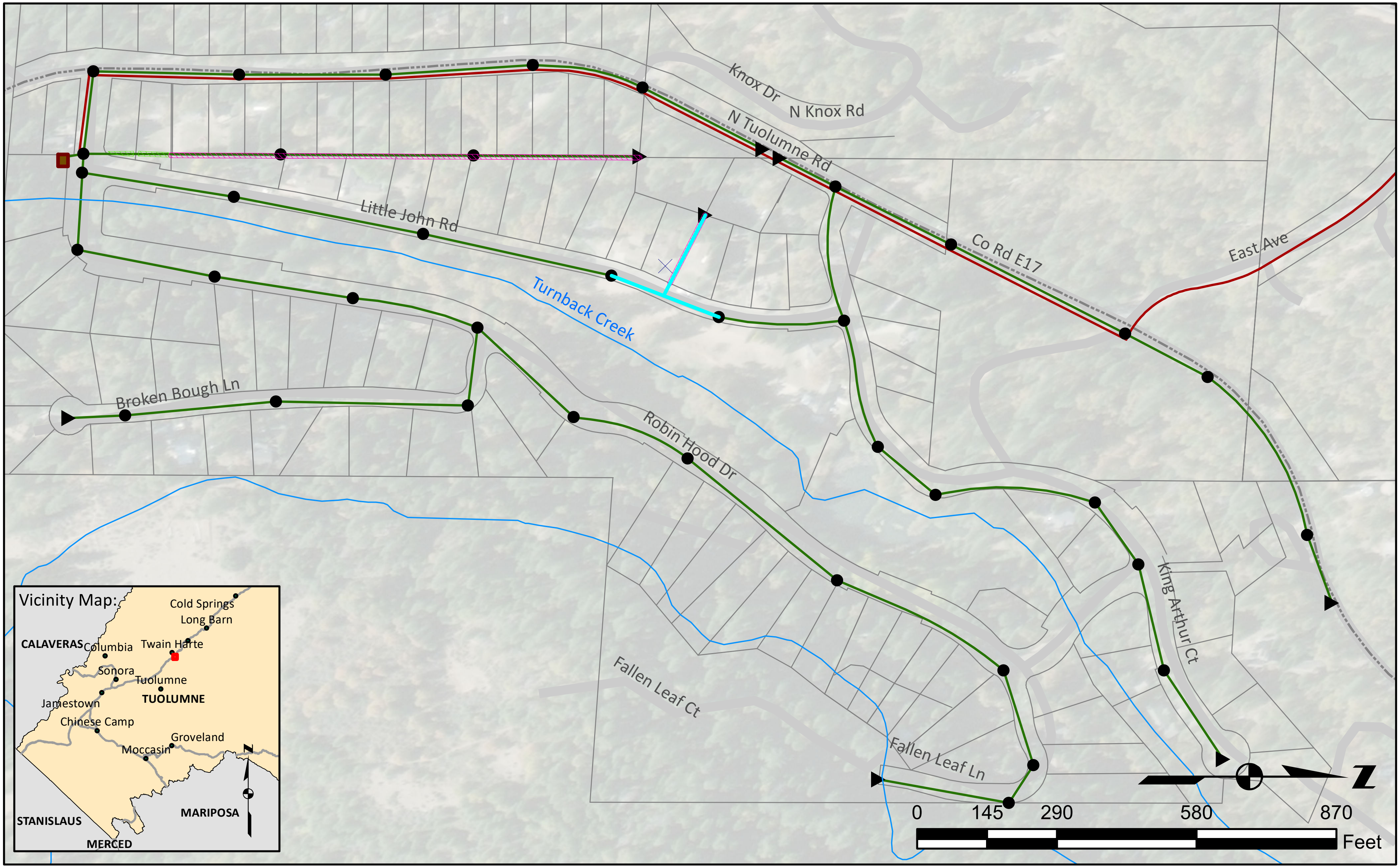


Figure 4: Sherwood Forest Conceptual Collection System - Option 1

Author: Tyler Lee

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Twain Harte Parks & Recreation Fire Water Sewer Community Services District

Existing Manhole	Gravity Colleciton	Waterways
Cleanout	Lot Line	Sewer Easement
Manhole	Major Roadways	PUE
Force Main	Roads	Pump Station

OPTION 2

This option provides an alternative to the continuous easement between N. Tuolumne Road and Little John Road presented in Option 1. This option uses easements from east to west perpendicular to Little John Road. Each easement would service both the lot west of Little John Road and the lots along the east side of N. Tuolumne Road. Gravity sewers would be encased with CLSM to protect them from accidental damage by property owners. This option would require end of line cleanouts along each of the mains. (**Figure 5**). The additional cleanouts required make this option impractical. This option creates multiple unnecessary crossings of existing utilities. Additionally, this option increases the amount of infrastructure in PUE's which are difficult to access and maintain. Lastly, this option requires additional construction through the front and side yards of the properties along Little John Rd. A preliminary cost estimate is shown in **Table 4**.

Table 4: Cost Estimate for Option 2.

Item	Unit	Quantity	Unit Cost, $	Total Unit Cost, $
Collection System (Option 2)				
Mobilization	ls	1	$ 8,000	$ 8,000
Connections to existing piping	ls	1	$ 1,600	$ 1,600
Collection System Piping	lf	12300	$ 173	$ 2,127,740
6" Lateral Connections	ea	124	$ 1,200	$ 148,800
SS Manhole	ea	52	$ 4,359	$ 226,652
Pump Station/Force Main				
Civil Site Improvements	ls	1	$ 50,000	$ 50,000
Wet Well	ls	1	$ 40,000	$ 40,000
Submersible Pumps	ea	3	$ 16,000	$ 48,000
Force Main Pipe and Spool	lf	4200	$ 161	$ 676,650
Electrical and Instrumentation	ls	1	$ 120,000	$ 120,000
Site Piping and Appurtenances	ls	1	$ 150,000	$ 150,000
20 kW Generator	ls	1	$ 60,000	$ 60,000
			Estimated Construction Cost	$ 3,657,442
			40% construction contingency	$ 1,462,977
Engineering, Construction Services, and Administration			Preparation of bid documents	$ 250,000
			Consultant assistance during bidding	$ 9,000
			Engineering services during construction	$ 25,000
			Construction management	$ 150,000
			Estimated Project Cost	$ 5,554,419

[1] Engineering News Record, Construction Cost Index for 2/8/2021=$ 11,698.80

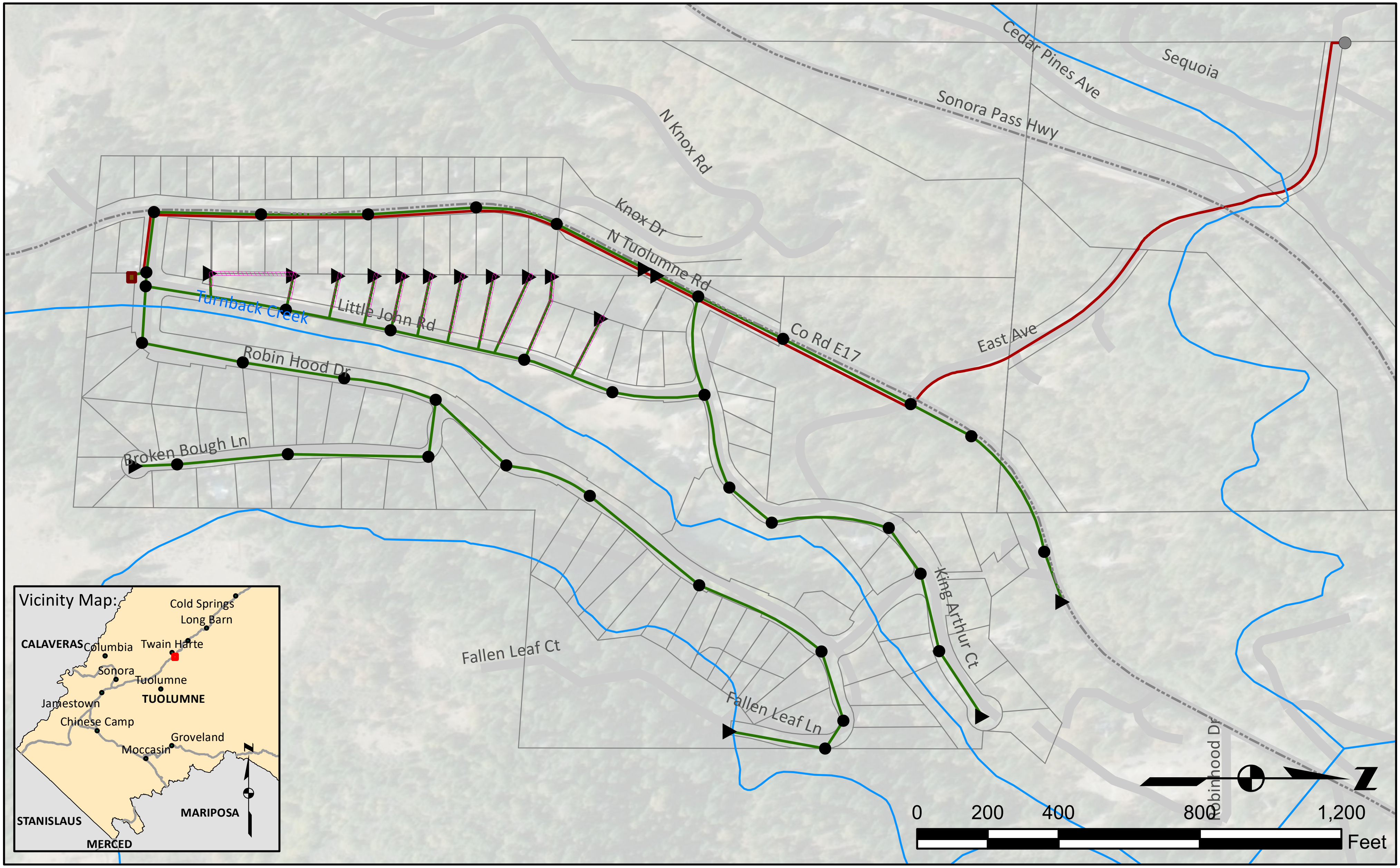

Figure 5: Sherwood Forest Conceptual Collection System - Option 2

Author: Tyler Lee

TWAIN HARTE PARKS & RECREATION FIRE WATER SEWER COMMUNITY SERVICES DISTRICT

BLACKWATER CONSULTING ENGINEERS, INC.

- Existing Manhole
- Proposed Cleanout
- Proposed Manhole
- Force Main
- Gravity Collection
- Lot Line
- Major Roadways
- Roads
- Waterways
- PUE
- Pump Station

OPTION 3

This option provides an alternative to trenching or tunneling through the high point in Broken Bough Lane. This option would use an existing PUE between Robin Hood Drive and Broken Bough Lane. Wastewater from the properties at the end of Broken Bough Lane would flow through this PUE to Robin Hood Drive. This option would require two additional manholes and construction along the steep slope between Broken Bough Lane and Robin Hood Drive (**Figure 6**). In addition to the previous issues, there would be increased construction costs associated with clearing the land and working on the steep slope. Assuming that the contractors were able to work on the slope, this line would require cutoff walls to avoid gradual creep down the hill. This option will have similar costs to Option 1 and would create additional access and maintenance issues associated with steep slopes. The associated cost estimate for Option 3 is shown in **Table 5**.

Table 5: Cost estimate for Option 3.

Item	Unit	Quantity	Unit Cost, $	Total Unit Cost, $
Collection System (Option 3)				
Mobilization	ls	1	$ 8,000	$ 8,000
Connections to existing piping	ls	1	$ 1,600	$ 1,600
Collection System Piping	lf	11825	$ 173	$ 2,045,571
6" Lateral Connections	ea	124	$ 1,200	$ 148,800
SS Manhole	ea	48	$ 4,359	$ 209,217
Pump Station/Force Main				
Civil Site Improvements	ls	1	$ 50,000	$ 50,000
Wet Well	ls	1	$ 40,000	$ 40,000
Submersible Pumps	ea	3	$ 16,000	$ 48,000
Force Main Pipe and Spool	lf	4200	$ 161	$ 676,650
Electrical and Instrumentation	ls	1	$ 120,000	$ 120,000
Site Piping and Appurtenances	ls	1	$ 150,000	$ 150,000
20 kW Generator	ls	1	$ 60,000	$ 60,000
			Estimated Construction Cost	$ 3,557,838
			40% construction contingency	$ 1,423,135
Engineering, Construction Services, and Administration			Preparation of bid documents	$ 250,000
			Consultant assistance during bidding	$ 9,000
			Engineering services during construction	$ 25,000
			Construction management	$ 150,000
			Estimated Project Cost	$ 5,414,973

[1] Engineering News Record, Construction Cost Index for 2/8/2021=$ 11,698.80

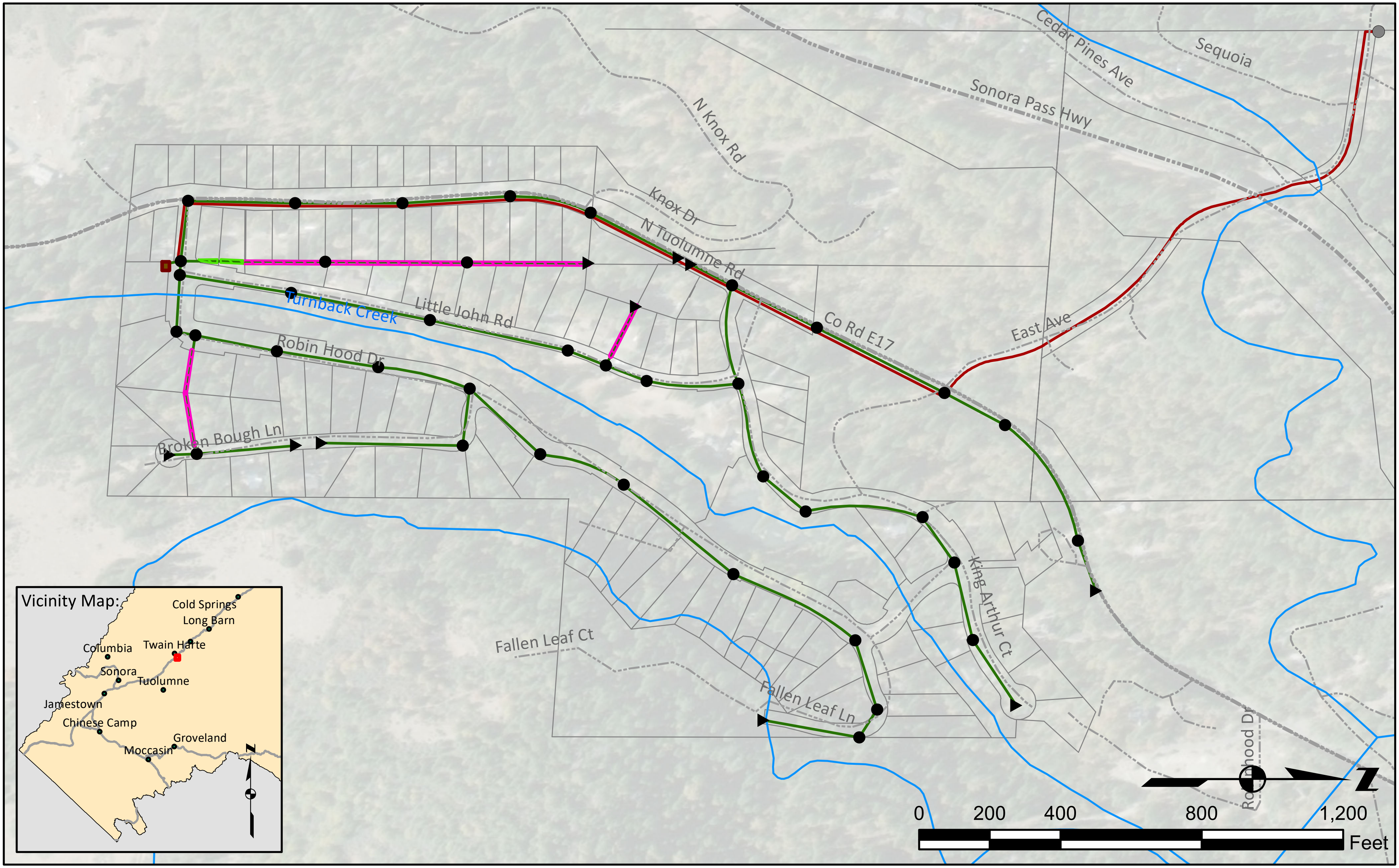

Figure 6: Sherwood Forest Conceptual Collection System-Option 3

Author: Tyler Lee

TWAIN HARTE PARKS & RECREATION FIRE WATER SEWER COMMUNITY SERVICES DISTRICT

BLACKWATER CONSULTING ENGINEERS, INC.

COMPARISON OF OPTIONS

Table 6 compares the three options using the following factors:

- Permitting
- Community and Traffic
- Constructability, Elements, and Schedule
- Environmental Impact
- Utilities
- Operations and Maintenance

Based on this analysis, Option 1 is most desirable for the project. Option 1 is estimated to cost between $5.07 million and $6.14 million. Costs have been estimated using previous construction information from projects in the county of Tuolumne and adjacent counties.

Table 6 – Comparison of Project Options

Item	Weight	Option 1 Recommended Alternative	Rank	Weighted Rank	Option 2 PUE Alternative	Rank	Weighted Rank	Option 3 Broken Bough Ln Alternative	Rank	Weighted Rank
Permitting	5%	**Advantages:** **Disadvantages:**	3	0.15	**Advantages:** **Disadvantages:**	3	0.15	**Advantages:** **Disadvantages:**	3	0.15
Community and Traffic	5%	**Advantages:** • Back yard disruption is less visual than side yard construction. • Does not result in a shared lateral situation. **Disadvantages:**	3	0.15	**Advantages:** **Disadvantages:** • Const. in side yards will be disruptive to property owners. • Additional traffic in Little John Road due to lateral connections.	1	0.05	**Advantages:** • Back yard disruption is less visual than side yard construction. • Does not result in a shared lateral situation. **Disadvantages:** • Extended traffic disruption on Broken Bough associated with boring.	2	0.10
Constructability	50%	**Advantages:** • Least pipe length • Less likely to intersect utilities **Disadvantages:** • Requires bore or deep open cut along Broken Bough • Const. in back yard • Need to relocate existing water main to N Tuolumne Rd	3	1.50	**Advantages:** • Fewest sewer structures **Disadvantages:** •Repeated Utility crossings on Little John Rd. • Const. in side yard • Most potential utility conflicts. • Utility crossings with Water main between N. Tuolumne and Little John	2	1.00	**Advantages:** • Less likely to conflict with existing utilities. **Disadvantages:** •Const. on steep slope between Robin Hood and Broken Bough • Slope requires Cut-off walls. • Const. in back yard • Relocate ex water main to N Tuolumne Rd	1	0.50
Environmental Impact	10%	**Advantages:** • Use of previously impacted area from water relocation project **Disadvantages:** • 1,100 linear ft of impacted property outside of roadway.	3	0.30	**Advantages:** **Disadvantages:** • 1,700 linear ft of impacted property outside of the roadway.	2	0.20	**Advantages:** • Use of previously impacted area from water relocation project **Disadvantages:** • 1,400 linear ft of impacted property outside of roadway. • Potential Environmental impacts between Robin Hood and Broken Bough.	1	0.10
Operations and Maintenance	30%	**Advantages:** **Disadvantages:** • Service lines and main only accessible from back yards.	2	0.60	**Advantages:** • Service lines are accessible from Little John **Disadvantages:**	3	0.90	**Advantages:** **Disadvantages:** • Difficult maintenance between Robin Hood and Broken Bough. • Service lines and main only accessible from back yards.	1	0.30
Total Σ:	100%			**2.70**			**2.30**			**1.15**

*Note :

1. Unweighted Score: Least Desireable = 1, Most Desireable = 3.

RECOMMENDATION

Given THCSD's experience with maintenance and root intrusion, it is recommended that the collection system minimize the number of sewer lines, manholes, cleanouts, and use of PUEs/sewer easements by selecting Option 1. Option 1 provides an effective collection system that limits the need for PUEs. It is recommended upon approval from the SWRCB that THCSD begin developing design documents for this option. It is further recommended that the design follow THCSD standards where applicable. The design documents will provide the locations of manholes and cleanouts that maintain separation from existing water mains and surface water bodies. The collection system should be further evaluated to limit steep slopes that would result in pipe flow velocities above 10.0 ft/s.

In addition to a properly designed collection system, the design documents will include a sewer pump station. The preliminary design documents will outline the design standards required by THCSD. Finally, the force main will be designed to achieve scouring velocities greater than 3.0 ft/s. In addition to velocities above 3.0 ft/s, the force main will be designed with appropriate check valves, control valves, bypass facilities, and air release valves.

CONCLUSION

It is recommended that THCSD proceed with Option 1 by finalizing the planning project, preparing 30% preliminary design documents, initiating CEQA work, and applying for construction funds.

DISCLOSURE STATEMENT

Funding for this project has been provided in full or in part through an agreement with the SWRCB. California's Clean Water State Revolving Fund is capitalized through a variety of funding sources, including grants from the United States Environmental Protection Agency and state bond proceeds. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

REFERENCES

[1] Tuolumne County Setbacks
https://www.tuolumnecounty.ca.gov/DocumentCenter/View/376/Chapter-1308---On-Site-Sewage-Treatment-and-Disposal-Code?bidId=

[2] Tuolumne County Surface Water Quality
https://www.waterboards.ca.gov/water_issues/programs/tmdl/2014_16state_ir_reports/02982.shtml#52461

Attachment A

Table 1 - Valley Vista Sewer Capacity Analysis

Project Name: THCSD Sewer Collection

Legend
Gold Update to Match Project Geometry
Cyan Input
Purple Output
Orange Look up

Preapred By: TCL
Checked By:
Date: 3/19/2020
Black Water Consulting Eng.

=IF($J$12="max",VLOOKUP(K16,Sheet1!$D$13:$E$21,2),IF($J$12="min",VLOOKUP(K16,Sheet1!$D$13:$F$21,2),""))

Inputs

Peaking Factor:	3		P_F	rec max	0.08345		
Pipe Size:	8	in	Ø	min permited	0.00334		
Mannings n:	0.013		n	min designed	0.00334		
Average Flow:	437	gpd/ESFR	E_F				
Infiltration Rate:	500.00	gpd/(in*mile)	I_F	Drop Across MH:	0.2	ft	
Gravity:	32.17	ft/s²	g	Max Recommended Slope	min		r = Ø/2

Warning Above: 0.7
Pressure Pipe: 1
θ = ∡ CL and Inv to WS
Itterate for Values
R_h = A/P

									Isolated Sewer Segment Flow					
Upstream Rim Elev.	Downstream Rim Elev.	Upstream MH	Downstream MH	Inv_1 (ft) Upstream Invert	Inv_2 (ft) Downstream Invert	L (ft) Pipe Length	S = (Inv_1 - Inv_2)/L (#/#) Slope	Ø (in) Pipe Size	E No. of ESFR	α = E E_F (gpd) Avg Daily Flow	P Peaking Factor	I = I_F L/5280 (gpd) Infiltration	Q_A = α P + I (gpd) Design Flow	Q_B = Q_A Convert (ft³/s) Design Flow
3715.8	3701.0	FL-01	FL-02	3710.57	3696.00	275.00	0.05296	8.00	5	2,185	3.0	208	6,763	0.010
3701.0	3682.5	FL-02	FL-03	3695.80	3677.50	93.47	0.19578	8.00	1	437	3.0	71	1,382	0.002
3682.5	3640.0	FL-03	FL-04	3677.30	3634.99	205.86	0.20551	8.00	4	1,748	3.0	156	5,400	0.008
3640.0	3617.6	FL-04	RH-09	3634.79	3612.65	399.32	0.05546	8.00	6	2,622	3.0	303	8,169	0.013
3617.6	3607.8	RH-09	RH-08	3612.45	3602.83	400.00	0.02404	8.00	6	2,622	3.0	303	8,169	0.013
3607.8	3607.0	RH-08	RH-07	3602.63	3601.70	255.36	0.00365	8.00	1	437	3.0	193	1,504	0.002
3607.0	3595.0	RH-07	RH-06	3601.50	3590.00	272.27	0.04224	8.00	1	437	3.0	206	1,517	0.002
3680.0	3691.4	BB-01	BB-02	3676.30	3675.91	117.85	0.00334	8.00	6	2,622	3.0	89	7,955	0.012
3691.4	3675.0	BB-02	BB-03	3675.71	3670.00	314.34	0.01816	8.00	4	1,748	3.0	238	5,482	0.008
3675.0	3623.1	BB-03	BB-04	3669.80	3618.12	397.80	0.12991	8.00	3	1,311	3.0	301	4,234	0.007
3623.1	3595.0	BB-04	RH-06	3617.92	3590.00	152.65	0.17166	8.00	1	437	3.0	123	1,434	0.002
3595.0	3579.5	RH-06	RH-05	3589.80	3574.50	257.39	0.05722	8.00	3	1,311	3.0	203	4,136	0.006
3579.5	3569.6	RH-05	RH-04	3574.30	3564.61	290.00	0.03341	8.00	3	1,311	3.0	220	4,153	0.006
3569.6	3560.6	RH-04	RH-03	3564.41	3555.62	290.00	0.03033	8.00	3	1,311	3.0	220	4,153	0.006
3560.6	3559.3	RH-03	RH-02	3555.42	3554.27	154.00	0.00745	8.00	2	874	3.0	117	2,739	0.004
3667.6	3651.5	KA-03	KA-02	3662.43	3646.46	223.75	0.07137	8.00	4	1,748	3.0	170	5,414	0.008
3651.5	3649.3	KA-02	KA-01	3646.26	3644.27	223.75	0.00889	8.00	4	1,748	3.0	170	5,414	0.008
3649.3	3645.0	KA-01	RH-10	3644.07	3640.00	157.19	0.02589	8.00	2	874	3.0	119	2,741	0.004
3645.0	3622.2	RH-10	RH-11	3639.80	3617.16	335.63	0.06744	8.00	1	437	3.0	254	1,565	0.002
3622.2	3617.9	RH-11	RH-12	3616.96	3613.93	155.83	0.01948	8.00	1	437	3.0	118	1,429	0.002
3617.9	3625.0	RH-12	LJ-05	3613.73	3611.97	273.18	0.00644	8.00	2	874	3.0	207	2,829	0.004
3752.0	3739.6	T-13	T-12	3746.78	3734.63	150.00	0.08102	8.00	2	874	3.0	114	2,736	0.004
3739.6	3706.6	T-12	T-11	3734.43	3701.60	396.23	0.08286	8.00	1	437	3.0	300	1,611	0.002
3706.6	3690.2	T-11	T-10	3701.40	3685.17	200.00	0.08111	8.00	1	437	3.0	152	1,463	0.002
3690.2	3659.3	T-10	T-09	3684.97	3654.27	400.00	0.07676	8.00		0	3.0	303	303	0.000
3659.3	3652.0	T-09	T-08	3654.07	3647.00	267.92	0.02639	8.00	1	437	3.0	203	1,514	0.002
3655.2	3652.0	T-07	T-08	3650.02	3647.00	130.01	0.02323	8.00	2	874	3.0	98	2,720	0.004
3652.0	3625.0	T-08	LJ-05	3646.80	3611.97	284.51	0.12242	8.00	1	437	3.0	216	1,527	0.002
3625.0	3608.2	LJ-05	LJ-04	3611.77	3603.19	261.40	0.03282	8.00	3	1,311	3.0	198	4,131	0.006
3608.2	3596.8	LJ-04	LJ-03	3602.99	3591.84	238.71	0.04673	8.00	3	1,311	3.0	181	4,114	0.006
3596.8	3584.0	LJ-03	LJ-02	3591.64	3579.00	400.00	0.03159	8.00	5	2,185	3.0	303	6,858	0.011
3584.0	3567.0	LJ-02	LJ-01	3578.80	3561.99	400.00	0.04203	8.00	4	1,748	3.0	303	5,547	0.009
3567.0	3559.3	LJ-01	RH-02	3561.79	3554.27	319.10	0.02357	8.00	1	437	3.0	242	1,553	0.002
3654.0	3646.4	T-06	T-05	3648.80	3641.38	280.14	0.02650	8.00	3	1,311	3.0	212	4,145	0.006
3646.4	3628.7	T-05	T-04	3641.18	3623.68	234.68	0.07456	8.00	2	874	3.0	178	2,800	0.004
3628.7	3613.5	T-04	T-03	3623.48	3608.54	306.07	0.04880	8.00	5	2,185	3.0	232	6,787	0.011
3613.5	3596.3	T-03	T-02	3608.34	3591.27	303.00	0.05636	8.00	4	1,748	3.0	230	5,474	0.008
3596.3	3580.0	T-02	T-01	3591.07	3574.97	303.00	0.05311	8.00	4	1,748	3.0	230	5,474	0.008
3580.0	3562.5	T-01	RH-01	3574.77	3553.91	171.95	0.12133	8.00	4	1,748	3.0	130	5,374	0.008
3625.0	3604.0	E-03	E-02	3619.80	3599.00	344.05	0.06046	8.00	5	2,185	3.0	261	6,816	0.011
3604.0	3584.0	E-02	E-01	3598.80	3579.00	400.00	0.04950	8.00	5	2,185	3.0	303	6,858	0.011
3584.0	3562.5	E-01	RH-01	3578.80	3553.91	409.65	0.06076	8.00	5	2,185	3.0	310	6,865	0.011
3559.3	3562.5	RH-02	RH-01	3554.07	3553.91	46.00	0.00343	8.00	0	0	3.0	35	35	0.000
3562.5	3557.6	RH-01	LS	3553.71	3552.60	41.00	0.02707	8.00	0	0	3.0	31	31	0.000
			Maximum Req'd Elevation:		**3746.78**			Σ Total:	124					

		Cumulative Basin Flow					Goal Seek Values								Flow Regime Check	
Upstream MH	Downstream MH	E_S = E + (upstream ESFR) Σ No. of ESFR	$α_S$ = E_S E_F (gpd) Σ Avg Daily Flow	I_S = I + (upstream basin I) (gpd) Σ Infiltration	Q_C = $α_S$ P + I_S (gpd) Σ Design Flow	Q_D = Q_C Convert (ft³/s) Σ Design Flow	d/Ø (%) Percent Full	d (ft) Depth	θ = π - cos⁻¹(d/Ø - 1) (radians) Theta	A = (2θ - sin[2θ])Ø² 0.125 (ft²) Area	W = θ Ø (ft) Wet Perimeter	V = Q/A (ft/s) Velocity	Δ = (Q - Q_D)100 Δ Used for Goal Seek	Q = 1.49 $S^{0.5}$ $R_h^{0.67}$A /n (ft³/s) Goal Seek Flow	T = sin(q) Ø (ft) Top Width	= [V /√(g A/T)]² (#/#) Froude Squared
FL-01	FL-02	5	2,185	208	6,763	0.0105	4.46%	0.030	0.43	0.0055	0.284	1.900	8.2E-06	0.0105	0.28	5.61
FL-02	FL-03	6	2,622	279	8,145	0.0126	3.59%	0.024	0.38	0.0040	0.254	3.167	7.1E-06	0.0126	0.248	19.41
FL-03	FL-04	10	4,370	435	13,545	0.0210	4.50%	0.030	0.43	0.0056	0.285	3.761	1.4E-05	0.0210	0.276	21.81
FL-04	RH-09	16	6,992	738	21,714	0.0336	7.63%	0.051	0.56	0.0122	0.373	2.753	3.3E-05	0.0336	0.354	6.83
RH-09	RH-08	22	9,614	1,041	29,883	0.0462	10.83%	0.072	0.67	0.0204	0.447	2.264	1.1E-04	0.0462	0.414	3.23
RH-08	RH-07	23	10,051	1,234	31,387	0.0486	19.29%	0.129	0.91	0.0472	0.606	1.259	1.1E+00	0.0594	0.526	0.55
RH-07	RH-06	24	10,488	1,440	32,904	0.0509	9.85%	0.066	0.64	0.0178	0.426	2.827	-6.7E-02	0.0502	0.397	5.55
BB-01	BB-02	6	2,622	89	7,955	0.0123	7.10%	0.047	0.54	0.0110	0.360	0.645	-5.2E-01	0.0071	0.342	0.40
BB-02	BB-03	10	4,370	327	13,437	0.0208	9%	0.060	0.61	0.0154	0.405	1.744	6.1E-01	0.0269	0.381	2.33
BB-03	BB-04	13	5,681	629	17,672	0.0273	5.67%	0.038	0.48	0.0079	0.321	3.478	7.9E-04	0.0274	0.308	14.74
BB-04	RH-06	14	6,118	752	19,106	0.0296	5.51%	0.037	0.47	0.0075	0.316	3.924	8.8E-06	0.0296	0.304	19.32
RH-06	RH-05	41	17,917	2,395	56,146	0.0869	11.90%	0.079	0.70	0.0234	0.470	3.706	9.4E-05	0.0869	0.432	7.86
RH-05	RH-04	44	19,228	2,615	60,299	0.0933	14.02%	0.093	0.77	0.0298	0.512	3.136	3.6E-06	0.0933	0.463	4.76
RH-04	RH-03	47	20,539	2,834	64,451	0.0997	14.82%	0.099	0.79	0.0323	0.527	3.092	1.7E-06	0.0997	0.474	4.36
RH-03	RH-02	49	21,413	2,951	67,190	0.1040	21.32%	0.142	0.96	0.0545	0.640	1.909	2.0E-05	0.1040	0.546	1.14
KA-03	KA-02	4	1,748	170	5,414	0.0084	3.75%	0.025	0.39	0.0043	0.260	1.969	2.8E-05	0.0084	0.253	7.17
KA-02	KA-01	8	3,496	339	10,827	0.0168	8.47%	0.056	0.59	0.0142	0.394	1.178	2.3E-05	0.0168	0.371	1.13
KA-01	RH-10	10	4,370	458	13,568	0.0210	7.32%	0.049	0.55	0.0115	0.365	1.830	7.9E-05	0.0210	0.347	3.15
RH-10	RH-11	11	4,807	712	15,133	0.0234	6.15%	0.041	0.50	0.0089	0.334	2.641	5.9E-05	0.0234	0.320	7.83
RH-11	RH-12	12	5,244	830	16,562	0.0256	8.04%	0.054	0.57	0.0132	0.383	1.686	-3.4E-01	0.0222	0.363	2.43
RH-12	LJ-05	14	6,118	1,037	19,391	0.0300	14.77%	0.098	0.79	0.0321	0.526	1.422	1.6E+00	0.0457	0.473	0.93
T-13	T-12	2	874	114	2,736	0.0042	2.65%	0.018	0.33	0.0025	0.218	1.670	2.4E-05	0.0042	0.214	7.32
T-12	T-11	3	1,311	414	4,347	0.0067	3.27%	0.022	0.36	0.0035	0.242	1.939	4.2E-05	0.0067	0.237	7.99
T-11	T-10	4	1,748	565	5,809	0.0090	3.76%	0.025	0.39	0.0043	0.260	2.103	5.1E-05	0.0090	0.254	8.16
T-10	T-09	4	1,748	868	6,112	0.0095	3.90%	0.026	0.40	0.0045	0.265	2.096	4.3E-05	0.0095	0.258	7.81
T-09	T-08	5	2,185	1,071	7,626	0.0118	5.56%	0.037	0.48	0.0076	0.317	1.547	4.9E-05	0.0118	0.305	2.98
T-07	T-08	2	874	98	2,720	0.0042	3.53%	0.024	0.38	0.0039	0.252	1.081	1.1E-05	0.0042	0.246	2.29
T-08	LJ-05	8	3,496	1,385	11,873	0.0184	4.77%	0.032	0.44	0.0061	0.294	3.018	5.4E-05	0.0184	0.284	13.22
LJ-05	LJ-04	25	10,925	2,621	35,396	0.0548	10.90%	0.073	0.67	0.0206	0.449	2.656	2.1E-05	0.0548	0.416	4.42
LJ-04	LJ-03	28	12,236	2,802	39,510	0.0611	10.56%	0.070	0.66	0.0197	0.441	3.107	1.2E-04	0.0611	0.410	6.25
LJ-03	LJ-02	33	14,421	3,105	46,368	0.0717	12.52%	0.083	0.72	0.0252	0.482	2.843	1.3E-05	0.0717	0.441	4.39
LJ-02	LJ-01	37	16,169	3,408	51,915	0.0803	12.34%	0.082	0.72	0.0247	0.479	3.250	6.5E-05	0.0803	0.439	5.82
LJ-01	RH-02	38	16,606	3,649	53,467	0.0827	14.39%	0.096	0.78	0.0309	0.519	2.677	8.8E-04	0.0827	0.468	3.37
T-06	T-05	3	1,311	212	4,145	0.0064	4.17%	0.028	0.41	0.0050	0.274	1.287	3.1E-04	0.0064	0.267	2.75
T-05	T-04	5	2,185	390	6,945	0.0107	4.17%	0.028	0.41	0.0050	0.274	2.157	5.2E-04	0.0108	0.267	7.74
T-04	T-03	10	4,370	622	13,732	0.0212	6.34%	0.042	0.51	0.0093	0.339	2.291	2.1E-04	0.0212	0.325	5.71
T-03	T-02	14	6,118	851	19,205	0.0297	7.18%	0.048	0.54	0.0111	0.362	2.667	4.1E-05	0.0297	0.344	6.83
T-02	T-01	18	7,866	1,081	24,679	0.0382	8.19%	0.055	0.58	0.0135	0.387	2.819	2.2E-04	0.0382	0.366	6.67
T-01	RH-01	22	9,614	1,211	30,053	0.0465	7.40%	0.049	0.55	0.0117	0.367	3.990	1.5E-04	0.0465	0.349	14.82
E-03	E-02	5	2,185	261	6,816	0.0105	4.34%	0.029	0.42	0.0053	0.280	1.994	1.6E-05	0.0105	0.272	6.35
E-02	E-01	10	4,370	564	13,674	0.0212	6.30%	0.042	0.51	0.0092	0.338	2.299	1.1E-05	0.0212	0.324	5.79
E-01	RH-01	15	6,555	874	20,539	0.0318	7.28%	0.049	0.55	0.0114	0.364	2.794	4.9E-05	0.0318	0.346	7.39
RH-02	RH-01	87	38,019	6,635	120,692	0.1867	35.05%	0.234	1.27	0.1091	0.845	1.712	1.1E-04	0.1867	0.636	0.53
RH-01	LS	124	54,188	8,752	171,316	0.2651	24.66%	0.164	1.04	0.0669	0.693	3.960	1.6E-06	0.2651	0.575	4.18

Total Gravity Collection Length:	11552.07	ft
Total Trench Length:	13294.47	ft
ForceMain Length from Lift Station by Gravity:	2396.77	ft
ForceMain Length not adjacent to Gravity:	1742.4	ft
Total Est. ForceMain Length:	4139.17	ft
Easement Line:	1153.70	ft
SDR 35 Pipe:	10398.37	ft

Attachment B

SHERWOOD FOREST
Twain Harte, CA
Wastewater Pumping Station
Calculation Work Sheet

Date: 3/19/2020
Calculated By: TCL
Job: 17196_05 Sherwood

Legend

Cyan =	Input
Purple =	Ouptut
Orange =	Dropmenu
Red =	Look up Value
CHECK	Check Cell

Abreviations

NO =	Normal Operation
OF =	Overflow
NA =	Not Applicable
∞ =	Infinate

			Variable
Peak Flow to Pump Station:	118.95	gpm	PF
Number of Pumps:	2	Active	N_{act}
	1	Stand-By	N_{std}
Total Pumps	3		N_{all}

Step 1: Compute Wet Well Active Volume

Max Starts per Hour:	6	cyc/hr	C_{hr}	
Wet Well Shape:	Cylinder			
~~Wet well length:~~	~~5~~	~~ft~~	~~L_{wet}~~	
~~Wet well width:~~	~~3~~	~~ft~~	~~W_{wet}~~	
Wet Well Diameter:	72	in	Ø	
Wet Well Area:	28.27	ft²	A_{wet}	
Pump Capacity:	59.47535	gpm	Q_{pump}	
Inlet Flow:	59.48	gpm	$Q_{in} = Q_{out}/2$	*Max number of starts occurs when $Q_{in} = Q_{out}/2$*
Outlet Flow (Pump):	118.95	gpm	$Q_{out} = N_{act}\ Q_{pump}$	
Cycle total time:	10	min	$T_{tot} = 60\ min/C_{hr}$	
Cycle fill time:	5	min	$T_{fill} = V_{0\ act}/Q_{in}$	
Cycle empty time:	5	min	$T_{empty} = V_{0\ act}/(Q_{out} - Q_{in})$	
Active Volume of Wet Well:	297.3767	gal	$V_{0\ act} = Q_{in}\ T_{tot}/2$	
Active Volume of Wet Well:	40	ft³	$V_{act} = V_{0\ act}$ Conversion	
Active Depth of Wet Well:	1.41	ft	$d_{act} = V_{act}/A_{wet}$	OK

Step 2: Design Tank Controls (Approximate)

	Calc'd	Use		
Wet Well Inlet:			E_{inlet}	
Alarm:	-	3549.00	E_{alarm}	*Recommend 1ft below overflow*
Lag Pump On:	-	3549.00	E_{lag}	*Recommend 1ft below alarm*
Lead Pump On:	-	3548.00	E_{lead}	
Pump(s) off:	-	3546.50	E_{off}	
Bottom of Wet Well:	-	3546.00	E_{min}	

V_{act} = *1.5* 317.3 19.88

Step 3: Variable Operations Check

	Normal Operation				Hypothetical Control				
PF x	0.20	0.50	0.75	1.00	1.25	1.38	1.5	1.68	1.75
time from E_{lag} to E_{alarm}	NA	NA	NA	NA	NA	NA	∞	0.00	0.00
time from E_{lead} to E_{lag}	NO	NO	NO	∞	7.11	4.74	3.56	2.63	2.37
(Stand-By) T_{empty}	NA	NA	NA	NA	10.67	21.34	∞	OF	OF
(NO) T_{empty}	3.33	5.33	10.67	∞	NA	NA	NA	NA	NA
T_{fill}	13.34	5.33	3.56	2.67	2.13	1.94	∞	OF	OF
T_{cycle}	16.67	10.67	14.22	∞	12.80	23.28	∞	∞	∞
C_{hr}	3.60	5.62	4.22	< 1	4.69	2.58	< 1	< 1	< 1

Date: 3/19/2020
Calculated By: TCL
Job: 17196_05 Sherwood

Step 4: Friction Head Approximation

Discharge Elevation:	3766.26		E_{final}	*Assumes Tank has a velocity of 0.00*
Static Lift:	219.76	ft	$\Delta_z = E_{final} - E_{off}$	*Assumes Discharge to Atmosphere*
FM Diameter:	4	in	$Ø_{FM}$	
FM Length:	4139.17	ft	L_{FM}	
FM Vel.:	3.04	ft/s	$V_{FM} = Q_{out}\ (\text{Convert})/(Ø_{FM}{}^2 \pi\ 0.25)$	

	K Value	Quantity
Gate Valve	0.1	1
Check Valve	0.65	1
Tee Branch Flow	0.78	1
90° Bend	0.39	3

Σ K Values:	2.70		K	*Value not specific but general*
Minor Losses:	0.39	ft	$h_{minor} = K\ V^2/2g$	

Using Hazen-Williams

C-Value:	120		C
Major Losses:	50.03	ft	h_{hz} = Hazen-Williams Equation
Est. TDH	**270.31**	ft	$TDH_{hz} = \Delta_z + h_{minor} + h_{hz} + V_{FM}{}^2/(2g)$

Using Swamee-Jain Equation w/ Darcy Wiesbach

Gravity:	32.17	ft/s²	g	*input swamee*
Kinematic Viscosity:	1.06E-05		ν	*input swamee*
Reynols Number:	9.55E+04		$Re = VØ_{FM}/\nu$	
Material Roughness:	9.84E-04	ft	*e*	*input swamee*
friction factor:	0.028		f = Swamee-Jain Equation	
Major Losses:	49.24	ft	$h_{sw} = f\ L\ V_{FM}{}^2/(2\ g\ Ø_{FM})$	
Est. TDH:	**269.53**	ft	$TDH_{sw} = \Delta_z + h_{minor} + h_{sw} + V_{FM}{}^2/(2g)$	

Swamee-Jain

TDH	116.79	psi
α:	706.58	for ft³/s