FINAL REPORT | JULY 2022

2022 Local Water Supply Enhancement Study

Novato Water Service Area

APPENDICES

PREPARED JOINTLY BY

NORTH MARIN WATER DISTRICT

WEST YOST
Water. Engineered.

Appendix A

Public Announcements

North Marin Water District study will explore options to expand Novato water supply

(Updated September 16, 2021) A study is scheduled for approval at the September 21, 2021 Board meeting for North Marin Water District to explore options for expanding local water supply in our Novato Service Area.

A range of options will be explored during the Local Water Supply Enhancement Study, including expanding our recycled water distribution, capturing stormwater runoff from nearby areas such as Bowman Canyon, and groundwater banking, in which the groundwater aquifer can be recharged during wet years and drawn from during drought years.

The study will also include increasing the capacity of our Stafford Lake reservoir by raising lake elevation by three feet. Approximately 20% of Novato's water supply comes from Stafford Lake, with imported Russian River water sourced from the Sonoma Water agency making up the rest.

Based on potential growth in Marin County in the coming decade and the prospect of longer drought periods, North Marin Water District board members expressed support for exploring desalination options in this study.

The study would begin in October 2021 and potential options would be brought back to the board by March 2022.

funding the forward-looking study into the resilience of the regional water system. The Regional Water Supply Resiliency Study was crafted to better understand existing and future water supply challenges facing the region and to increase resilience by adopting water supply options that more fully integrate the regional systems.

Due to the current drought conditions, portions of the study addressing drought risks are being put on a fast-track schedule to determine risks of an extended 2021-2022 drought and evaluate options to reduce or manage drought risks in the region. This portion of the study is set to be finished by October 2021.

Latest News

Water Conservation Ordinance Extended Past November 1, 2021

West Marin Low Sodium Water Fill Station

Drought Drop-By Event #3

Read all News

North Marin Water District is Developing New Water Supplies

(Updated September 30, 2021)

In recent months, North Marin Water District (NMWD) has received questions, comments, and ideas from customers and others about how we plan to ensure reliable water supplies as we face a hotter and drier future. Here is an update.

The Latest News: In late September, NMWD's Board of Directors approved a significant new Local Water Supply Enhancement Study to identify potential new water sources for District customers. The Enhancement Study will explore numerous water supply options, including expanding water recycling, adding desalination, capturing and storing stormwater, increasing Stafford Lake's capacity, and storing water in underground basins in wet years and saving it for dry years. The goal of this study is to identify local solutions for possible implementation.

NMWD is committed to increasing long-term water supply reliability for District customers. In 2018, the District updated its Strategic Plan, and Goal No. 1 was to increase long-term water supply reliability. We have been working to increase the water supply since that goal was established. For example, in 2019, the District joined a Water Supply Resiliency Study with Marin Municipal Water District and seven other water suppliers that receive water from the Russian River and the Sonoma County Water Agency. The regional study is scheduled for completion in Summer 2022. Because of the current drought, we accelerated the schedule to identify some new near-term water supply projects this fall.

projects constructed in nearly every decade from the 1950s through today.

In recent years, the District, along with two local sanitary districts, massively expanded the recycled water system. As a result, NMWD now delivers over 250 million gallons of recycled water each year to large landscape irrigation customers and drive-through car washes. Every gallon of recycled water used saves a gallon of valuable drinking water for our potable water customers.

In 2019, NMWD installed electronic meters providing real-time data that helps customers monitor their water use and detect leaks.

Last winter, we anticipated water needs during this severe drought, and the District imported water to refill Stafford Lake to over one-half of its capacity for use this summer. We will refill the Lake again in the coming winter if the drought continues.

The Residential Recycled Water Pick-Up Program and Recycled Water Truck Programs are back. Residential customers can fill tanks and containers with clean, safe, recycled water for hand-watering of outdoor plants. Contractors with water trucks can pick up recycled water for dust control, power washing mixing concrete, street cleaning, and more. See our website at www.nmwd.com or call 415-897-4133 details.

In addition, our industry-leading conservation programs have helped build a permanent culture of mindful water use in Novato. We are especially grateful for our customers' conservation efforts during this severe drought. Through their cooperative actions, our customers are on track to meet District-wide conservation requirements.

New water projects can take time to complete, so we need to keep conserving. Careful water use stretches our existing supplies, especially during droughts, and identify new water supply opportunities. Please visit our website at www.nmwd.com to learn more about our efforts, and to take advantage of our WaterSmart Portal, free Water Smart home surveys, rebates, and other water conservation information and resources.

Latest News

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West Marin Low Sodium Water Fill Station

Drought Drop-By Event #3

Read all News

Water Supply Workshop April 26

North Marin Water District invites customers to attend a second virtual public workshop to review potential new water supplies

North Marin Water District is inviting customers to attend a second New Water Supplies workshop which will be held virtually on Zoom on Tuesday, April 26 at 6:00 PM.

The District has been working with an engineering consultant with expertise in water supply alternatives, West Yost, to carry out a Local Water Supply Enhancement Study. The Study has considered numerous options to develop new local water sources, with the goal of ensuring that the North Marin Water District has a solid, resilient strategy for sustainable water supply, to minimize the impacts of future droughts.

These potential new water sources were presented to the Board and reviewed at a public workshop with customers on January 25, 2022. Ideas included expanding water recycling, adding desalination, capturing and storing stormwater, increasing Stafford Lake's capacity, and storing water in underground basins in wet years and to save for use in dry years.

The upcoming workshop on April 26, 2022 will recap and summarize the potential new water sources, and consultants and staff will then present a draft report with findings and recommendations in order to gain public feedback. The draft report is available here: Local Water Supply Enhancement Study – Public Review Draft – April 2022 Compressed recommendations of the draft Water Supplies report."

Some of the supply options which are not necessarily feasible for local supply enhancement are possible through collaboration and partnership with other agencies at a regional level, which the workshop will explore.

The workshop will take place on Tuesday, April 26 at 6:00 PM and customers are invited to attend by Zoom. To attend, go to:

https://us02web.zoom.us/j/82191971947

Password: 466521

Or sign into Zoom and search for meeting ID: 821 9197 1947, and enter password 466521

Latest News

Water Supply Workshop April 26

Residential Recycled Water Fill Station for 2022

Fix-A-Leak Week

Read all News

Water Supply Workshop April 26 (Recap)

(Updated April 28, 2022) North Marin Water District held a second New Water Supplies workshop on April 26, 2022 at 6:00pm

The District has been working with an engineering consultant with expertise in water supply alternatives, West Yost, to carry out a Local Water Supply Enhancement Study. The Study has considered numerous options to develop new local water sources, with the goal of ensuring that the North Marin Water District has a solid, resilient strategy for sustainable water supply, to minimize the impacts of future droughts.

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Current Projects

Media & Downloads

Press Contacts

Brand Files

Meetings

Agendas & Minutes

Calendar

Appendix B

Board Workshop Presentations and Minutes

Board Workshop: Water Supply Alternative Options and Evaluation Criteria & Ranking

Local Water Supply Enhancement Study

January 25, 2022

Purpose

- Provide the Board and the Public a preview
- Review the following:
  - Developed water supply options
  - Criteria for evaluation
  - Criteria scoring and weighting
  - Next steps

Introductions

North Marin Water District

- Project Manager: Tony Williams, Assistant General Manager/Chief Engineer
- Drew McIntyre, General Manager
- Robert Clark, Operations/Maintenance Superintendent

West Yost

- Project Manager: Rhodora Biagtan
- Project Engineer: Megan McWilliams

- Technical Experts:
  - Groundwater and ASR: Ken Loy
  - Recycled Water: Anita Jain
  - Indirect Potable Reuse: Charles Hardy
  - Stormwater: Doug Moore
  - Treatment Plant Optimization: Craig Thompson, Charles Hardy
  - Treatment Optimization and Desalination: Kathryn Gies
  - Permitting and Regulation Compliance: Sandi Potter

Water Supply Alternatives

Developed Water Supply Alternatives/Variations

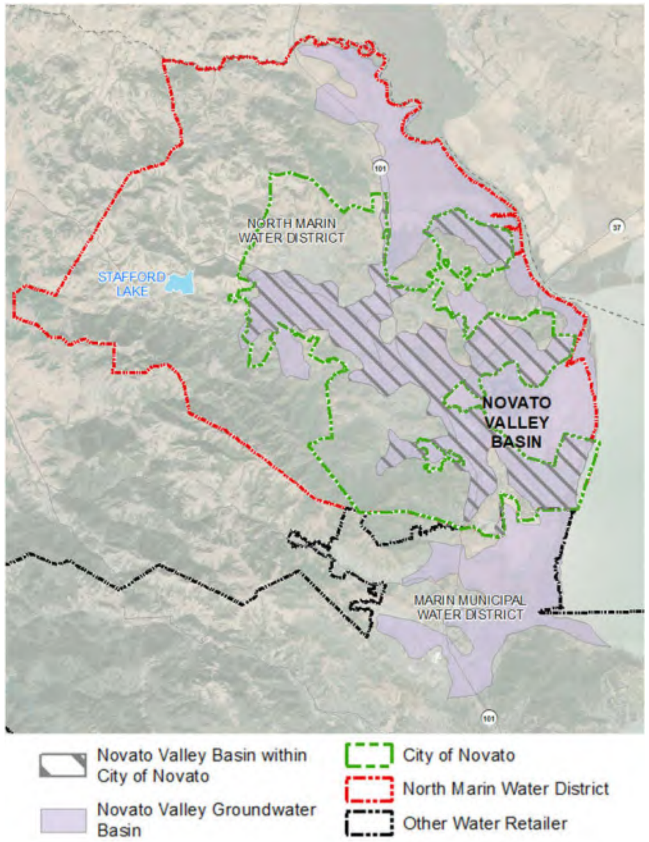
- Aquifer Storage Recovery in Novato Basin
- Recycled Water System Expansion
- Indirect Potable Reuse
- Improve Stafford Treatment Plant Process Water Recapture Efficiency
- Divert Captured Stormwater Into Stafford Lake
- Increase Stafford Lake Storage Capacity
- Desalination

Aquifer Storage Recovery in Novato Basin

Ken Loy

Aquifer Storage Recovery in Novato Basin

- Aquifer storage is very low
    - Estimated at 50-100 acre-feet (AF)
    - Estimate accounts for potentially usable acreage of the Novato Basin, basin thickness, and aquifer characteristics
- Storage and recovery rates are low
- Tens of gallons per minute
    - Estimate based on existing wells
- Costs per acre-foot would be infeasibly high



Regional Aquifer Storage Recovery

- NMWD may benefit from a regional ASR program, if excess treated water allocated to NMWD can be stored and recovered when needed.

- Regional groundwater banking on other basins (Santa Rosa Plain, Sonoma Valley, Petaluma)

Aquifer Storage Recovery

Preliminary Conclusions and Recommendations

- Continued regional coordination is recommended
- Estimated yield – 50 to 100 AF
- Cost estimate for local ASR is in progress

Discussion and Questions

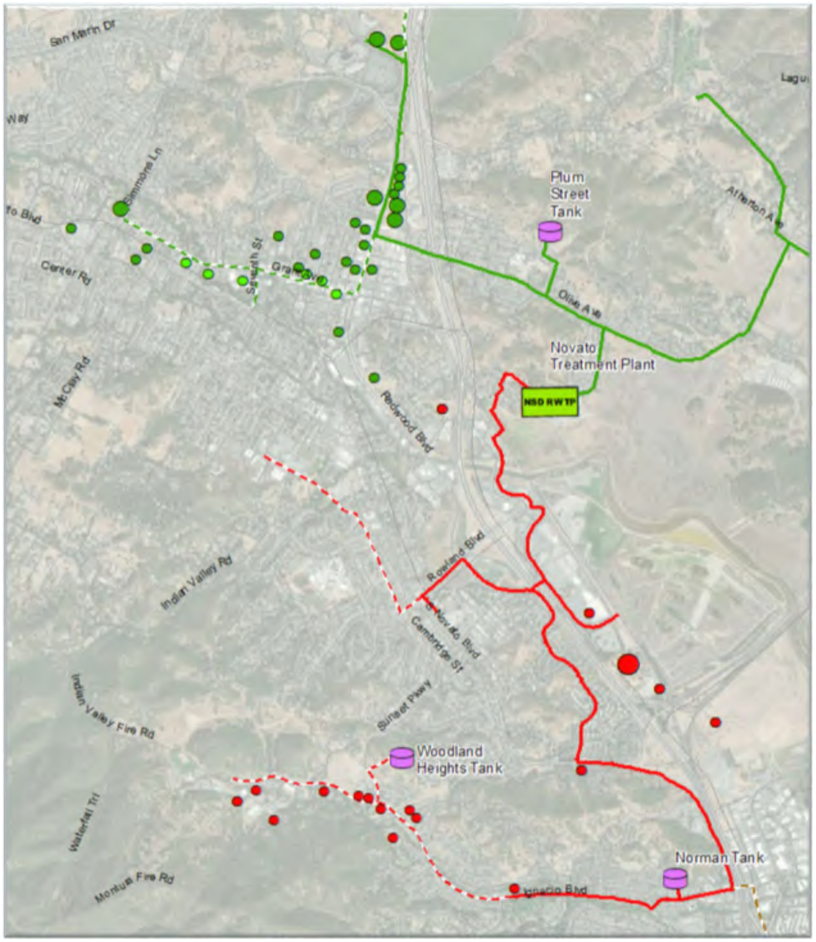
Recycled Water System Expansion

Anita Jain

Recycled Water Expansion

- Focus of this effort:
  - Evaluate expansion of the existing distribution system
  - Explore other opportunities to increase recycled water use without expanding the existing distribution system

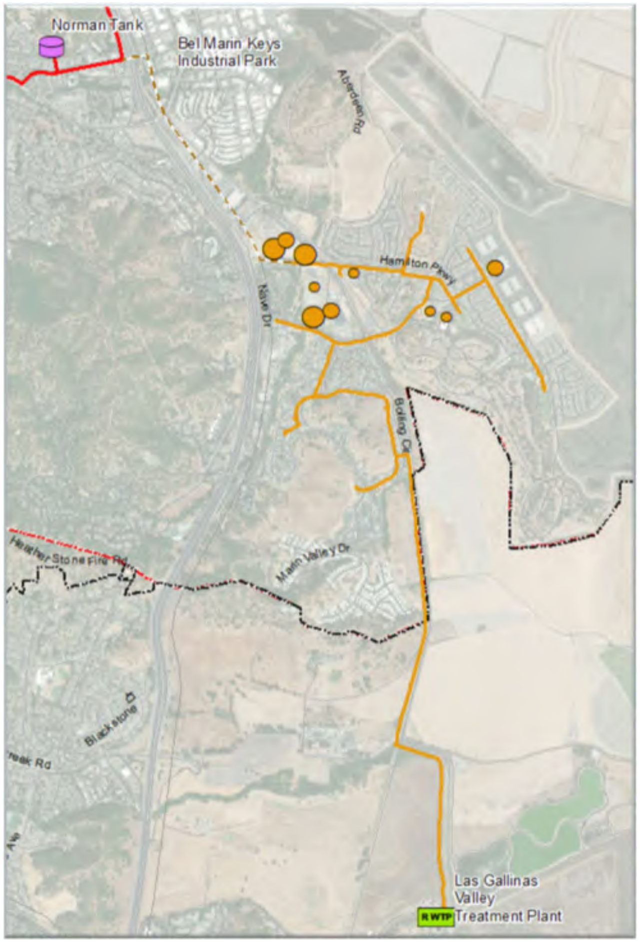
Recycled Water Expansion North and Central



Service Area	Projected Recycled Water Demand, AFY
North	100
Central	100
Total	**200**

Less Than 1
1 - 3 AFY
3 - 5 AFY
Central Service Area Pipeline
Northern Service Area Pipeline
Southern Service Area Pipeline
Recycled Water Proposed Pipeline
RWTP Recycled Water Treatment Plant
Plum Street Tank
North Marin Water District
Marin Municipal Water District

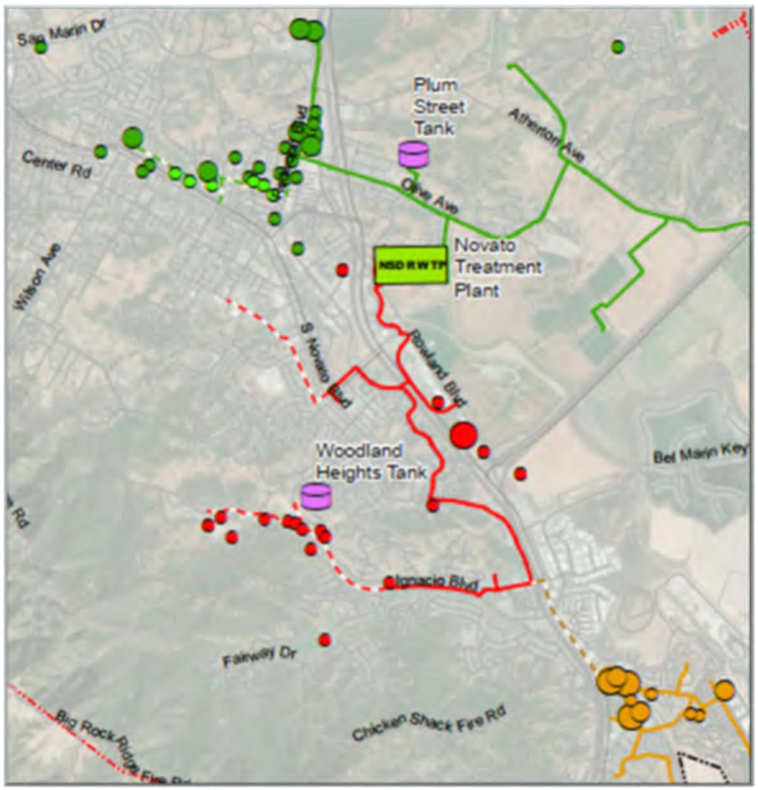
Recycled Water Expansion South



Service Area	Projected Recycled Water Demand, AFY
South	20

- Less Than 1
- 1 - 3 AFY
- 3 - 5 AFY
- Central Service Area Pipeline
- Northern Service Area Pipeline
- Southern Service Area Pipeline
- Recycled Water Proposed Pipeline
- R WTP Recycled Water Treatment Plant
- Plum Street Tank
- North Marin Water District
- Marin Municipal Water District

Recycled Water Expansion



Less Than 1
1 - 3 AFY
3 - 5 AFY
Central Service Area Pipeline
Northern Service Area Pipeline
Southern Service Area Pipeline
Recycled Water Proposed Pipeline
R WTP Recycled Water Treatment Plant
Plum Street Tank
North Marin Water District
Marin Municipal Water District

Service Area	Projected Recycled Water Demand, AFY
North	100
Central	100
South	20
Total	**220**

Potential potable water offset of 220 AFY

Other Near-Term Opportunities Without Distribution System Expansion

- Construct additional hydrants or commercial fill stations
  - NMWD installed two new hydrants in 2021
- Optimize residential fill station operations to increase use
- Facilitate connection of in-fill sites
  - Update District regulations (Reg 18)
- Assess dual-plumbing requirements for toilet flushing

Recycled Water Use Opportunities for Future Study

- Privately-owned recycled water storage tanks

- Delivery of recycled water to residential customers

- Livestock watering
  - Prohibited by current regulations

Recycled Water System Expansion
Next Steps

- Conduct planning level hydraulic analysis to determine infrastructure sizing
- Work with the District to prioritize alignments and phasing plan for construction
- Develop planning level cost estimate
- Future Study – pending expansion timeline, confirm recycled water supply reliability to meet demand

Recycled Water Expansion

Preliminary Conclusions and Recommendations

- Potential potable water offset of up to 220 AFY with distribution system expansion
- Cost estimate for expanding the distribution system is in progress
- Continue to assess opportunities for increasing recycled water use within existing distribution system

Discussion and Questions

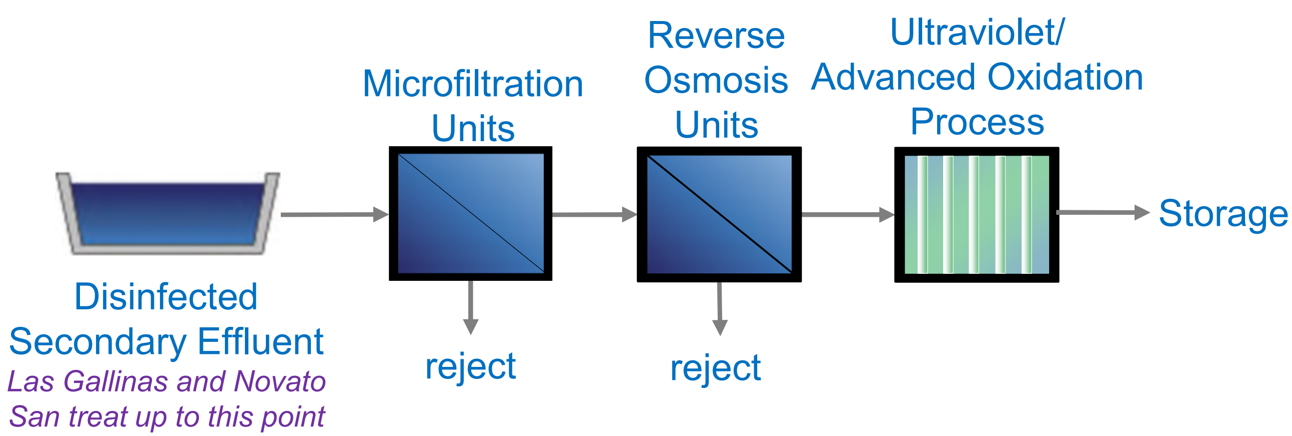
Indirect Potable Reuse

Charles Hardy

Indirect Potable Reuse Requirements

- State regulations allow “indirect” potable reuse through:
  - Groundwater replenishment (augmentation)
  - Surface water source augmentation

- “Full Advanced Treatment” required:



Indirect Potable Reuse Feasibility

- IPR water cannot mix directly with potable water

- No viable local IPR storage options
  - Groundwater aquifer
  - Surface water storage

- Groundwater Augmentation (in local groundwater basin)
  - Limited local aquifer storage available ~50-100 AF

- Surface Water Source Augmentation (at Stafford Lake)
  - Regulations require blending ratio of ≤ 10 percent and retention time ≥ 60 days
  - IPR limited by volume of Stafford Lake, even if the lake is kept full
  - Maximum potential is approximately 100 - 400 AF

Indirect Potable Reuse Infrastructure

- Unit cost of treatment prior to storage at least $3,000 per AF without economy of scale seen by other agencies with IPR

- Additional costs for groundwater recharge, injection and extraction wells and associated infrastructure

- New conveyance pipeline would be required for Stafford Lake augmentation
  - Estimated pipeline length – 28,000 linear feet
    - From Novato San to Stafford Lake
  - Estimated cost - $20 million +
    - 16-inch diameter transmission pipeline

Indirect Potable Reuse

Preliminary Conclusions and Recommendations

- Suggest no further analysis of (local) IPR
  - Groundwater Augmentation ~ 50 – 100 AF
  - Surface Water Augmentation ~ 100 – 400 AF

- Unit cost of treatment prior to storage ~ $3,000 per AF
  - No economy of scale seen by other agencies with IPR

- Regional IPR may be viable: potentially ~ 3,100 AFY from Novato San

- *Direct* potable reuse potentially viable option in future as regulations and public acceptance evolve (at least 10+ years out)

Discussion and Questions

Improve Stafford Treatment Plant Process Water Recapture Efficiency

Charles Hardy

Improve Stafford Treatment Plant Process Water Recapture Efficiency

- STP potable water production limited by wastewater discharge permit.
- STP has several reject water streams:
  - Hydrocyclone return accounts for 80-90% of total wastewater discharge
  - Potential hydrocyclone modifications could reduce discharge by 50-75%
- Modifications subject to performance testing and regulatory approval
- Additional yield of at least 100 AFY by 50% reduction of hydrocyclone discharge during a dry year
- Potentially achieve additional yield of 600 AFY
  - During average rainfall year
  - Or, if supplemental water stored during a dry year

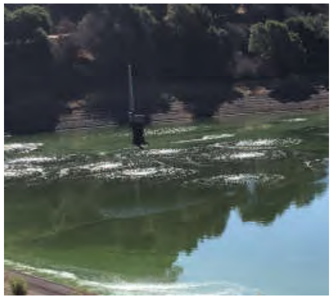
Improve Stafford Treatment Plant Process Water Recapture Efficiency

- District staff previously conducted plant-scale study of modifying hydrocyclone return to reduce reject flow volume

- Recommend additional plant-scale study of modified hydrocyclone operation with external technical support to confirm capital/operations changes needed*:*
  - Change to sludge diversion point
  - Change to diversion return point

- Raw water intake also may need modifications for more consistent intake water quality

- Should account for replacing 4-inch discharge pipeline to Novato San sewer to reduce maintenance efforts



Improve Stafford Treatment Plant Process Water Recapture Efficiency

Preliminary Conclusion and Recommendations

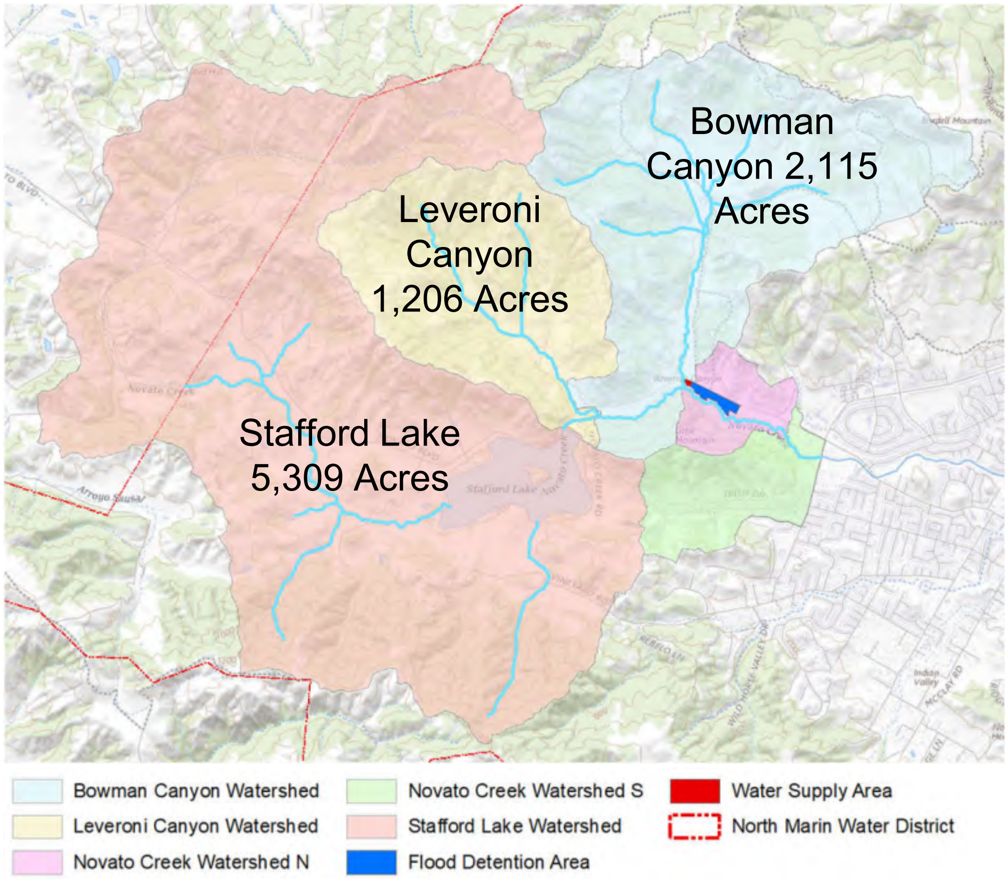
- Recommended for District to conduct additional plant-scale testing with technical support
- Potential estimated yield ~ 100 - 600 AFY
- Cost estimate is in progress

Discussion and Questions

Divert Captured Stormwater Into Stafford Lake

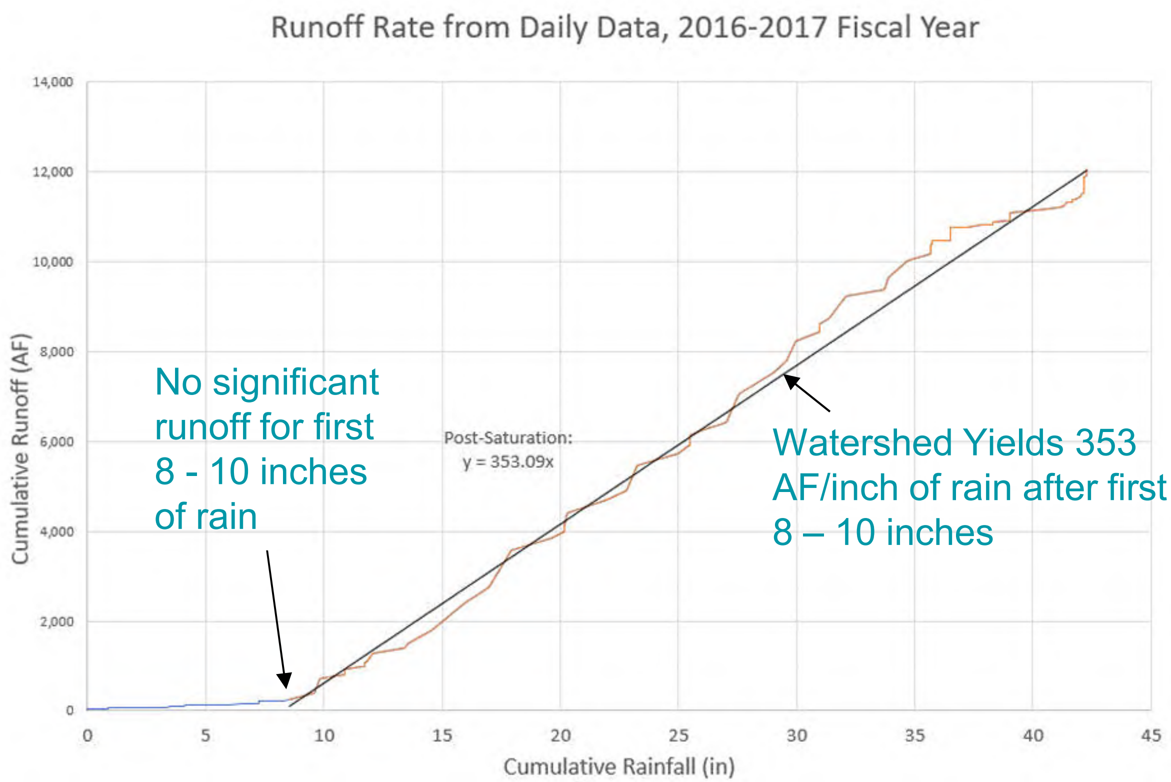
Doug Moore

Divert Captured Stormwater Into Stafford Lake



- **Delineate Watersheds**
- Quantify Rainfall to Runoff Relationship
- Calculate Leveroni and Bowman Canyon Yield (Runoff)
- Evaluate Increased Water Supply to Stafford Lake
- Evaluate Costs

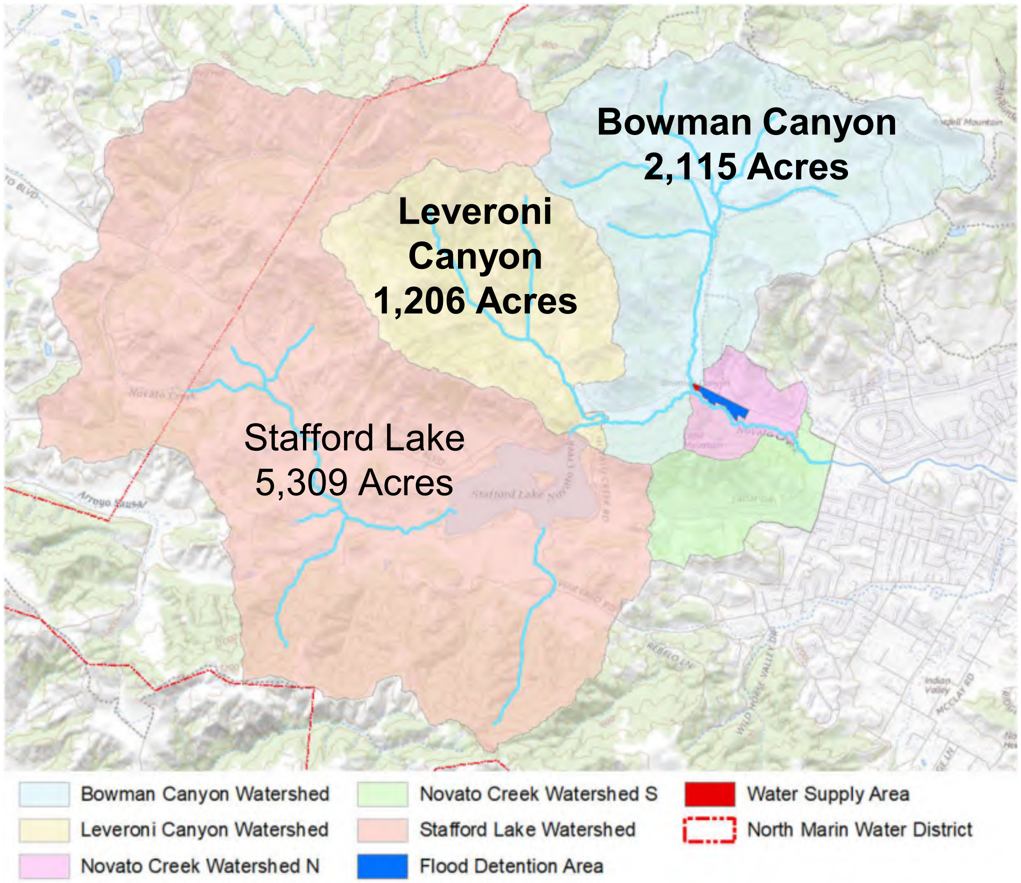
Divert Captured Stormwater Into Stafford Lake



- Delineate Watersheds
- **Quantify Rainfall to Runoff Relationship**
- Calculate Leveroni and Bowman Canyon Yield
- Evaluate Increased Water Supply to Stafford Lake
- Evaluate Costs

Stafford Lake 2016-2020 Average Watershed Yield: 4,000 AFY from 5,309 acres

Divert Captured Stormwater Into Stafford Lake



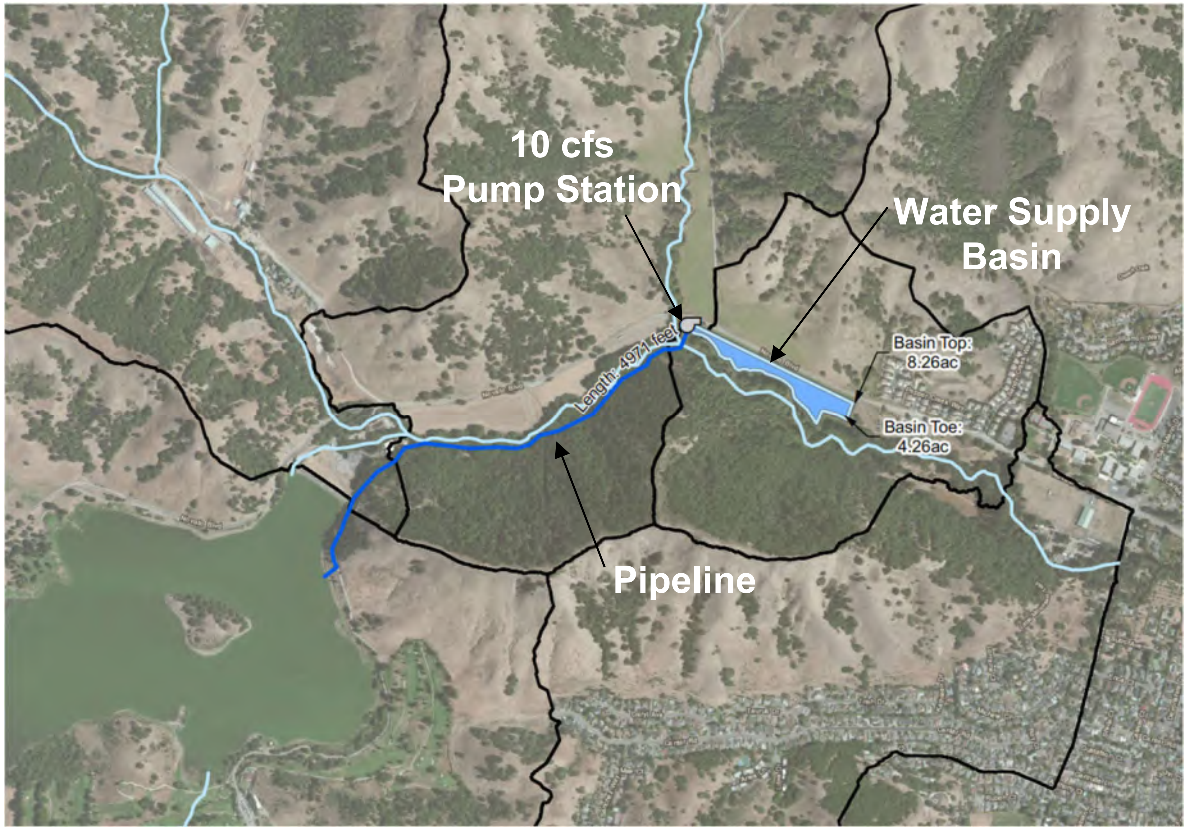
- Delineate Watersheds
- Quantify Rainfall to Runoff Relationship
- **Calculate Leveroni and Bowman Canyon Yield**
- Evaluate Increased Water Supply to Stafford Lake for a Range of Pump Station Capacities
- Evaluate Costs

2016-2020 Estimated Yields:

- **Leveroni: 910 AFY**
- **Bowman: 1,590 AFY**
- **Combined: 2,500 AFY**

Alternative only works if there is stormwater runoff available

Divert Captured Stormwater Into Stafford Lake



- Delineate Watersheds
- Quantify Rainfall to Runoff Relationship
- Calculate Leveroni and Bowman Canyon Yield
- **Evaluate Increased Water Supply to Stafford Lake**
- Evaluate Costs

Leveroni and Bowman Canyon Annual Water Supply with Basin and 10 cfs Pump: 788 AFY

Divert Captured Stormwater Into Stafford Lake

Capital Costs

Infrastructure	Cost, $ million
Basin (80 AF)	9.6
Pump Station (10 cfs)	1.5
Pipeline (15-inch)	1.6
Total	**12.7**

- Delineate Watersheds
- Quantify Rainfall to Runoff Relationship
- Calculate Leveroni and Bowman Canyon Yield
- Evaluate Increased Water Supply to Stafford
- **Evaluate Costs**

Total Annual Cost per AF (O&M plus Annual Cost of Capital)

Infrastructure	Cost, $ per AF
Combined (788 AF w/ Basin)	$1,352 per AF
Leveroni Canyon (no basin)	$182 per AF for 245 AF
Bowman Canyon (no basin)	$143 per AF for 433 AF
Combined (no basin)	$101 per AF for 628 AF

Divert Captured Stormwater Into Stafford Lake

Preliminary Conclusions and Recommendations

Conclusions

- Use of Leveroni and Bowman Canyon water is cost feasible
- Use of the detention basin is cost prohibitive (unless there is cost sharing)

Future Considerations

- Evaluate long-term benefit of Bowman and Leveroni Canyon flow diversion using 20-40 years of rain data, but adjusted for future climate change
- Begin monitoring flows and water quality from Leveroni and Bowman Canyons

Discussion and Questions

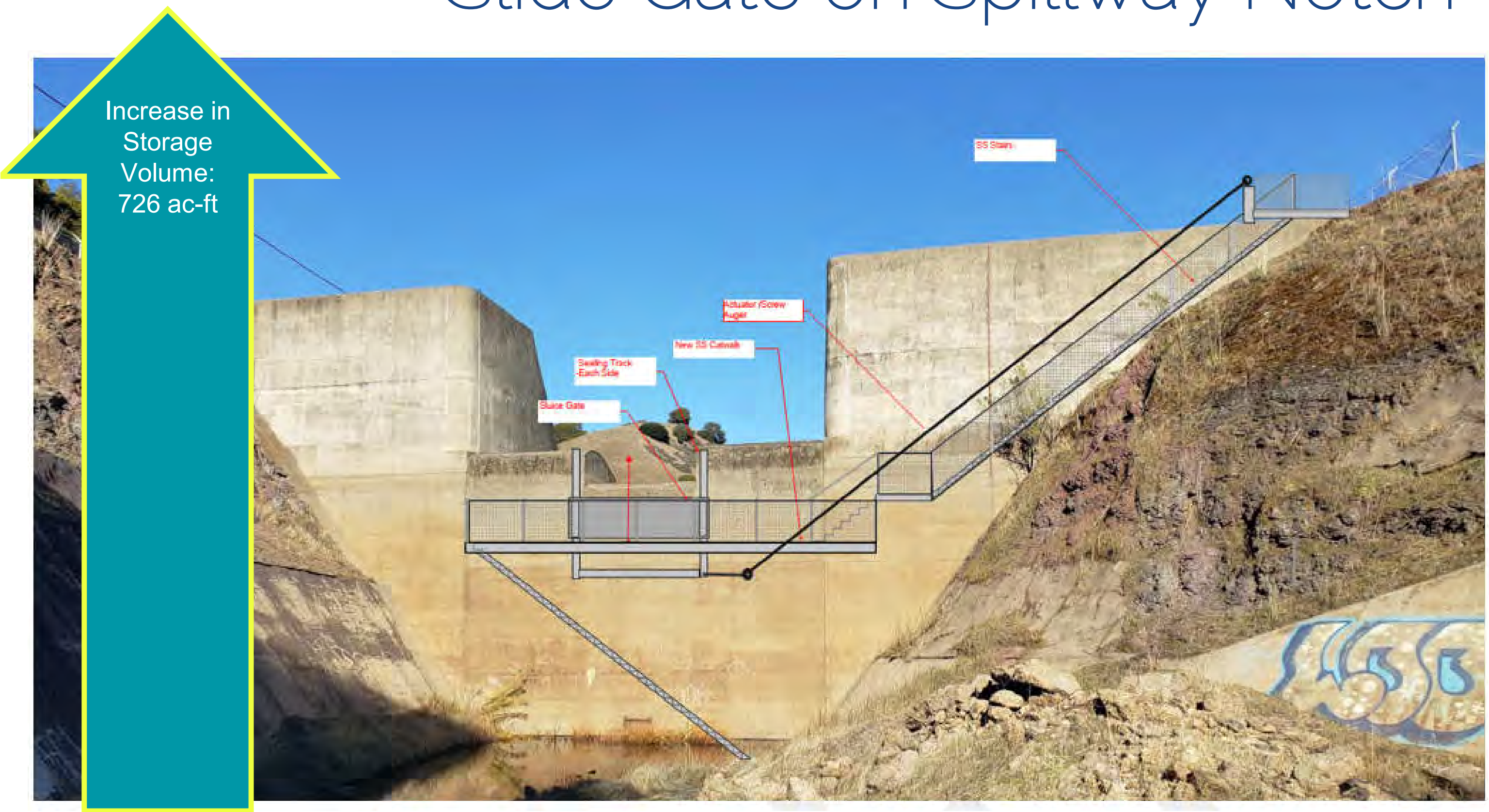
Increase Stafford Lake Storage Capacity

Modify Spillway

Remove Sediment

Doug Moore

Increase Stafford Lake Storage Capacity
Slide Gate on Spillway Notch



Increased storage volume is only useful when there is enough rain to overtop the spillway notch

Increase Stafford Lake Storage Capacity Slide Gate on Spillway Notch

- Total Capital Cost: $710,000
- Capital Cost per AF of Increased Storage Volume: $1,000 per AF

An Inverted Slide Gate is a Standard Product from Waterman Industries (and other manufacturers)

Increase Stafford Lake Storage Capacity – Remove Sediment, Excavate Lake Bottom

Excavation Depth, feet	Storage Volume, AF	Cost, $ million
1	49	2.4
10	411	19.9
15	551	26.7

Capital Cost per AF of Increased Storage Volume (for 15 ft Depth): $48,500 per AF

- Location is based on constructability of the sediment removal
- Minor Benefit: Removal of nutrient rich soils temporarily helps the treatment process

Modify Spillway Preliminary Conclusions and

Preliminary Conclusions and Recommendations

Conclusions

- The Slide Gate is cost feasible
- Excavation of sediment from the lakebed is cost prohibitive

Future Considerations

- Evaluate long-term benefit of slide gate using 20-40 years of rain data, but adjusted for future climate change
- Evaluate long-term benefit of slide gate combined with Leveroni and Bowman Canyon flow diversion using 20-40 years of rain data, but adjusted for future climate change

Discussion and Questions

Desalination

Kathryn Gies

Desalination

- Must be pursued as a regional partnership to be viable
  - Economy of scale
  - Environmental considerations
  - No viable intake or brine discharge locations for NMWD

Desalination

- MMWD
    - Completed study in 2008, opted not to pursue
    - Reviewed again in 2021, opted not to pursue
    - Currently investigating a pipeline connection with EBMUD for emergency supply
    - Proceeding with an EIR, which looks at desalination as an alternative
        - 2021 estimated 15 MGD desal plant at approximately $230 million
    - Any desalination partnership would be a long-term project (15+ years)

- Sonoma Water is preparing a regional study
    - Desalination is one opportunity being evaluated at the regional level
    - If Sonoma Water Study is not available, findings cannot be incorporated into this local study

Discussion and Questions

Evaluation Criteria

Evaluation Criteria

- Cost
- Water Supply Yield and Reliability
- Operational Impacts
- Regulations and Permitting
- Public and Institutional Considerations
- Other Considerations

Cost

Planning level cost estimate:

- Capital Cost + Operations and Maintenance cost estimate
- Cost estimates to include additional labor, materials, energy, and chemicals needed, as applicable
- Compare using $ per AF for each water supply alternative
- Translatable to NMWD’s rates
- Revenue impacts will be relative to the volume of water generated, except for new recycled water uses

Water Supply Yield and Reliability

- Estimate of the expected water supply yield
- Reliability: Likelihood of the water supply alternative producing the anticipated yield
    - Climate change may impact the reliability

Operational Impacts

- Evaluate the impact to distribution and treatment operations
- Consider the following items:
  - Challenges to blending from different supply sources
  - Additional chemicals required to produce and maintained high-quality of water
  - Energy intensity
  - Additional staff resources or special certifications required

Regulations and Permitting

- Identify required permits
- Evaluate applicable regulations and anticipated permitting requirements
- Considerations:
  - Environmental impacts
  - Conformance with CEQA
  - Permitting requirements specific to the water supply alternative
  - Water rights (only for alternatives that may have water rights issues)

Public and Institutional Considerations

- Public acceptance
- Coordination and collaboration with other entities
- Need for partnerships or agreements
- Required easements from other entities

Other Considerations

- Each water supply alternative is unique
  - May have other important considerations that are relevant to each water supply alternative

- Will be discussed but not scored

Discussion and Questions

Criteria Ranking/Weighting

Criteria Scoring

- Quantitative Criteria:

Criteria	Measure	Units
Cost	Quantitative	$ per AF
Water Supply Yield	Quantitative	Volume, AF

- Qualitative Criteria:

Criteria	Measure	Low Score (1)	Medium Score (3)	High Score (5)
Reliability	Degree of Reliability	Least Reliable	Moderately Reliable	Most Reliable
Operational Impacts	Operational Demands	Most Impacted	Moderately Impacted	Least Impacted
Regulations and Permitting	Complexity	Most Complex	Moderately Complex	Least Complex
Public and Institutional Considerations	Challenges	Most Challenging	Moderately Challenging	Least Challenging

Qualitative Criteria Priorities and Weight

Criteria	Weight (%)
Water Supply Reliability	40
Operational Impacts	30
Regulations and Permitting	20
Public and Institutional Considerations	10
Total	100

Discussion and Questions

Next Steps

Next Steps

Prepare
Evaluations and Complete Study

Present
Findings to Board and Public (Spring 2022)

Board Acceptance

Discussion and Questions

Date Posted: 2/11/2022

NORTH MARIN WATER DISTRICT

NORTH MARIN WATER DISTRICT
AGENDA - REGULAR MEETING
February 15, 2022 – 6:00 p.m.
Location: Virtual Meeting
Novato, California

NOTE: REVISED INFORMATION HAS BEEN PROVIDED FOR ITEM #12

Information about and copies of supporting materials on agenda items are available for public review at 999 Rush Creek Place, Novato, at the Reception Desk, or by calling the District Secretary at (415) 897-4133. A fee may be charged for copies. District facilities and meetings comply with the Americans with Disabilities Act. If special accommodations are needed, please contact the District Secretary as soon as possible, but at least two days prior to the meeting.

ATTENTION: This will be a virtual meeting of the Board pursuant to the authorizations provided by Government Code section 54953(e).”.

There will not be a public location for participating in this meeting, but any interested member of the public can participate telephonically by utilizing the dial-in information printed on this agenda.

Video Zoom Method

CLICK ON LINK BELOW:		SIGN IN TO ZOOM:
Go to: https://us02web.zoom.us/j/82191971947	**OR**	Meeting ID: 821 9197 1947
Password: 466521		Password: 466521

Call in Method:

Dial:
+1 669 900 9128
+1 253 215 8782
+1 346 248 7799
+1 301 715 8592
+1 312 626 6799
+1 646 558 8656

Meeting ID: 821 9197 1947#

Participant ID: #

Password: 466521#

For clarity of discussion, the Public is requested to MUTE except:
1. During Open Time for public expression item.
2. Public comment period on agenda items.

Please note: In the event of technical difficulties during the meeting, the District Secretary will adjourn the meeting and the remainder of the agenda will be rescheduled for a future special meeting which shall be open to the public and noticed pursuant to the Brown Act.

All times are approximate and for reference only.
The Board of Directors may consider an item at a different time than set forth herein.

Date Posted: 2/11/2022

Est. Time	Item	Subject	
6:00 p.m.		***CALL TO ORDER***	
	1.	***APPROVE MINUTES FROM REGULAR MEETING,*** January 25, 2022	
	2.	***APPROVE MINUTES FROM REGULAR MEETING***, February 1, 2022	
	3.	**REDISTRICTING PROCESS PUBLIC HEARING NO. 2** Solicit Public Input and Consider Adopting Resolution 22-XX	Resolution
	4.	***SONOMA WATER REGIONAL WATER SUPPLY RESILIENCY STUDY PRESENTATION NO. 2***	
	5.	***GENERAL MANAGER'S REPORT***	
	6.	***OPEN TIME: (Please observe a three-minute time limit)*** This section of the agenda is provided so that the public may express comments on any issues not listed on the agenda that are of interest to the public and within the jurisdiction of the North Marin Water District. When comments are made about matters not on the agenda, Board members can ask questions for clarification, respond to statements or questions from members of the public, refer a matter to staff, or direct staff to place a matter of business on a future agenda. The public may also express comments on agenda items at the time of Board consideration.	
	7.	***STAFF/DIRECTORS REPORTS***	
	8.	***MONTHLY PROGRESS REPORT***	
		CONSENT CALENDAR The General Manager has reviewed the following items. To his knowledge, there is no opposition to the action. The items can be acted on in one consolidated motion as recommended or may be removed from the Consent Calendar and separately considered at the request of any person.	
	9.	***Consent - Approve:*** *Re-Authorizing Meetings by Teleconference of Legislative Bodies of North Marin Water District*	*Resolution*
	10.	***Approve:*** Amend Contract with Kennedy/Jenks Consultants – General Services Agreement	
		ACTION CALENDAR	
	11.	***Approve:*** NMWD Administration and Laboratory Upgrade Project – Approve Bid Advertisement	
	12.	***Approve:*** NMWD Administration and Laboratory Upgrade Project -Temporary Leases	REVISED 2/15/2022
	13.	***Approve:*** San Marin Pump Station Battery Backup System	
		INFORMATION ITEMS	
	14.	Administration and Laboratory Upgrade Project Financing Alternatives	
	15.	Reinstatement of Water Shut-Offs and State Water Arrearage Payment Program Status	
	16.	Community Microgrid Enablement Program – Oceana Marin	
	17.	NBWA Meeting – February 4, 2022	
	18.	***MISCELLANEOUS*** Disbursements – Dated February 3, 2022 Disbursements – Dated February 10, 2022 Reimbursement Program 2021 Green House Gas Emission Reduction Progress – Reporting Year 2020 County of Marin and City of Novato Paving Moratoriums Point Reyes Light- North Marin Water District Summary of Emergency Water Conservation	

All times are approximate and for reference only.
The Board of Directors may consider an item at a different time than set forth herein.

Date Posted: 2/11/2022

Est. Time	Item	Subject
		Ordinance No. 39

<u>News Articles</u>:
Marin IJ – Districts in Marin on hunt for water – DROUGHT
Marin IJ – Water use rules for West Marin are eased – DROUGHT
Marin IJ – District close to drilling for well – WEST MARIN
Press Democrat – PD Editorial: A two-basin plan is still best bet for North Coast water
Point Reyes Light – NMWD downgraded its drought restrictions for West Marin
Point Reyes Light – North Marin to drill well in March, at double the cost

<u>Social Media Posts</u>:
NMWD Web and Social Media Report – January 2022

8:30 p.m. 19. ***ADJOURNMENT***

1

DRAFT
NORTH MARIN WATER DISTRICT
MINUTES OF REGULAR MEETING
OF THE BOARD OF DIRECTORS
January 25, 2022

CALL TO ORDER

President Petterle announced that due to the Coronavirus outbreak and pursuant to the Brown Act as modified by Assembly Bill 361, this was a virtual meeting. President Petterle called the regular meeting of the Board of Directors of North Marin Water District to order at 6:00 p.m. and the agenda was accepted as presented. President Petterle added that there was not a public location for participating in this meeting, but any interested members of the public could participate remotely by utilizing the video or phone conference dial-in method using information printed on the agenda.

President Petterle welcomed the public to participate in the remote meeting and asked that they mute themselves, except during open time and while making comments on the agenda items. President Petterle noted that due to the virtual nature of the meeting he will request a roll call of the Directors. A roll call was done, those in remote attendance established a quorum. Participating remotely were Directors Jack Baker, Rick Fraites, Jim Grossi, Michael Joly and Stephen Petterle.

President Petterle announced that in the event of technical difficulties during the meeting, the District Secretary will adjourn the meeting and the remainder of the agenda will be rescheduled for a future special meeting which shall be open to the public and noticed pursuant to the Brown Act.

President Petterle announced that all public attendees will be invited to speak and will need to use the raised hand icon in Zoom or dial *9 to be called upon.

Mr. McIntyre performed a roll call of staff, participating remotely were Drew McIntyre (General Manager), Tony Williams (Assistant GM/Chief Engineer), Terrie Kehoe (District Secretary), Julie Blue (Auditor-Controller), Tony Arendell (Construction/Maintenance Superintendent), Robert Clark (Operations/Maintenance Superintendent) and Tim Fuette (Senior Engineer). Also participating remotely were West Yost consultants; Rhodora Biagtan, Megan McWilliams, Anita Jain, Charles Hardy, Doug Moore, Ken Loy and Kathryn Geis; in addition to IT consultant Clay Smedshammer (Core Utilities).

President Petterle requested that for those joining the virtual meeting from the public to identify themselves. Attending remotely were Bob Maselli, Jim Homet, Christopher Johnson, Mark Hosletter, Hilary Maslon, Phillip Maddley, Jerry Peters and Jolly Brown.

OPEN TIME

President Petterle asked if anyone from the public wished to bring up an item not on the agenda and there was no response.

LOCAL WATER SUPPLY ENHANCEMENT STUDY WORKSHOP

Mr. Williams introduced West Yost Associates as the presenter for the workshop. He stated there will be a series of presenters that will summarize each category and will outline various water supply alternatives that would be relevant to NMWD. Mr. Williams noted the original intent was to be in sync with Sonoma Water's Regional Water Supply Resiliency study, however NMWD's local water supply study is ahead of them in this process and will probably work in parallel soon. Mr. Williams stated that the primary goal is to increase local supply to a minimum threshold of 1,000-acre feet (AF) and if we can increase it to 2,000 AF that would be even better. Mr. Williams apprised the Board that the purpose of the study was to evaluate the best alternative and the workshop is an opportunity for the Board and the public to discuss and comment on possible water supply enhancement opportunities that are presented.

Rhodora Biagtan of West Yost Associates began the presentation on the Local Water Supply Enhancement Study Board Workshop and provided an overview on Water Supply Alternative Options and Evaluation Criteria and Ranking. She stated the purpose of the workshop was to provide the Board and the public with a preview and discuss the following topics; developed water supply options, criteria for evaluation, criterial scoring and weights, and next steps. Ms. Biagtan added the presentation will be broken up in the following local water supply alternatives: Aquifer Storage Recovery in Novato Basin; Recycled Water System Expansion; Indirect Potable Reuse, Improve Stafford Treatment Plant Process Water Recapture Efficiency; Divert Captured Stormwater Into Stafford Lake; Increase Stafford Lake Storage Capacity and Desalination.

The first alternative, Aquifer Storage and Recovery in Novato Basin, was presented by Ken Loy. Mr. Loy noted aquifer storage is very low at an estimated 50-100 AF, noting this estimate accounts for potentially usable acreage of the Novato Basin, basin thickness, and aquifer characteristics. Mr. Loy reported storage and recovery rates are also low, the estimate based on existing well productions was only tens of gallons per minute and made the costs per acre-foot infeasibly high. In reference to regional aquifer storage recover, Mr. Loy stated NMWD may benefit from a regional aquifer storage recovery program, if excess treated water allocated to NMWD could be stored and recovered when needed. He added that regional groundwater banking on other basins could include Santa Rosa Plain, Sonoma Valley and Petaluma. Mr. Loy stated that the preliminary conclusions is an estimated 50-100 AF of new storage volume and noted the cost estimate for local aquifer storage recovery is still in progress. His recommendation was to focus on regional groundwater recovery programs.

President Petterle asked if there were any comments or questions from the Directors.

Director Grossi asked how deep the Novato basin is, noting most wells in the area are not that deep. Mr. Loy agreed, replying fifty feet is the typical depth. Director Grossi asked if Mr. Loy meant the aquifer was 50 feet thick and 50 feet down. Mr. Loy replied the bedrock underlying the aquifer sediments is 50 feet below the ground surface and the water depth is approximately 10 feet. Mr. Williams noted when looking at the regional study be aware that Sonoma Water is actively engaged in three wells in the Santa Rosa Plain, therefore there is definitely a regional opportunity.

President Petterle asked if were any comments or questions from the public and there was no response.

The second alternative, Recycled Water System Expansion, was presented by Anita Jain. Ms. Jain stated that the focus of this effort was to evaluate expansion of the existing distribution system and explore other opportunities to increase recycled water use without expanding the existing distribution system. She evaluated the north, south and central service areas of Novato, which in total has a potential to offset an additional 220 AF of potable water. Ms. Jain also introduced other near-term opportunities that would not include an expansion of the distribution system which included: constructing additional hydrants or commercial fill stations; optimize residential fill station operations to increase use; and facilitate connection of in-fill sites and assess dual-plumbing requirements for toilet flushing. Ms. Jain also informed the Board of recycled water use opportunities for future study, which included: privately-owned recycled water storage tanks and delivery of recycled water to residential customers. She noted that livestock watering is not a consideration at this time since it is prohibited by current regulations. Ms. Jain stated the next steps would be to conduct planning level hydraulic analysis to determine: infrastructure sizing; prioritize alignments and phasing plan for construction; and develop planning level cost estimate. An additional future study would be needed to determine if recycled water supply reliability can meet future demand. In conclusion Ms. Jain reported that potential potable water offset of up to 220 AF is possible with a distribution system expansion. She noted a cost estimate for expanding this system is still in process; however, she recommended to continue to assess opportunities for increasing recycled water use within the existing distribution system.

President Petterle asked if there were any comments or questions from the Directors.

Director Petterle stated he had a question for Mr. McIntyre or Mr. Williams, stating if we look at ABAG requirements for affordable housing and potential future development, what is our projected additional need. He asked in perspective of what we are looking at for short or long-term needs is 1,000 AF enough. Mr. Williams replied there are always a lot of variables with development. He stated that there are the known development sites like Fireman's Fund and vacant lots and commercial developments, and the projection between now and 2035 is to be about 1,000 AF of new potable demand. Mr. Williams that noted Fireman's Fund already receives recycled water and we are looking at 900 to 1,000 AF as the range for future build out in the City of Novato. Mr. Williams added there is additional forecast information in the Urban Water Management Plan. Director Petterle replied that this gave him a sense of where the District stands. Director Joly asked on behalf of the customers that are listening, he would like to ask Mr. McIntyre or Mr. Williams when we look at water supply, how many AF do we currently supply for Novato and how big is Stafford Lake. Mr. Williams replied if Stafford Lake is filled to the spillway it can hold 4,300 AF, however we never drain it down to zero. Mr. Clark added the typical annual production goal is 2,000 AF of local treated supply and that this amount supplements water from SONOMA WATER. Mr. Williams noted that the total annual water demand is approximately 8,000 AF total use in the Novato area.

President Petterle asked if any of the public had any comments or questions.

Jerry Peters commented that the District needs to do more to promote the recycled water residential fill station and expanding that program. He added there are some who are not aware of the programs available to them, and recycled water could allow us to keep our trees.

The third alternative, Indirect Potable Reuse, was presented by Charles Hardy. Mr. Hardy apprised the Board that state regulations allow "indirect" potable reuse through groundwater replenishment (augmentation), surface water source argumentation, noting full advanced treatment is required in this process. Mr. Hardy spoke about the feasibility of Indirect Potable Reuse (IPR) and noted IPR water cannot mix directly with potable water.

Mr. Hardy also informed the Board about the feasibility of indirect potable reuse (IPR). He noted IPR water cannot mix directly with potable water and there are not viable local IPR storage options in Novato in the groundwater aquifer or as surface water storage. Mr. Hardy reported groundwater augmentation in the local groundwater basin is limited to approximately 50-100 AF in storage availability. He also reviewed the surface water augmentation options at Stafford Lake. He stated regulations require a blending ratio of less than ten percent and a retention time of more than sixty days. Mr. Hardy added IPR is limited by the small volume of Stafford Lake, even if the lake is kept full, the maximum supply potential is approximately 100-400 AF. Mr. Hardy explained the indirect potable reuse infrastructure to the Board. He stated the unit cost of treatment prior to storage is at least $3,000 per AF without economy of scale seen by other agencies. He noted that additional costs for groundwater recharge, injection and extraction wells and associated infrastructure. Mr. Hardy reported a new conveyance pipeline would be required for Stafford Lake augmentation with an estimated pipeline length of 28,000 linear feet that would run from Novato Sanitary District to Stafford Lake. He added this 16-inch diameter transmission pipeline would have an estimated cost of over $20M dollars. Mr. Hardy recommended no further analysis of local IPR is feasible with a groundwater augmentation of approximately 50-100 AF and surface water augmentation of approximately 100-400 AF. Mr. Hardy however, did note that regional IPR may be viable, potentially with approximately 3,100 AF from Novato Sanitary District. In conclusion, Mr. Hardy stated direct potable reuse would be a potentially viable option in the future as regulations and public acceptance evolve, but that would be at least ten years out.

President Petterle asked if there were any comments or questions from the Directors.

Director Grossi suggested further analysis of surface water getting into Stafford Lake, noting there is a potential for raising the capacity another 700 AF if we add it back into the lake or find another place to store the water. Director Baker asked about the treatment process for IPR and the requirement is that it must go through both microfiltration and the reverse osmosis units. Mr. Hardy confirmed, they were both part of the process. Director Baker asked if the water rejected was a significant amount. Kathryn Gies of West Yost responded it is about 5-10% of the total. Director Joly stated the AF of recycled water from Novato Sanitary District is a good supply. Director Joly asked what the prohibited cost was, and what is Novato Sanitary District capable of converting. Ms. Jain replied that would be a discussion with Novato Sanitary. Mr. Hardy added the facilities for treatment would still need to be produced.

President Petterle asked if any of the public had any comment or questions and there was no response.

The fourth alternative, Improve Stafford Treatment Plant (STP) Process Water Recapture Efficiency, was also presented by Charles Hardy. Mr. Hardy noted STP potable water production is limited by a wastewater discharge permit from Novato Sanitary District. He stated STP has several reject water streams: hydrocyclone which accounts for 80-90% of total wastewater discharge and has the potential to reduce the discharge by 50-75% with hydrocyclone modifications. He noted these modifications are subject to performance testing and regulatory approval. Mr. Hardy reported an additional yield of at least 100 AF could occur by a 50% reduction of hydrocyclone during a dry year. Additionally, he stated that there is a potential to achieve an additional yield of 600 AF during an average rainfall year or if supplemental water is stored during a dry year. Mr. Hardy explored improving the Stafford Treatment Plant process in regard to water recapture efficiency. He apprised the Board that District staff previously conducted a plant-scale study of modifying hydocyclone return to reduce reject flow volume, however he recommended an additional plant-scale study be done with external technical support to confirm capital/operations changes needed in order to change sludge diversion. He added raw water intake may also need modifications for more consistent intake water quality and the District should account for replacing the 4-inch discharge pipeline to Novato Sanitary District to reduce maintenance efforts. Mr. Hardy recommended the District should conduct additional plant-scale testing with technical support. He concluded there is a potential estimated yield of approximately 100-600 AF and a cost estimate is still in progress.

President Petterle asked if there were any comments or questions from the Directors.

Director Fraites stated Jolly Brown sent in a question on the Zoom chat platform. Director Petterle read Mr. Brown's comment and a discussion ensued.

President Petterle asked if any of the public had any comments or questions and there was no further discussion.

The fifth alternative, Divert Captured Stormwater Into Stafford Lake was presented by Doug Moore. Mr. Moore reported on the watersheds in Leveroni and Bowman Canyons, he quantified the rainfall to runoff relationship to calculate the yield of the Leveroni and Bowman Canyon runoff, evaluated increased water supply to Stafford Lake and evaluated costs. In addition, he reported on possible capture of diverted stormwater in Stafford Lake. Mr. Moore stated there was no significant runoff for the first eight to ten inches of rain, however the watershed yields 353 AF per inch of rain after the first eight to ten inches. He reported the 2016-2020 average watershed yield for Stafford Lake was 4,000 AF, the estimated yields for the same time period were 910 AF for Leveroni Canyon, 1,590 AF for Bowman Canyon and 2,500 AF combined. Mr. Moore noted however, this alternative only works if there is stormwater runoff available. The increased water supply to Stafford Lake could be 788 AF. Mr. Moore also reviewed the estimated total annual cost per AF, which included the capital, operations and maintenance cost. In conclusion, Mr. Moore stated that the use of Leveroni and Bowman Canyon water is cost feasible, however the use of the detention basin is cost prohibitive unless there is a cost sharing. He recommended evaluating the long-term benefit of Bowman and Leveorni Canyon flow diversion using twenty to forty years of rain data, but adjusting for future climate change. Additionally, he recommended monitoring flows and water quality from Leveroni and Bowman Canyons.

President Petterle asked if there were any comments or questions from the Directors.

Director Baker asked aside from the operational and treatment of water, does the District need to buy property or the rights of the property. Mr. Moore replied that he did not mention acquisition of property in his report. Director Baker responded that is a big deal, not only the cost, but possible environmental implications. Mr. Moore replied, that Director Baker is absolutely right, the capital cost of the land and other possible issues was not included. Director Baker stated that there will be a cost associated as political and environmental issues arise. Director Fraites stated that last week he has a discussion with a county supervisor, and Bowman Canyon is Agricultural or A60 zoning. He added, the County of Marin is looking to put development in the Bowman Canyon area as they continue to get pressure from the state for more housing. Director Fraites asked if a housing development were to be constructed, how would that affect the District's ability to extract water from Bowman Canyon. Mr. Moore said the facility could be constructed on the south side of the roadway and may not be affected by a development. However, he added there would be a difference of urban runoff versus a natural watershed. Director Fraites stated it is something we should be aware of. Director Grossi stated it is a complicated analysis. He noted Bowman Canyon has been sitting there with threats of development for a long time. Director Grossi stated the analysis on Leveroni Canyon and Bowman Canyon was excellent. He added a simpler approach might be to store the water and make one reservoir, it could store the excess water and solve some of the flooding problems. Director Grossi stated there is an excess of 3,000 AF of water there, noting a lot of water is running down the watershed and we should save it. He added there would be the cost for infrastructure, and building of a dam, but think of the potential possibilities. Director Grossi asked Mr. Moore how much could be held back in one or both of the canyons, and what can we do to work with the county and sanitary district to make this a multi-agency project. He also recognized there are various opinions on dams. Mr. Moore replied, Director Grossi is correct about environmental concerns. He added, from a cost perspective you would need to get storage and then have to extract the storage and that is an idea they have not put cost or volume to yet. Director Grossi stated it would be something the District should look at, especially if desalination is not feasible for this District. He noted this study has brought to light that we have a lot of sources for water; but our problem is the storage. Mr. Williams stated the disadvantage we have tonight is that we do not have the information of the Sonoma Water regional study. He noted there is a potential to physically store water in Sonoma County to provide regional storage. Director Grossi stated that we need to throw everything on the table and look at the long term with radical changes in rainfall and drought as critical factors. Director Petterle stated water rights and fishery is a concern, considering a dam in the canyon is an interesting proposition and it may be worth giving it some consideration.

President Petterle asked if any of the public had any comments or questions.

Mr. Brown (via Zoom chat) asked how long the amortization cost would be for the basin, is twenty-five years realistic or would it last longer; what would be the cost of the project. He added we don't' have a drought as much as we have a storage issue. Hilary Maslon sent in a

Zoom chat request and asked how is it that Israel does desalination and we cannot. She asked if there is a way to store the brine, or use it for another purpose. Director Petterle replied we will look at desalination later in this study, however it is really expensive and the District's is not directly near the ocean. He reassured Ms. Maslon that the Board and staff will look at that option and it is not completely off the table. Ms. Maslon suggested staff could setup a training program for residential passive gray water use. She noted washing machines, for example could be on a simple low grey water system for low cost. Mr. McIntyre reported NMWD does offer gray water rebates and the County of Marin has a program to teach customers about gray water use and storage. He suggested Ms. Maslon contact NMWD's Water Conservation Coordinator, Ryan Grisso.

The sixth alternative, Increase Stafford Lake Storage Capacity, was also presented by Doug Moore. Mr. Moore discussed two options; modifying the spillway and removing sediment. He noted one way to increase the storage capacity would be to install a slide gate on the spillway "notch". He noted the increased storage volume is only useful when there is enough rain to overtop the spillway notch, however it could increase storage volume up to 726 AF. Mr. Moore stated the slide gate had an estimated total capital cost of $710,000, adding the capital cost of increased storage volume would be around $1,000 per AF. Another option discussed by Mr. Moore is to remove sediment by excavating the bottom of the lake. He stated the capital cost of increased storage volume for a 15-foot depth is estimated to be $48,500 per AF. Mr. Moore noted a minor benefit of excavation is removal of nutrient rich soils that can temporarily help the treatment process. In conclusion, Mr. Moore stated the slide gate is cost feasible and the excavation of sediment from the lakebed is cost prohibitive. He noted some future considerations which included: evaluating long-term benefit of slide gate using 20-40 years of rain data, but adjusted for future climate change. Additionally, he considered evaluating the long-term benefit of slide gate combined with Leveroni and Bowman Canyon flow diversion using 20-40 years of rain data, but adjusted for future climate change.

President Petterle asked if there were any comments or questions from the Directors.

Director Grossi asked if pouring concrete to raise the level could be done instead of using a slide gate. Secondly, he asked what factors was used to generate the cost for the removal of sediment, noting it is about fifty dollars a cubic yard to remove dirt. Mr. Moore replied they used $30 per cubic yard as an estimated cost for sediment removal. He added that the number is a reasonable value as a starting point. Mr. Moore added this option is a very expensive and not feasible. In answer to Director Grossi's question about filling the notch with concrete, Mr. Moore explained the notch is part of the flood control feature of the dam, his understanding is the notch allows water to release in a controlled fashion before the water spills over the larger spillway. Director Grossi stated if you combine the storage you would end up with a complicated three-dimensional matrix. Jolly Brown Zoom chatted that the gate sounds like a great idea. Director Joly stated the gate option sounds very attractive, and asked if it would create an inundation issue when walking around the dam. Mr. Moore replied the facilities are constructed below so there should not be any potential for an issue. Director Joly stated that the average rainfall for Novato is 27 inches, and asked how many inches would it cause it to spill if analyzing inch of rain per get 700 AF. Mr. Moore stated that he has not done that calculation; however, the Stafford Lake watershed yields 353 AF per inch of rain after the first 8-10 inches. He noted with two added inches, a yield of about 700 AF would be a ball park number. Director Joly asked if it would be the metric of Leveroni and Bowman Canyon, and Mr. Moore confirmed. Mr. McIntyre stated the idea of an adjustable gate is for utilization after the January-February months, so the spillway can still act as it was designed to attenuate sudden flooding events due to heavy rainfall. Mr. McIntyre added, during spring time we could have higher water levels along the perimeter of the lake, but no higher than what is experienced during major storm events. Mr. Williams stated NMWD Senior Engineer, Tim Fuette, came up with the concept and sent it to West Yost. He added staff would have to work with the Division of Safety of Dams to approve the spillway gate and we would have more details on that later. Mr. Clark stated that in a previous report the lake generally spills 70% of the time and we would need details to see how much we would gain. Director Baker reminded the Board that 35 years ago there was a joint project initiated by Marin County Flood Control District (MCFCD) when downtown Novato flooded. He stated at that time they contributed financially to raise the top of the dam and rebuild the spillway to what it is today. Director Baker stated that the conceptual changes to modify the spillway will need to consider some standing agreements with the County of the Marin and MCFCD on who is responsible for what. Mr. Williams stated that staff has already reached out to the MCFCD and there is a benefit in this. He added when the County via the MCFCD did the Novato Watershed study, a modification of the spillway was an alternative to consider and if we decide to pursue this it will take a lot of coordination and review of any agreements in place.

President Petterle asked if any of the public had any comments or questions and there was no response.

The seventh alternative, Desalination, was presented by Kathryn Gies. Ms. Gies apprised the Board that this must be pursued as a regional partnership in order to be a viable project due to: economy of scale, environmental consideration, and the fact that there is no viable intake or brine discharge locations for NMWD. She shared some agency comparisons. Ms. Gies stated that MMWD completed a desalination study in 2008 and again in 2021, and opted not to pursue. She noted MMWD is currently investigating a pipeline connection with EBMUD for emergency supply as an alternative option. Additionally, Ms. Gies added MMWD is proceeding with an EIR for the pipeline, which will look at desalination as an alternative, noting an estimated 15 MGD desalination plant has an estimated cost of $230M. She noted that any desalination partnership would be a long-term project of fifteen or more years. Ms. Gies also reported that Sonoma Water is preparing a regional study and desalination is one option being evaluated. She added that if the Sonoma Water Study is not available, the findings will not be incorporated into NMWD's local study.

President Petterle asked if there were any comments or questions from the Directors.

Director Joly noted the study said that NMWD did not have an appropriate place to access the ocean water. He added he would be hesitant to wait for Sonoma Water's regional desalination report. Director Joly stated that there is an irony of running out of water when we are next to the largest body of water on the planet. He noted if other communities like Israel can bring on desalinated water then clearly, we should be at least studying the technology and not relying on water from the sky. Director Fraites stated that desalination is enormously expensive, but maybe we can look at the bay, Petaluma River or Blackpoint as an option, noting Petaluma River is brackish water, not sea water. Mr. McIntyre stated that with respect to desalination, whether is it ocean water or brackish water, we are too small of an agency to do it on our own, we need a partner. Mr. McIntyre added Sonoma Water's regional study is looking at brackish water desalination with the potential location in the Petaluma area. Director Joly stated we need not just regional money, but federal money. He noted the Bay Area is large and he would expect federal money would be available and it is worth pursuing. Director Grossi stated that he agrees that desalination is something we can not be the lead agency on, we don't have the money. He noted we will need to partner with others, whether it is MMWD, Sonoma Water, the state or federal government. Director Grossi added he also agrees desalination needs to be looked at and we need to keep monitoring the agencies around us. He noted, however, it will not solve our problems right now. Director Grossi stated that even if you got funding it would be fifteen years before you would be able to get water. He emphasized we need to look at options that will work for us now, and the report from West Yost is very beneficial to us. Director Petterle stated California is water rich, it was the coastal areas that were hit, which is why they took on desalination. He noted ultimately the solution is desalination, but it takes a regional coordination. Director Petterle stated that as an example look where solar was thirty years ago, we have made so many advances since then. Director Petterle stated that in thirty years we will see many advances in desalination too, but we need to be realistic on the expense and the environmental consequences. Director Petterle stated we need to look at the shorter-term options, especially with ABAG decision on affordable housing units in Novato, we need solutions now.

President Petterle asked if any of the public had any comments or questions and there was no further discussion.

Rhodora Biagtan gave a presentation on Evaluation Criteria, which included: cost, water supply yield and reliability; operational impacts; regulations and permitting; public and institutional considerations and other considerations. In regards to cost Ms. Biagtan stated they considered the following: capital cost plus operations and maintenance cost estimate; cost estimates to include additional labor, material, energy and chemicals needed; compare using dollar per AF for each water supply alternative; making the cost estimate translatable to NMWD's water; noting revenue impacts that would be relative to the volume of water generated, except for new recycled water uses. In regards to water supply yield, Ms. Biagtan stated they included an estimate of the expected water supply yield. Additionally, she considered reliability and the likelihood of the water supply alternative producing the anticipated yield, noting climate change may impact the reliability. Ms. Biagtan stated that inn regards to operational impacts, they evaluated the impact to distribution and treatment operations. She stated they also considered the following: challenges to blending from different supply sources; additional chemicals required to produce and maintained high-quality of water; energy intensity; and additional staff resources or special certifications required. In regards to regulations and permitting, Ms. Biagtan stated that first they need to identify the required permits and then evaluate applicable regulations and anticipated permitting requirements. She noted considerations include: environmental impacts; conformance with CEQA, permitting requirements specific to the water supply alternative and water right for alternatives that may have water rights issues. In regards to public and institutional considerations, Ms. Biagtan included: public acceptance; coordination and collaboration with other entities; need for partnerships or agreements; and required easements from other entities. In conclusion, she stated that each water supply alternative is unique and may have other important considerations that are relevant to each water supply alternative and will be discussed, but not scored.

President Petterle asked if there were any comments or questions from the Directors and there was no response.

. President Petterle asked if any of the public had any comments or questions and there was no response.

Ms. Biagtan reviewed criteria ranking and weighting. She stated the criteria scoring was based on a quantitative criterion that included cost and water supply yield. Additionally, the qualitative criteria would include: reliability; operational impacts; regulations and permitting; and public and institutional considerations. In regards to qualitative criteria priorities and weight, Ms. Biagtan stated the criteria were ranked by weight. In conclusion of the presentation, Ms. Biagtan reviewed the next steps. She stated West Yost will prepare evaluations and complete the study, they will present their findings to the Board and public in spring of 2022 and then it will be up to the Board to accept.

Director Petterle thanked West Yost and staff for a study, that he felt was done well beyond his expectations. He stated the study looked at many things he had not considered, it was fascinating discussion and it was absolutely an amazing presentation. Director Joly stated he couldn't agree more, noting it was extremely helpful for the Board and the public to see. He noted as a criteria water supply should be higher in weight; the allotment of percentage should be higher for water. Mr. Williams stated if we don't have supply, we don't have water. He added we want to look at the other factors, and he agrees in principal, but other impacts do have weight. Director Joly stated in reference to water enhancement, our partner Sonoma Water has a three well storage program and just got a $9M grant. Mr. Williams replied, in talking about catchment, or water from the sky", we need to look at the regional aquifer storage and recovery, as well stormwater storage and aquifer recharge known as flood-managed aquifer recovery. He added we can take stormwater and put it back in the ground and extract it during dry periods, noting Sonoma Water is looking at this as part of the regional study.

ADJOURNMENT

President Petterle adjourned the meeting at 7:30 p.m.

Submitted by

Theresa Kehoe
District Secretary

Item #2

WEST YOST
Water. Engineered.

NORTH MARIN
WATER DISTRICT

Board Workshop:
Findings and Recommendations

Local Water Supply Enhancement Study for Novato Water Service Area

April 26, 2022

Purpose

- Provide the Board and the Public a preview of the 2022 Local Water Supply Enhancement Study findings and recommendations

- Overview the following:
  - Water Supply Alternatives Evaluation
  - Feasible Projects
  - Next steps

Project Team Introductions

North Marin Water District

- Project Manager: Tony Williams, Assistant General Manager/Chief Engineer
- Drew McIntyre, General Manager
- Robert Clark, Operations/Maintenance Superintendent

West Yost

- Project Manager: Rhodora Biagtan
- Project Engineer: Megan McWilliams

- Technical Experts:
  - Stormwater: Doug Moore
  - Treatment Plant Optimization: Charles Hardy
  - Funding Strategy: Monique Day

Local Water Supply Enhancement

Current and Projected Water Demands

Current and Projected Water Demands, AF						
Water Type	2020	2025	2030	2035	2040	2045
Potable Water	7,992	9,866	10,031	10,245	10,254	10,284
Raw Water	202	218	218	218	218	218
Recycled Water	658	595	508	622	636	650
Total	**8,852**	**10,679**	**10,757**	**11,085**	**11,108**	**11,152**

Source: North Marin Water District. June 2021. 2020 Urban Water Management Plan. Table 4-1, Table 4-4, and Table 4-8.

- NMWD's water demand expected to increase by 2,300 AF (~26% increase) over the next 25 years
  - ➢ Primarily due to the projected increase in population

Study Objectives

- Enhance NMWD local water supply by 1,000 to 2,000 acre-ft per year*
- Identify feasible water supply alternatives

*1 acre-feet ≈ 326,000 gallons

Water Supply Alternatives Developed

- Aquifer Storage Recovery in Novato Basin
- Recycled Water System Expansion
- Indirect Potable Reuse
- Improve Stafford Treatment Plant Process Water Recapture Efficiency
- Divert Captured Stormwater Into Stafford Lake
- Increase Stafford Lake Storage Capacity
- Desalination

Evaluation Criteria

- Quantitative Criteria:

Criteria	Measure	Units
Cost	Quantitative	$ per AF
Water Supply Yield	Quantitative	Volume, AF

- Qualitative Criteria:

Criteria	Measure	Low Score (1)	Medium Score (3)	High Score (5)
Reliability	Degree of Reliability	Least Reliable	Moderately Reliable	Most Reliable
Operational Impacts	Operational Demands	Most Impacted	Moderately Impacted	Least Impacted
Regulations and Permitting	Complexity	Most Complex	Moderately Complex	Least Complex
Public and Institutional Considerations	Challenges	Most Challenging	Moderately Challenging	Least Challenging

Findings and Conclusions

Local Water Supply Alternative			Quantitative Criteria		Qualitative Criteria				
			Unit Cost over 30 Years ($ per AF)	Annual Yield (AFY)	Water Supply Reliability	Operational Impacts	Regulations and Permitting	Public and Institutional Considerations	**Weighted Qualitative Score**
Local ASR[a]			11,200	15	3	3	2	2	2.7
Recycled Water System Expansion[b]		*Segment N-1*	5,300	17	5	4	4	5	**4.5**
		Segment N-2	6,600	23	5	4	4	5	**4.5**
		Segment C-1	22,000	4	5	4	4	5	**4.5**
		Segment C-2	8,600	19	5	4	4	5	**4.5**
Local Indirect Potable Reuse[c]			3000	1,000 - 3,100	5	1	1	1	2.6
Improve STP Process Water Recapture Efficiency[d]		*Pretreatment Modification*	70 - 240	20 - 70	4	5	5	5	4.6
		Pretreatment Modification and Ancillary Improvements[e]	1,500 - 5,200	20 - 70	5	5	5	5	5
Divert Captured Stormwater Into Stafford Lake[f]	*Without Basin[g]*	*Option 1. Leveroni Canyon*	710	245	3	4	2	4	3.2
		Option 2. Bowman Canyon	470	433	3	4	2	4	3.2
		Option 3. Novato Creek	330	628	3	4	2	4	3.2
	With Basin[g]	*Option 2. Bowman Canyon*	960	593	4	3	2	3	3.2
		Option 3. Novato Creek	730	788	4	3	2	3	3.2
	Option 4. Dam at Leveroni Canyon		1,700	175	3	3	2	2	2.7
	Option 5. Dam at Bowman Canyon		800	752	3	3	2	2	2.7
Increase Stafford Lake Storage Capacity[h]		*Spillway Notch Slide Gate[i]*	90	726	5	5	2	5	4.4
		Sediment Removal[i]	2,600	551	3	2	2	3	2.5
Desalination[h]			-	-	5	1	1	1	2.6

Feasible Local Projects

Local Water Supply Alternative	Estimated Capital Cost	Estimated Implementation Time	NPV of Total Cost ($ per AF)	Annual Yield (AFY)	Weighted Qualitative Score
Improve Stafford Treatment Plant Process Water Recapture Efficiency - Pretreatment Modification	$140,000*	~ 2 – 3 years	70 - 240	20 - 70	4.6
Increase Stafford Lake Storage Capacity - Spillway Notch Slide Gate	$1.238M	2 - 4+ Years	90	726	4.4
Divert Captured Stormwater Into Stafford Lake	$2.46M - $13.64M	5+ Years	330 - 960	245 - 788	3.2

*Includes performance testing

Potential 991 AF to 1,584 AF of additional local water supply

Potential Regional Collaboration

- Sonoma Water *Regional Water Supply Resiliency Study*
  - Aquifer Storage Recovery (ASR)
  - Indirect Potable Reuse (IPR)
  - Desalination

Near-Term Drought Management Options

SCWA Regional Study	
Resiliency Option	Current Status
Maximize Delivery of Natural Flows in the Russian River (RR)	• NMWD purchased available RR water to back feed Stafford Lake
Kastania Pump Station Rehabilitation	• MMWD completed construction in January 2022 • NMWD working closely on start-up/operations and testing
Increase Groundwater Production	• SCWA's Santa Rosa Plain Drought Resiliency Project includes 3 wells • Todd Rd well online in October 2021 • 1.4 mgd available now • Additional 4.1 mgd by year end
Regulatory Flexibility (through TUCPs)	• TUCO issued in December 2021 lowering minimum instream flows for RR
Water Conservation and Water Use Efficiency	• NMWD Ord No. 41 in place with 20% reductions

Next Steps

Next Steps

- Receive feedback
- Finalize Report
- Publish Report for public availability

Next Steps

Feasible Local Water Supply Alternative	Conduct Further Studies	Explore Funding Options	Outreach to Public and Regional Agencies	Environmental Review	Follow Regulations and Permitting Requirements	Design and Construction
Improve Stafford Treatment Plant Process Water Recapture Efficiency	✓					✓
Increase Stafford Lake Storage Capacity - Spillway Notch Slide Gate	✓	✓	✓	✓	✓	✓
Divert Captured Stormwater Into Stafford Lake	✓	✓	✓	✓	✓	✓

Funding Strategy

Potential Funding Programs by Project			
Funding Program	Improve STP Process Water Recapture Efficiency	Increase Stafford Lake Storage Capacity	Divert Captured Stormwater into Stafford Lake
State Programs			
DWR IRWM	X	X	X
DWR Drought Relief Funding	X	X	X
SWRCB Water Recycling Funding			
I-Bank (loans only)	X	X	X
Federal Programs			
FEMA BRIC	X	X	X
FEMA HMPG	X	X	X
USBR WaterSMART Drought Response[(c)]	X	X	X
USBR Title XVI Recycled Water			
WIFIA (loans only)	X	X	X

Acknowledgements

- North Marin Water District Staff
  - Drew McIntyre, General Manager
  - Tony Williams, Assistant General Manager, Chief Manager, and Project Manager for the Local Water Supply Enhancement Study
  - Robert Clark, Operations and Maintenance Superintendent
  - Brad Stompe, Distribution & Treatment Plant Supervisor
  - Jeff Corda, Senior Water Distribution & Treatment Plant Operator
  - Ryan Grisso, Water Conservation Coordinator
  - Pablo Ramudo, Recycled Water Quality Supervisor

- Marin County Parks Staff
  - Jason Hoorn, Natural Resources Coordinator
  - Tara McIntire, Principal Landscape Architect
  - Jon Campo, Principal Natural Resources Planner

- Roger Leventhal, Advisor from Marin County Flood Control & Water Conservation District
- Paul Sellier, Advisor from Marin Municipal Water District
- Jay Jasperse, Chief Engineer and Direct of Groundwater Management, Sonoma Water

Discussion and Questions

Date Posted: 4/22/2022

NORTH MARIN WATER DISTRICT
AGENDA - SPECIAL MEETING
April 26, 2022 – 6:00 p.m.
Location: Virtual Meeting
Novato, California

Information about and copies of supporting materials on agenda items are available for public review at 999 Rush Creek Place, Novato, at the Reception Desk, or by calling the District Secretary at (415) 897-4133. A fee may be charged for copies. District facilities and meetings comply with the Americans with Disabilities Act. If special accommodations are needed, please contact the District Secretary as soon as possible, but at least two days prior to the meeting.

ATTENTION: This will be a virtual meeting of the Board of Directors pursuant to Assembly Bill 361 issued by the Governor of the State of California.

There will not be a public location for participating in this meeting, but any interested member of the public can participate telephonically by utilizing the dial-in information printed on this agenda.

Video Zoom Method

CLICK ON LINK BELOW:		**SIGN IN TO ZOOM:**
Go to: https://us02web.zoom.us/j/82191971947	**OR**	Meeting ID: 821 9197 1947
Password: 466521		Password: 466521

Call in Method:

Dial:
+1 669 900 9128
+1 253 215 8782
+1 346 248 7799
+1 301 715 8592
+1 312 626 6799
+1 646 558 8656

Meeting ID: 821 9197 1947#

Participant ID: #

Password: 466521#

For clarity of discussion, the Public is requested to MUTE except:
1. During Open Time for public expression item.
2. Public comment period on agenda items.

Please note: In the event of technical difficulties during the meeting, the District Secretary will adjourn the meeting and the remainder of the agenda will be rescheduled for a future special meeting which shall be open to the public and noticed pursuant to the Brown Act.

All times are approximate and for reference only.
The Board of Directors may consider an item at a different time than set forth herein.

Est. Time	Item	Subject
6:00 p.m.		***CALL TO ORDER***
	1.	***OPEN TIME: (Please observe a three-minute time limit)***
		This section of the agenda is provided so that the public may express comments on any issues not listed on the agenda that are of interest to the public and within the jurisdiction of the North Marin Water District. When comments are made about matters not on the agenda, Board members can ask questions for clarification, respond to statements or questions from members of the public, refer a matter to staff, or direct staff to place a matter of business on a future agenda. The public may also express comments on agenda items at the time of Board consideration.
	2.	***LOCAL WATER SUPPLY ENHANCEMENT STUDY WORKSHOP NO. 2***
7:30 p.m.	3.	***ADJOURNMENT***

NORTH MARIN WATER DISTRICT
MINUTES OF SPECIAL MEETING
OF THE BOARD OF DIRECTORS
April 26, 2022

CALL TO ORDER

President Petterle announced that due to the Coronavirus outbreak and pursuant to the Brown Act as modified by Assembly Bill 361, this was a virtual meeting. President Petterle called the special meeting of the Board of Directors of North Marin Water District to order at 6:00 p.m. and the agenda was accepted as presented. President Petterle added that there was not a public location for participating in this meeting, but any interested members of the public could participate remotely by utilizing the video or phone conference dial-in method using information printed on the agenda.

President Petterle welcomed the public to participate in the remote meeting and asked that they mute themselves, except during open time and while making comments on the agenda items. President Petterle noted that due to the virtual nature of the meeting he will request a roll call of the Directors. A roll call was done, those in remote attendance established a quorum. Participating remotely were Directors Jack Baker, Rick Fraites, Jim Grossi, Michael Joly and Stephen Petterle.

President Petterle announced that in the event of technical difficulties during the meeting, the District Secretary will adjourn the meeting and the remainder of the agenda will be rescheduled for a future special meeting which shall be open to the public and noticed pursuant to the Brown Act.

President Petterle announced that all public attendees will be invited to speak and will need to use the raised hand icon in Zoom or dial *9 to be called upon.

Mr. McIntyre performed a roll call of staff, participating remotely were Drew McIntyre (General Manager), Tony Williams (Assistant GM/Chief Engineer), Terrie Kehoe (District Secretary), Julie Blue (Auditor-Controller), Robert Clark (Operations/Maintenance Superintendent) and Ryan Grisso (Water Conservation Coordinator). Also participating remotely were West Yost consultants; Rhodora Biagtan, Megan McWilliams, Anita Jain, Charles Hardy, Doug Moore, and Monique Day; in addition to IT consultant Clay Smedshammer (Core Utilities).

President Petterle requested that for those joining the virtual meeting from the public to identify themselves. Attending remotely were Will Houston (Marin IJ), Ken Levin (Point Reyes Station Village Association), DK, Mary and Guy.

OPEN TIME

President Petterle asked if anyone from the public wished to bring up an item not on the agenda and there was no response.

LOCAL WATER SUPPLY ENHANCEMENT STUDY WORKSHOP No. 2

Mr. Williams introduced West Yost Associates as the presenter for the workshop. Mr. Williams noted that the original intent was to be in sync with Sonoma Water's Regional Water Supply Resiliency study, and NMWD's local water supply study is working in parallel with their study. Mr. Williams apprised that the Board that the purpose of the workshop was to provide the Board and the public with a preview of the 2022 Local Water Supply Enhancement Study findings and recommendations.

Rhodora Biagtan of West Yost Associates began the presentation on the Local Water Supply Enhancement Study Board Workshop No. 2. She gave an overview on the evaluation of water supply alternatives, feasible projects and next steps.

Ms. Biagtan discussed the findings and conclusions of the 2022 Local Water Supply Enhancement Study and the focus was on feasible local projects and potential regional collaboration. The feasible local projects included: improvement of recapture efficiency and pretreatment modifications for Stafford Treatment Plant; installation of a spillway notch slide gate to increase Stafford Lake storage capacity; and diverting captured stormwater into Stafford Lake. Ms. Biagtan stated that some potential regional collaboration projects to consider as part of the SCWA Regional Water Supply Resiliency Study were; aquifer storage recover, indirect potable reuse and desalination. Additionally, she reported on some near-term drought management options which included: maximizing delivery of natural flows in the Russian River; rehabilitation of Kastania Pump Station, Increase Groundwater Production, regulatory flexibility through Temporary Urgency Change Petitions; Water Conservation and Water Use Efficiency. In the conclusion of the presentation next steps and funding strategies were discussed.

Ms. Biagtan also acknowledged staff that aided in the study from; NMWD, Marin County Parks, Marin County Flood Control and Water Conservation District, and Sonoma Water.

President Petterle thanked Ms. Biagtan and West Yost for the concise presentation.

President Petterle asked if there were any comments or questions from the Directors.

Director Joly asked about the large increase in potable demands and asked why there was a huge increase from 2020 to 2025. Mr. Williams replied that this information was an excerpt from the Urban Water Management Plan and not from West Yost. He stated that it is staff's best guess about upcoming development in Novato and reflects some of the known projects like Fireman's Fund. Director Joly asked if it included ABAG housing projections. Mr. Williams confirmed.

Director Fraites stated that on the final page, the funding strategy does not show any federal or state funds to tap into. Ms. Biagtan replied that the headings do include subcategories that provide both state and federal funding. Director Fraites stated that he was concerned about funding, adding he appreciated the clarification and the study.

Director Grossi stated that he thought the study was well thought out and thorough and he was impressed by all the information provided in this one study. He added that this is the first step, the big job it to make sure some of these projects happen.

President Petterle asked if there were any comments or questions from the public and there was one anonymous question. An anonymous participant asked about the options presented and inquired about which ones would result in the best quality water and which are the most sustainable. Mr. Williams replied that the option to improve the operation of Stafford Treatment Plant and minimized the water we reject in the drinking water process is huge on a sustainability scale, it has minimal waste and the approach is very efficient. The others as far as the water quality is concerned, is the same quality we already see in the Novato Creek Watershed. Mr. Williams emphasized that all identified feasible projects have equal water quality implications and they all are sustainable. Mr. Clark added that the quality of the treated water won't change.

President Petterle asked if the Directors had any further questions or comments.

Director Fraites stated that he knows desalination is ruled out due to cost, but asked if there are other serious discussions about desalination with the other water contractors Mr. McIntyre responded that Jacobs Engineering is in contract with MMWD to future evaluation a Marin County desalination option.

Director Grossi stated that he realizes the cost of sediment removal is prohibitive from Stafford Lake, however over time it may be necessary to increase capacity. Additionally, he commented that there may also be some water quality advantages to remove the sediment. Mr. Clark replied that this has been discussed in the past, and staff have also looked to see if they can trap the nutrients in the sediment and look at what the District is doing currently to keep the sediments from building up. Mr. Clark added that this is the question we should ask the consultants in the future, noting there is also a lot more we can do further downstream on the tributaries in the lake. Director Grossi stated that this year at his ranch they cleaned up the pond sediment, noting the cost was less if you do not have to haul it off site. He added there may be a more cost effective to way to get rid of the sediment. Mr. Clark replied that the transportation cost alone is expensive. Director Grossi stated that he thought it was still something to discuss and explore. Director Petterle noted that there may be an opportunity to stock pile the soil and make it available for the park if they are interested. Mr. Williams stated that he and Mr. Clark had discussed this in the past. He added that Marin County Parks staff are talking about a trail project in which they may use sediment from the lake and it would be an opportunity to dispose of the sediment locally. Tony Williams stated that Roger Leventhal at the Marin County Flood Control District said they are facing a shoreline problem along the bay because there is a lack of sediment from the sea level rise. He added that the Regulatory Water Quality Control Board is also looking at the concept of hydraulically dredging.

Director Joly stated that he was glad the NMWD is still tracking desalination, noting it is an expensive proposition, but we need to look at it. He added that he is happy that SCWA and MMWD are potential regional desalination players. Director Joly asked if West Yost could do an addendum to the study to see what new technology is in the forefront to improve water supply in the next decade. Mr. Clark asked for clarification, if he meant extracting water out of the aquifers or out of the atmosphere as part of the study. Director Joly replied that climate change and water supply is a big political issue around the world and we need to see what possibilities are out there to enhance water supply. Mr. McIntyre stated that these are all good questions, and it is good to think outside of the box. He emphasized that during his years of work at NMWD, studies have shown that it is more efficient and cost effective to develop new water supply options on a regional level than local. Mr. McIntyre added that these questions should be given to SCWA who supply the bulk of our water, noting they have future studies planned for long-term water supply improvement projects. Director Joly agreed, stating it is good for all of us and benefits all regions.

Director Fraites stated that he would like to look closer at the Bowman Canyon Dam option. He noted that creating a new reservoir may be dicey, but it is worth consideration. Director Grossi stated that the Bowman Canyon Dam option may also benefit the Flood Control District and that could provide the opportunity for more funding. He added that what is important now is coordinating with SCWA, MMWD and using the Jacobs Study to help us come up with the best cost per acre-foot scenario.

Director Petterle stated that these reports are great for those in the water industry who typically use acre-foot (af) or hundred cubic feet (ccf) for volume measurements. He added that the typical consumer however only understands gallons. Director Petterle stated that the water agencies wonder why the public don’t listen and that is partly because of the terminology used. He emphasized that NMWD as an agency should report in terms our customers can relate to. Mr. McIntyre responded that Mr. Williams can review the units concern with Ms. Biagtan before the report is finalized.

A discussion ensued about the Districts existing, comprehensive recycled water network, Director Joly added that with the supply of recycled water it is almost like adding another Stafford Lake, noting irrigation is our biggest need. Director Petterle asked about using recycled water for a project like Fireman's Fund with 1,100 houses. Mr. McIntyre replied that recycled water use would be feasible at this location since there is a recycled waterline that already fronts the property. Mr. Williams stated that there will be several new projects like the Residence Inn and Landsea Homes that will connect to recycled water, noting there is a lot of opportunities on the Redwood corridor.

President Petterle asked if there were any further questions from the public and there was no response.

Mr. McIntyre asked Mr. Williams what the timeline is for the Board and public to submit final comments. Mr. Williams replied that he heard many good comments tonight. He added that if any of the Board of Directors or public have comments they would like to share, to submit them by May 6th and then the final report will be brought back to the Board for acceptance.

ADJOURNMENT

President Petterle adjourned the meeting at 7:02 p.m.

Submitted by

Theresa Kehoe
District Secretary

Appendix C

Russian River Emergency Regulation

State of California
Office of Administrative Law

In re:
State Water Resources Control Board

Regulatory Action:

Title 23, California Code of Regulations

Adopt sections: **877, 877.1, 877.2, 877.3, 877.4, 877.5, 877.6, 878, 878.1, 879, 879.1, 879.2**
Amend sections:
Repeal sections:

NOTICE OF APPROVAL OF EMERGENCY REGULATORY ACTION

Government Code Sections 11346.1 and 11349.6

OAL Matter Number: 2021-0630-01

OAL Matter Type: Emergency (E)

The proposed emergency regulation would provide the State Water Resources Control Board's Division of Water Rights and users within the Russian River watershed a methodology for determining the extent to which water is unavailable for diversion at water users' priority of right. It would also authorize the Deputy Director to issue curtailment orders requiring recipients to cease diversions unless and until (1) they have authorization to continue diverting pursuant to one of the exceptions enumerated in the regulation, or (2) they receive notice that the curtailment order has been lifted.

The emergency regulation would provide the State Water Resources Control Board's Deputy Director for the Division of Water Rights authority to implement curtailment actions in the event that Lake Mendocino storage targets are not met (for Upper Russian River watershed curtailments) or when flows are insufficient to support all water right priorities (for Lower Russian River watershed curtailments). The proposed regulations also: define non-consumptive uses and minimum human health and safety needs; provide a pathway to allow for continued diversions for non-consumptive uses; provide procedures for authorizing continued diversion to meet minimum human health and safety needs; and establish reporting requirements for water right holders issued a curtailment notice.

OAL approves this emergency regulatory action pursuant to sections 11346.1 and 11349.6 of the Government Code.

This emergency regulatory action is effective on 7/12/2021 and, pursuant to Water Code section 1058.5(c), will expire on 7/12/2022. The Certificate of Compliance for this action is due no later than 7/11/2022.

Date: July 12, 2021

Dale P. Mentink
Senior Attorney

For: Kenneth J. Pogue
Director

Original: Eileen Sobeck, Executive Director
Copy: Andrew Deeringer

STATE OF CALIFORNIA--OFFICE OF ADMINISTRATIVE LAW

NOTICE PUBLICATION/REGULATIONS SUBMISSION

EMERGENCY

STD. 400 (REV. 10/2019)

For use by Secretary of State only

ENDORSED - FILED
in the office of the Secretary of State
of the State of California
JUL 12 2021
1:18 pm

OAL FILE NUMBERS	NOTICE FILE NUMBER	REGULATORY ACTION NUMBER	EMERGENCY NUMBER
	Z-		2021-0630-01E

For use by Office of Administrative Law (OAL) only

2021 JUN 30 P 1:47
OFFICE OF ADMINISTRATIVE LAW

NOTICE | REGULATIONS

AGENCY WITH RULEMAKING AUTHORITY
State Water Resources Control Board

AGENCY FILE NUMBER (If any)

A. PUBLICATION OF NOTICE (Complete for publication in Notice Register)

1. SUBJECT OF NOTICE: Diversion Curtailment,Russian River Watershed
TITLE(S): 23
FIRST SECTION AFFECTED: 877
2. REQUESTED PUBLICATION DATE:

3. NOTICE TYPE: [X] Notice re Proposed Regulatory Action [ ] Other
4. AGENCY CONTACT PERSON: Andrew Deeringer
TELEPHONE NUMBER: (916) 539-2132
FAX NUMBER (Optional):

OAL USE ONLY — ACTION ON PROPOSED NOTICE: [ ] Approved as Submitted [ ] Approved as Modified [ ] Disapproved/Withdrawn
NOTICE REGISTER NUMBER:
PUBLICATION DATE:

B. SUBMISSION OF REGULATIONS (Complete when submitting regulations)

1a. SUBJECT OF REGULATION(S): Emergency Actions to Protect Water Supplies and Threatened and Endangered Fish in the Russian River Watershed

1b. ALL PREVIOUS RELATED OAL REGULATORY ACTION NUMBER(S)

2. SPECIFY CALIFORNIA CODE OF REGULATIONS TITLE(S) AND SECTION(S) (Including title 26, if toxics related)

SECTION(S) AFFECTED (List all section number(s) individually. Attach additional sheet if needed.)

ADOPT: 877, 877.1, 877.2, 877.3, 877.4, 877.5, 877.6, 878, 878.1, 879, 879.1, and 879.2

OM per agency request 7/12/21

AMEND:

TITLE(S): 23

REPEAL:

3. TYPE OF FILING
- [ ] Regular Rulemaking (Gov. Code §11346)
- [ ] Resubmittal of disapproved or withdrawn nonemergency filing (Gov. Code §§11349.3, 11349.4)
- [X] Emergency (Gov. Code, §11346.1(b))
- [ ] Certificate of Compliance: The agency officer named below certifies that this agency complied with the provisions of Gov. Code §§11346.2-11347.3 either before the emergency regulation was adopted or within the time period required by statute.
- [ ] Resubmittal of disapproved or withdrawn emergency filing (Gov. Code, §11346.1)
- [ ] Emergency Readopt (Gov. Code, §11346.1(h))
- [ ] File & Print
- [ ] Other (Specify)
- [ ] Changes Without Regulatory Effect (Cal. Code Regs., title 1, §100)
- [ ] Print Only

4. ALL BEGINNING AND ENDING DATES OF AVAILABILITY OF MODIFIED REGULATIONS AND/OR MATERIAL ADDED TO THE RULEMAKING FILE (Cal. Code Regs. title 1, §44 and Gov. Code §11347.1)

5. EFFECTIVE DATE OF CHANGES (Gov. Code, §§ 11343.4, 11346.1(d); Cal. Code Regs., title 1, §100)
- [ ] Effective January 1, April 1, July 1, or October 1 (Gov. Code §11343.4(a))
- [X] Effective on filing with Secretary of State
- [ ] §100 Changes Without Regulatory Effect
- [ ] Effective other (Specify)

6. CHECK IF THESE REGULATIONS REQUIRE NOTICE TO, OR REVIEW, CONSULTATION, APPROVAL OR CONCURRENCE BY, ANOTHER AGENCY OR ENTITY
- [ ] Department of Finance (Form STD. 399) (SAM §6660)
- [ ] Fair Political Practices Commission
- [ ] State Fire Marshal
- [ ] Other (Specify)

OM per agency request 7/12/21

7. CONTACT PERSON: Andrew Deeringer
TELEPHONE NUMBER: (916) 539-2132
FAX NUMBER (Optional):
E-MAIL ADDRESS (Optional): Andrew.Deeringer@waterboards

8. I certify that the attached copy of the regulation(s) is a true and correct copy of the regulation(s) identified on this form, that the information specified on this form is true and correct, and that I am the head of the agency taking this action, or a designee of the head of the agency, and am authorized to make this certification.

SIGNATURE OF AGENCY HEAD OR DESIGNEE: Eileen Sobeck — Digitally signed by Eileen Sobeck Date: 2021.06.30 10:51:00 -07'00'

DATE: June 30, 2021

TYPED NAME AND TITLE OF SIGNATORY: Eileen Sobeck, Executive Director, State Water Resources Control Board

For use by Office of Administrative Law (OAL) only

ENDORSED APPROVED
JUL 12 2021
Office of Administrative Law

Curtailment of Diversions to Protect Water Supplies and Threatened and Endangered Fish in the Russian River Watershed

==

In Title 23, Division 3, Chapter 2, Article 24, add Sections 877, 877.1, 877.2, 877.3, 877.4, 877.5, 877.6, 878, 878.1, 879, 879.1 and 879.2 to read:

Article 24. Curtailment of Diversions to Protect Water Supplies and Threatened and Endangered Fish in the Russian River Watershed

§ 877 [Reserved]

§ 877.1 Definitions

(a) "Curtailment Order" refers to an order from the Deputy Director of the Division of Water Rights ordering a water right holder to cease diversions.

(b) "Deputy Director" refers to the Deputy Director of the Division of Water Rights, or duly authorized designee, at the State Water Resources Control Board.

(c) "Flood Control District" refers to the Mendocino County Russian River Flood Control and Water Conservation Improvement District.

(d) "Lower Russian River" refers to the surface waters, including underflow and subterranean streams, of the Russian River downstream of the confluence of Dry Creek and the Russian River.

(e) "Lower Russian River Watershed" refers to the area in Sonoma County that drains towards Dry Creek and the area downstream of the confluence of the Russian River and Dry Creek that drains towards the outlet of the Russian River to the Pacific Ocean.

(f) "Mainstem of the Upper Russian River" refers to the surface waters, including underflow and subterranean streams, of the Upper Russian River downstream of Lake Mendocino and upstream of the confluence of Dry Creek and the Russian River.

(g) "Minimum human health and safety needs" refers to the amount of water necessary for prevention of adverse impacts to human health and safety, for which there is no feasible alternate supply. "Minimum human health and safety needs" include:

(1) Indoor domestic water uses including water for human consumption, cooking, or sanitation purposes. For the purposes of this article, water provided outdoors for human consumption, cooking, or sanitation purposes, including but not limited to facilities for unhoused persons or campgrounds, shall be regarded as indoor domestic water use. As necessary to provide for indoor domestic water use, water diverted for minimum human health and safety needs may include water hauling and bulk water deliveries, so long as the diverter maintains records of such deliveries and complies with the reporting requirements of Section 879, and so long as such provision is consistent with a valid water right.

(2) Water supplies necessary for energy sources that are critical to basic grid reliability, as identified by the California Independent System Operator, California Public Utilities Commission, California Energy Commission, or a similar energy grid reliability authority.

(3) Water supplies necessary to prevent tree die-off that would contribute to fire risk to residences, and for maintenance of ponds or other water sources for fire fighting, in addition to water supplies identified by the California Department of Forestry and Fire Protection or another appropriate authority as regionally necessary for fire preparedness.

(4) Water supplies identified by the California Air Resources Board, a local air quality management district, or other appropriate public agency with air quality expertise, as necessary to address critical air quality impacts to protect public health.

(5) Water supplies necessary to address immediate public health or safety threats, as determined by a public agency with health or safety expertise.

(6) Other water uses necessary for human health and safety which a state, local, tribal or federal health, environmental, or safety agency has determined are critical to public health and safety or to the basic infrastructure of the state. Diverters wishing to continue diversions for these uses must identify the health and safety need, include approval or similar relevant documentation from the appropriate public agency,

describe why the amount requested is critical for the need and cannot be met through alternate supplies, state how long the diversion is expected to continue, certify that the supply will be used only for the stated need, and describe steps taken and planned to obtain alternative supplies.

(h) "State Water Board" refers to the State Water Resources Control Board.

(i) "Upper Russian River" refers to the surface waters, including underflow and subterranean streams, of the Russian River upstream of the confluence of the Russian River and Dry Creek and includes both the East and West Forks of the Russian River.

(j) "Upper Russian River Watershed" refers to the area located in Mendocino and Sonoma Counties that drains towards the confluence of Dry Creek and the Russian River.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art., X § 2; Sections 100, 100.5, 104, 105, 106.3, 275, 1058.5, Water Code; *Environmental Defense Fund v. East Bay Muni. Util. Dist.* (1980) 26 Cal.3d 183.

§ 877.2 Emergency Curtailments Due to Lack of Water Availability in the Lower Russian River Watershed

(a) This section applies to water diversions in the Lower Russian River Watershed.

(b) After the effective date of this regulation, when flows in the Lower Russian River Watershed are insufficient to support all diversions, the Deputy Director may issue curtailment orders to water right holders, requiring the curtailment of water diversion and use.

(c) In determining the extent to which water is available under a diverter's priority of right or when rescinding curtailment orders, the Deputy Director shall consider:

(1) Relevant available information regarding date of priority, including but not limited to claims of first use in statements of water diversion and use, judicial and State Water Board decisions and orders, and other information contained in the Division of Water Rights files;

(2) Monthly water right demand projections based on reports of water diversion and use for permits and licenses, or statements of water diversion and use, from 2017 through 2019.

(3) Water availability projections based on one or more of the following:

(A) Outputs from a United States Geological Survey's Precipitation Runoff Modeling System model, calibrated by State Water Board staff to estimate current or historical natural cumulative runoff throughout the watershed, as well as forecasts of monthly supplies;

(B) Climatic estimates of precipitation and temperature from the Parameter-elevation Regressions on Independent Slopes Model, commonly referred to as PRISM;

(C) Historical periods of comparable conditions with respect to daily temperatures, precipitation, or surface flows;

(D) Outputs from the Santa Rosa Plain Hydrologic Model developed by United States Geological Survey; or

(E) Stream gage data, where available.

(4) The Deputy Director may also consider additional pertinent and reliable information when determining water right priorities, water availability, and demand projections.

(5) Evaluation of available supplies against demands may be performed at the downstream outlet of the Lower Russian River, or at a smaller sub-watershed scale using the Drought Water Rights Allocation Tool, or comparable tool. Use of the Drought Water Rights Allocation Tool will be in accordance with the formulations document for the Drought Water Rights Allocation Tool (March 2, 2020) and Drought Water Right Curtailment Analysis for California's Eel River (November 20, 2017), which are hereby incorporated by reference.

(d) Water users and water right holders are responsible for checking the State Water Board's drought announcements website and signing up for the email distribution list referenced in subdivision (e)(2) to receive updated water supply forecasts. It is anticipated that forecasts of water supplies available to meet water rights demands will be updated on a monthly basis until cumulative rainfall of greater than 0.5 inches occurs as measured at Healdsburg, California. Following this precipitation event, it is anticipated that forecasts of supplies will be updated on a weekly basis until rescission of all curtailment orders under this section.

(e) (1) Initial curtailment orders will be sent to each water right holder or the agent of record on file with the Division of Water Rights. The water right holder or agent of record is responsible for immediately providing notice of the curtailment order(s) to all diverters exercising the water right(s) covered by the curtailment order(s).

(2) The State Water Board has established an email distribution list that water right holders may join to receive drought notices, water supply forecasts, and updates regarding curtailments. Notice provided by email or by posting on the State Water Board's drought web page shall be sufficient for all purposes related to drought notices and updates regarding curtailment orders.

(f) Rescission of curtailment orders shall be announced using the email distribution list and web page described in subdivision (e).

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 275, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

§ 877.3 Emergency Curtailment Where Insufficient Flows are Available in the Upper Russian River Watershed

(a) This section applies to water diversions in the Upper Russian River Watershed.

(b) (1) The Deputy Director may issue a curtailment order upon a determination that the conditions in subdivision (c) are occurring. Curtailment orders shall be effective the day after issuance.

(2) If maintaining minimum flows required for the protection of minimum human health and safety needs, fish and wildlife, or further preserving stored water in Lake Mendocino for human health and safety needs would require curtailment of uses otherwise exempt from curtailment under this article, then the Deputy

Director shall consider whether those uses should be allowed to continue based on the most current information available regarding fish populations, human health and safety needs, and the alternatives available to protect both human health and safety and threatened or endangered fish. Curtailment of water uses under this subdivision (b)(2) and any updates regarding such curtailments shall be noticed as described in subdivision (d).

(c) When storage levels in Lake Mendocino are below those specified in section 877.4, and Sonoma County Water Agency is making Supplemental Storage Releases to satisfy Inbasin Uses, diversion of water within the Upper Russian River Watershed that does not meet an exemption identified in section 878 or section 878.1 constitutes an unreasonable use of water and is prohibited.

(1) Inbasin Uses are defined as diversions from the Mainstem of the Upper Russian River to meet minimum human health and safety needs, Reach Losses, and minimum flows required for protection of fish and wildlife as required by a water right permit or license term, including any enforceable modifications of the foregoing. Export diversions, deliveries scheduled by the Flood Control District pursuant to License 13898, and Reach Losses associated with those exports and deliveries are specifically excluded from the definition of Inbasin Uses.

(2) Supplemental Storage Releases are defined as water released from Lake Mendocino which is in excess of inflows to Lake Mendocino, as calculated on a daily basis, to satisfy Inbasin Uses.

(3) Reach Losses are defined as water that is lost from the Mainstem of the Upper Russian River due to riparian habitat, evaporative losses, or percolation to groundwater.

(d) (1) Initial curtailment orders will be sent to each water right holder or the agent of record on file with the Division of Water Rights. The water right holder or agent of record is responsible for immediately providing notice of the curtailment order(s) to all diverters exercising the water right(s) covered by the curtailment order(s).

(2) The State Water Board has established an email distribution list that water right holders may join to receive drought notices, water supply forecasts, and updates regarding curtailments. Notice provided by email or by posting on the State Water Board's drought web page shall be sufficient for all purposes related to drought notices and updates regarding curtailment orders.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 275, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419; *Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

§ 877.4 Lake Mendocino Storage Levels

Curtailment orders for diversions in the Upper Russian River Watershed shall not be issued unless storage levels in Lake Mendocino fall below the following levels prior to the specified dates:

(a) 29,315 acre-feet before July 1.

(b) 27,825 acre-feet before July 15.

(c) 26,109 acre-feet before August 1.

(d) 24,614 acre-feet before August 15.

(e) 22,745 acre-feet before September 1.

(f) 21,251 acre-feet before September 15.

(g) 20,000 acre-feet on any date while the regulation is in effect.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 109, 275, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419; *City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

§ 877.5 Rescission of Curtailment Orders in Upper Russian River Watershed

(a) Following issuance of curtailment orders pursuant to section 877.3, the Deputy Director will notify water right holders of the extent to which curtailment orders will be rescinded following a determination by the Deputy Director that Sonoma County Water Agency is no longer making

Supplemental Storage Releases to satisfy Inbasin Uses and natural or abandoned flows are available.

(b) In determining the extent to which water is available under a diverter's priority of right when rescinding curtailment orders, the Deputy Director shall consider:

(1) Relevant available information regarding date of priority, including but not limited to claims of first use in statements of water diversion and use, judicial and State Water Board decisions and orders, and other information contained in the Division of Water Rights files;

(2) Monthly water right demand projections based on reports of water diversion and use for permits and licenses, or statements of water diversion and use, from 2017 through 2019.

(3) Water availability projections based on one or more of the following:

(A) Outputs from a United States Geological Survey's Precipitation Runoff Modeling System model, calibrated by State Water Board staff to estimate current or historical natural cumulative runoff throughout the watershed, as well as forecasts of monthly supplies.

(B) Climatic estimates of precipitation and temperature from the Parameter-elevation Regressions on Independent Slopes Model, commonly referred to as PRISM.

(C) Historical periods of comparable conditions with respect to daily temperatures, precipitation, or surface flows.

(D) Outputs from the Santa Rosa Plain Hydrologic Model developed by United States Geological Survey; or

(E) Stream gage data, where available.

(4) The Deputy Director may also consider additional pertinent and reliable information when determining water right priorities, water availability and demand projections.

(5) Evaluation of available supplies against demands may be performed at the downstream outlet of either the Upper Russian River or the

Lower Russian River, or at a smaller sub-watershed scale using the Drought Water Rights Allocation Tool, or comparable tool. Use of the Drought Water Rights Allocation Tool will be in accordance with the formulations document for the Drought Water Rights Allocation Tool (March 2, 2020) and Drought Water Right Curtailment Analysis for California's Eel River (November 20, 2017), which are hereby incorporated by reference.

(c) Water users and water right holders are responsible for checking the State Water Board's drought announcements website and signing up for the email distribution list referenced in section 877.3, subdivision (e)(2), to receive updated water supply forecasts. It is anticipated that forecasts of water supplies available to meet water rights demands will be updated on a monthly basis until cumulative rainfall of greater than 0.5 inches occurs as measured at Ukiah Municipal Airport precipitation stations within the watershed. Following this precipitation event, it is anticipated that forecasts of supplies will be updated on a weekly basis until rescission of all curtailment orders under this section.

(d) Rescission of a curtailment order shall be announced using the email distribution list and web page described in section 877.3, subdivision (e)(2).

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 275, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419; *Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

§ 877.6 Rediversion of Water Previously Stored in Lake Mendocino

(a) Rediversion by the Flood Control District of previously stored water released from Lake Mendocino shall be an unreasonable use of water and subject to the enforcement provisions described in section 879.2 unless such rediversion meets the requirements of this section.

(b) The Flood Control District shall schedule all deliveries of water pursuant to License 13898 at least one week in advance of release of the water.

(c) The timing of rediversion activities relative to release of water shall be based on a travel time of water along the Russian River agreed upon between the Flood Control District and Sonoma County Water Agency.

(d) The Flood Control District shall provide a monthly schedule of rediversions by the first day of each month and shall confirm by noon on Friday of each week whether those diversions will occur in the following week or have changed.

(e) No rediversions shall occur following September 1 unless Sonoma County Water Agency and the Flood Control District have jointly submitted an executed agreement to the Deputy Director specifying the amount of water stored in Lake Mendocino pursuant to License 13898, the amount of water that will remain stored in Lake Mendocino for use in 2022, and a methodology acceptable to the Deputy Director for determining how inflows to Lake Mendocino are attributed to the Flood Control District and SCWA's respective water rights.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 275, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419; *Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463; *City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224.

§ 878. Non-Consumptive Uses

Diversion and use described in this section under any valid basis of right may continue after issuance of a curtailment order without further approval from the Deputy Director, subject to the conditions set forth in this section. Diversions described in this section may not be required to curtail in response to a curtailment order under this article if their diversion and use of water does not decrease downstream flows. Any diverter wishing to continue diversion under this subdivision must submit to the Deputy Director a certification, under penalty of perjury, which describes the non-consumptive use and explains, with supporting evidence, how the diversion and use do not decrease downstream flows in the applicable watershed. The Deputy Director may request additional information or disapprove any certification if the information provided is insufficient to support the statement or if more convincing evidence contradicts the claims. If a certification submitted pursuant to this section is disapproved, the diversions are subject to any curtailment order issued for that basis of right. This section applies to:

(a) Direct diversions solely for hydropower if discharges are returned to the Russian

River or its tributaries and water is not held in storage.

(b) Direct diversions dedicated to instream uses for the benefit of fish and wildlife pursuant to Water Code section 1707, including those that divert water to a different location for subsequent release, provided the location of release is hydraulically connected to the Russian River.

(c) Direct diversions where the Deputy Director, the California Department of Fish and Wildlife, and the Executive Officer of the North Coast Regional Board have approved a substitution of releases of either stored water or groundwater into the Russian River or a tributary thereof for the benefit of fish and wildlife such that there is not a net decrease in stream flow as a result of the diversion at the next downstream USGS gage. The rate of releases made pursuant to this subdivision must be measured daily using a device or measurement method approved by the Deputy Director and provided to the Deputy Director on a monthly basis. Proposals involving the release of groundwater shall provide sufficient data and information to reasonably quantify any depletions of surface water caused by the groundwater pumping, the potential time lags of those depletions, and if additional groundwater releases beyond the diversion amounts are able to offset those depletions. The release of water does not have to be conducted by the owner of the water right proposed for the continued diversions, provided an agreement between the water right holder and the entity releasing the water is included in the proposal.

(d) Other direct diversions solely for non-consumptive uses, if those diverters file with the Deputy Director a certification under penalty of perjury demonstrating that the diversion and use are non-consumptive and do not decrease downstream flows in the watershed.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 187, 275, 348, Water Code

§ 878.1 Minimum Human Health and Safety Needs

(a) Diversions described in this section under any valid basis of right may be authorized to continue after issuance of a curtailment order, subject to the conditions set forth in this section. A diversion that would otherwise be subject to curtailment may be authorized if:

(1) The diversion is necessary for minimum human health and safety needs;

and therefore,

(2) The diversion is necessary to further the constitutional policy that the water resources of the state be put to beneficial use to the full extent they are capable, and that waste and unreasonable use be prevented, notwithstanding the effect of the diversions on more senior water rights or instream beneficial uses.

(b) (1) Diversions for minimum human health and safety needs under any valid basis of right of not greater than 55 gallons per person per day may continue after issuance of a curtailment order without further approval from the Deputy Director, subject to the conditions set forth in this section. Any diverter wishing to continue diversion under this subdivision must submit to the Deputy Director certification, under penalty of perjury, of compliance with the requirements of subdivisions (b)(1)(A)-(E), below. The Deputy Director may request additional information or set additional requirements on continued diversion.

(A) Not more than 55 gallons per person per day will be diverted under all bases of right.

(B) The diversion is necessary to serve minimum human health and safety needs as defined in section 877.1, subdivision (g), after all other alternate sources of water have been used. To the extent other water sources are available, those sources will be used first and the total used will not exceed 55 gallons per person per day.

(C) The diverter and all end users of the diverted water are operating under the strictest existing conservation regime for that place of use, if such a plan exists for the area or service provider, or shall be operating under such regime within 30 days. If additional approvals are required before implementation of the conservation regime, the diverter must certify that all possible steps will be taken immediately to ensure prompt approval.

(D) If the diverter is distributor of a public water supply under Water Code sections 350 et seq., that it has declared a water shortage emergency condition and either already has adopted regulations and restrictions on the delivery of water or will adopt conservation and water delivery restrictions and regulations within a timeframe specified by the Deputy Director as a condition of certification.

(E) The diverter has either pursued steps to acquire other sources of water, but has not yet been completely successful, as described in an attached report, or the diverter will pursue the steps in an attached plan to identify and secure additional water.

(2) To the extent that a diversion for minimum human health and safety needs requires more than 55 gallons per person per day, the continued diversion of water after issuance of a curtailment order for the diversion requires submission of a petition demonstrating compliance with the requirements of subdivisions (b)(2)(A)-(F), below, and approval by the Deputy Director. The Deputy Director may condition approval of the petition on implementation of additional conservation measures and reporting requirements. Any petition to continue diversion to meet minimum human health and safety needs of more than 55 gallons per person per day must:

(A) Describe the specific circumstances that make the requested diversion amount necessary to meet minimum human health and safety needs, if a larger amount is sought.

(B) Estimate the amount of water needed.

(C) Certify that the supply will be used only for the stated need.

(D) Describe any other additional steps the diverter will take to reduce diversions and consumption.

(E) Provide the timeframe in which the diverter expects to reduce usage to no more than 55 gallons per person per day, or why minimum human health and safety needs will continue to require more water.

(F) As necessary, provide documentation that the use meets the definition of minimum human health and safety needs provided in subdivision (g) of section 877.1.

(c) For public water systems with 15 or greater connections and small water systems of 5 to 15 connections, gallons per person per day shall be calculated on a monthly basis and the calculation methodology shall be consistent with the State Water Board's Percentage Residential Use and Residential Gallons Per Capita Daily Calculation (PRU and R-GPCD Calculation), dated September 22, 2020, which is hereby incorporated by reference.

(d) Diversions for minimum human health and safety needs that cannot be quantified on the basis of an amount per person per day require a petition and approval from the Deputy Director. The Deputy Director may approve a such a petition under this subdivision or subdivision (b)(2) upon a finding that the petition demonstrates that the requested diversion is in furtherance of the constitutional policy that the water resources of the state be put to beneficial use to the full extent they are capable, and that waste and unreasonable use be prevented, notwithstanding the effect of the diversion on senior water rights or instream beneficial uses, and may condition approval as appropriate to ensure that the diversion and use are reasonable and in the public interest.

(e) To the extent necessary to resolve immediate public health or safety threats, a diversion subject to a curtailment order may continue while a petition under subdivision (b)(2) or (d) is being prepared and is pending. The Deputy Director may require additional information to support the initial petition, information on how long the diversion is expected to continue, and a description of other steps taken or planned to obtain alternative supplies.

(f) Notice of certification, petitions, and decisions under this section and section 878 will be posted as soon as practicable on the State Water Board's drought webpage. The Deputy Director may issue a decision under this article prior to providing notice.

(g) Diversion and use within the Russian River Watershed that deprives water for minimum human health and safety needs in 2021, or which creates unacceptable risk of depriving water for minimum human health and safety needs in 2022, is an unreasonable use of water. The Deputy Director shall prevent such unreasonable use of water by implementing the curtailment methodology described in section 877.2 for diversions in the Lower Russian River Watershed and sections 877.3, 877.4, 877.5, and 877.6 for diversions in the Upper Russian River Watershed.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 106.3, 275, 1058.5, Water Code; *Environmental Defense Fund v. East Bay Muni. Util. Dist.* (1980) 26 Cal.3d 183; *Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

§ 879. Reporting

(a) All water right holders issued a curtailment order under this article are required, within seven calendar days, to submit under penalty of perjury a certification of one or more of the following actions taken in response to the curtailment order, certifying, as applicable, that:

(1) Diversions under the water right(s) identified have ceased;

(2) Any continued use is under other water rights not subject to curtailment, specifically identifying those other rights, including the basis of right and quantity of diversion;

(3) Diversions under the water right(s) identified continue only to the extent that they are non-consumptive uses for which a certification for continued diversion has been submitted as specified in section 878;

(4) Diversions under the water right(s) identified continue only to the extent that they are to provide for minimum human health and safety needs, a certification has been filed as authorized under section 878.1, subdivision (b)(1), and the subject water right authorizes the diversion in the absence of a curtailment order; or

(5) Diversions under the water right(s) identified continue only to the extent that they are consistent with a petition filed under section 878.1, subdivision (b)(2) or (d), and diversion and use will comply with the conditions for approval of the petition.

(b) All water users or water right holders whose continued diversion may be authorized under section 878.1 are required to submit, under penalty of perjury, information identified on a schedule established by the Deputy Director as a condition of certification or petition approval. The required information may include, but is not limited to, the following:

(1) The water right identification numbers under which diversions continue.

(2) How the diverter complies with any conditions of continued diversion, including the conditions of certification under section 878.1, subdivision (b)(1);

(3) Any failures to comply with conditions, including the conditions of certification under section 878.1, subdivision (b)(1), and steps taken to prevent further violations;

(4) Conservation and efficiency efforts planned, in the process of implementation, and implemented, as well as any information on the effectiveness of implementation;

(5) Efforts to obtain alternate water sources;

(6) If the diversion is authorized under an approved petition filed pursuant to section 878.1, subdivision (b)(2), progress toward implementing the measures imposed as conditions of petition approval;

(7) If the diversion is authorized under section 878.1, subdivision (d):

(A) The rate of diversion if it is still ongoing;

(B) Whether the water has been used for any other purpose; and

(C) The date diversion ceased, if applicable.

(8) The total water diversion for the reporting period and the total population served for minimum human health and safety needs. The total population must include actual or best available estimates of external populations not otherwise reported as being served by the water right holder, such as individuals receiving bulk or hauled water deliveries for indoor water use.

(9) Diversion amounts for each day in acre-feet per day, maximum diversion rate in cubic feet per second, and anticipated future daily diversion amounts and diversion rates.

(c) The Deputy Director, or delegee, may issue an order under this article requiring any person to provide additional information reasonably necessary to assess their compliance with this article. Any person receiving an order under this subdivision shall provide the requested information within the time specified by the Deputy Director, but not less than five (5) days.

Authority: Sections 348, 1058, 1058.5, Water Code

Reference: Sections 100, 187, 275, 348, 1051, 1058.5, 1841 Water Code

§ 879.1. Conditions of permits, licenses and registrations

Compliance with this article, including any conditions of certification or approval of a petition under this article, shall constitute a condition of all water right permits, licenses, certificates and registrations for diversions in the Russian River Watershed.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 275, 1253, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419.

§ 879.2. Compliance and Enforcement

(a) A diverter must comply with a curtailment order issued under this article, any conditions of certification or approval of a petition under this article, and any water right condition under this article, notwithstanding receipt of more than one curtailment order. To the extent of any conflict between applicable requirements, the diverter must comply with the requirements that are the most stringent.

(b) Diversion or use of water in the Upper Russian River Watershed in violation of this article constitutes an unreasonable use of water and is subject to any and all enforcement proceedings authorized by law.

(c) Diversion or use of water in the Lower Russian River Watershed in violation of this article is a trespass under Water Code section 1052 and shall constitute evidence of diversion or use in excess of a water user's rights.

(d) All violations of this article shall be subject to any applicable penalties under Water Code section 1058.5. Nothing in this section shall be construed as limiting the enforceability of or penalties available under any other applicable provision of law.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 275, 1052, 1055, 1058.5, 1825, 1831, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419.

DROUGHT WATER RIGHTS ALLOCATION TOOL
MARCH 2, 2020

RIPARIAN FORMULATION

$$0 \leq P_k \leq 1$$

for all basins, *k*

Basin proportions *Pk* are between 0 and 1.

$$A_i = P_k u_i$$

for all *i* users, in each basin *k*

Each user's allocation A_i is user *i*'s basin proportion P_k, of *i*'s demand u_i.

$$\sum_{i \in k} A_i \leq v_k - e_k$$

for all *i* users that are within each basin *k*

Mass Balance: within every basin *k*, the sum of all users' allocations are less than or equal to flow v_k in basin *k*, less any environmental instream flow requirement e_k.

$$P_j \leq P_k$$

for all basins *j* and all basins *k*

Upstream basin proportions P_j cannot exceed downstream basin proportions P_k.

$$w_k = \frac{n_i}{n_{i\ at\ basin\ outlet}}$$

for all users, *i*

A basin penalty w_k is applied that increases with the ratio of the number of users n_i upstream of basin *k*, to the number of users at the watershed outlet $n_{i\ at\ basin\ outlet}$.

Why?

- Because if upstream basins are not allowed to exceed downstream basins, then some offset is required so that downstream basins are not allocated more than upstream, to conform with the riparian doctrine of shared shared shortage.

$$\alpha < Min\left(\frac{w_k}{u_k}\right)$$

for all basins, *k*

The basin scalar α is the minimum of the ratios between downstream penalties w_k and basin-wide demands u_k.

Why?

- Because.

Riparian Objective Function:

$$\text{Minimize } z = -\sum_i A_i + \alpha \sum_k w_k P_k$$

For all users *i*, and all basins, *k*

Minimize shortage (left term) + but make the slightly modified sum of basin proportions as large as possible (right term).

APPROPRIATIVE FORMULATION

$$0 \leq A_i \leq u_i$$

for all users, *i*

Each appropriative user's allocation A_i must be between 0 and her reported demand u_i

$$\sum_{i \in k} A_{i,(appropriative)} \leq v_k - e_k - \sum_{i \in k} A_{i,(riparian)}$$

for all users *i*, in all upstream basins *k*

Mass Balance: the sum of all appropriative allocations $A_{i,appropriative}$ that are in basin *k*, must be less than or equal to available flow *vk*, less any environmental instream flow requirement e_k, less the sum of all upstream riparian allocations, $A_{i,riparian}$.

Appropriative Objective Function:

$$\text{Minimize } z = \sum_i p_i(u_i - A_i)$$

for all users, *i*

Minimize the difference between demand and allocation, or shortage, $(u_i - A_i)$ weighted by the inverse of the priority of user *i*.

Drought Water Right Curtailment Analysis for California's Eel River

Benjamin Lord, A.M.ASCE[1]; Bonnie Magnuson-Skeels[2]; Andrew Tweet, A.M.ASCE[3]; Chad Whittington[4]; Lauren Adams, S.M.ASCE[5]; Reed Thayer, A.M.ASCE[6]; and Jay Lund, Dist.M.ASCE[7]

Abstract: Water users in California's hybrid water rights system have different legal priorities to available surface water in times of water scarcity. A set of two linear programming models was developed to determine curtailments of water use under drought conditions according to riparian and appropriative water right doctrines with spatially varying water availability and water rights within a basin. The models were implemented in spreadsheets and extended to estimate water right reliability and factors of safety in water rights administration. Alternate methods for calculating water use curtailments are discussed. Curtailments from the models are compared with actual water shortage notices issued by the state for the Eel River, California for June 30, 2014. Analyzing water use curtailments with an algorithm in spreadsheet software offers a mechanistic, transparent, accessible, and precise approach derived from legal doctrines to support water rights administration during drought. **DOI: 10.1061/(ASCE)WR.1943-5452.0000820.** © *2017 American Society of Civil Engineers.*

Introduction

Droughts often require users to curtail their water right diversions. Escriva-Bou et al. (2016) reviewed the curtailment of water rights, requiring some water rightholders to cease or reduce diversions, in various western states and arid countries. The present paper provides mathematical formulations and an example application of formal methods to fully allocate limited water supplies in California's hybrid system of surface-water rights. The proposed approach mathematically represents the logic of riparian and appropriative water law doctrines for a basin with spatially varying available water supply and water demands. By representing California's water rights law as an allocation algorithm using linear programming, this drought water rights allocation tool (DWRAT) provides a precise, timely, and transparent analytical framework for the complicated and often controversial process of curtailing water rights use during drought.

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California's Water Rights and Drought

Surface-water rights in California predominantly follow prior appropriation and riparian water law doctrines. Riparian rights were introduced by the adoption of English common law under California's constitution. Riparian rightholders are equal in priority and entitled to the natural flow of the water body for direct uses on their riparian land, without storage, so long as downstream users are not "unreasonably affected." The doctrine of prior appropriation was developed for resolving water claim disputes for available water among miners diverting water from streams for uses sometimes far from the point of diversion, possibly involving diversions to storage. The principle of "first in time, first in right" determines priority among appropriative water rights; early diverters have a higher priority than later diverters (Kanazawa 2015). To resolve growing conflicts among water rightholders, the 1886 California Supreme Court Case *Lux v. Haggin* ruled that riparian water rights categorically have a higher priority than appropriative water rights.

The 1913 California Water Commission Act (effective in 1914) established the predecessor of today's State Water Resources Control Board (SWRCB) to organize all new appropriations of water. All appropriative water right claims after this Act came into effect are post-1914 appropriative water rights. Rights with dates of first use before January 1, 1914, are known as pre-1914 rights. Riparian rights are established as a class, share shortages proportionally among each other, and have higher priority than any appropriative rights (Kanazawa 2015; Attwater and Markle 1987).

Over the next century, the SWRCB granted water right allocations exceeding five times the state's mean annual runoff (Grantham and Viers 2014). Water rights in basins with particularly high allocations relative to natural availability, such as the Scott River, have been explicitly adjudicated as a result of legal conflicts among rightholders. Overallocation (allocating more water than is normally available), coupled with the extensive impoundment of California rivers, decreases flow variability, which in turn damages aquatic and riparian ecosystems (Kondolf and Batalla 2005). Grantham et al. (2014) demonstrated the need for transparent strategies during drought water years to preserve environmental flow protections while reducing water use in an equitable manner.

Despite longstanding legal authority, the SWRCB first declared water shortages in 1977, and then not again until 2014. The year

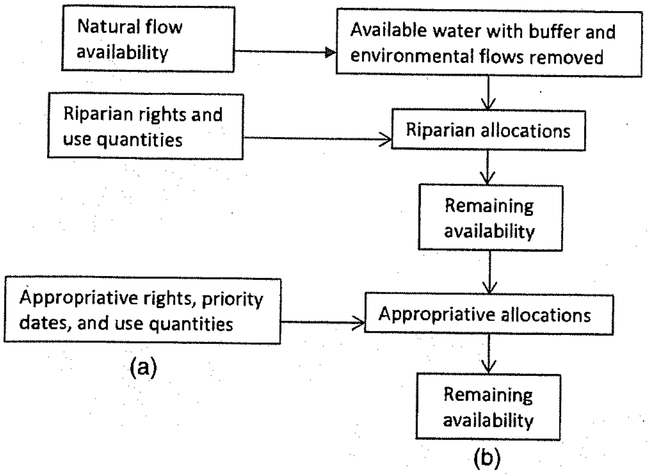

Fig. 1. DWRAT data flow: (a) input data; (b) allocation models

2014 was the third consecutive year of drought in California, and the SWRCB issued mandatory curtailments (formally called water shortage notices), supported by a declaration of drought emergency by Governor Jerry Brown. In May 2014, the Scott River was the first watershed with issued curtailments. In the following months, junior right holders in the Sacramento, San Joaquin, Russian, and Eel River Basins also were curtailed.

Water Allocation Models

Several previous water allocation models have used water rights for prioritizing users and demands (Wang et al. 2007). The Texas water availability modeling (WAM) system (Wurbs 2005) allocates streamflow and reservoir storage among rightholders with a prior appropriation doctrine. Many models represent priority-based water operations with different delivery, flow, and storage priorities (Sigvaldson 1976), such as *CalSim* (Draper et al. 2004) and *ModSim* (Fredericks et al. 1998). Linear or network flow optimization often are used to represent priority-based operations. Appropriative water right priorities can be represented through cost coefficients, with junior lower-priority rights having lower penalties for shortage. Israel and Lund (1999), Ferreira (2007), and Chou and Wu (2014) extended this approach with algorithms for determining cost coefficients accounting for return flows.

Despite an extensive body of literature on mathematically allocating water under the appropriative doctrine, few published methods exist on allocation under the riparian doctrine. In California, riparian water rightholders (riparians) are equal in priority to each other but categorically have a higher priority than appropriative water rightholders (appropriators).

Drought Water Rights Allocation Tool Formulation

DWRAT allocates water for rights under both major doctrines using spreadsheets and a free and open-source solver platform. DWRAT operates in two phases. The first phase distributes available water proportionally among riparian rightholders. The second phase allocates remaining available surface water by strict priority among appropriative rightholders. In both phases, water users are scattered over a network of subbasins with local water availabilities (initially without return flows). Total flow v into subbasin k is represented by v_k. Each user i has a normal use of u_i and receives water allocation A_i. Riparian users have unranked equal priority. Curtailment decisions among riparians limit diversions to a proportion of normal individual use varying by subbasin P_k, with a weighted penalty coefficient of w_k. These proportions determine a user's shortage. The shortage penalty weight per subbasin w_k increases with the number of upstream basins u_k to balance proportions across subbasins. Appropriative users have fixed priorities established by water right seniority. The unit shortage penalty p_i increases with seniority of right; minimizing shortages to senior rightholders reduces total penalty more than to junior rightholders. To assess allocations having mixed riparian and appropriative water rights, the riparian linear program is run first, followed by the appropriative linear program.

This overall approach represents the logic of each water law doctrine mathematically to allow implementation in software. Fig. 1 illustrates DWRAT's data flow. DWRAT models are run for a single daily time step, large enough to avoid issues of hydrologic routing for small basins.

Riparian Allocation Formulation

Riparian rightholders are equal in priority with water shortages distributed by restricting use proportionally across all basin users. Locally varying water availability can lead to differing proportional shortages within a basin. The following equations represent the logic of riparian water allocation. The allocation A_i for a riparian user i is defined in Eq. (1)

$$A_i = P_k u_i, \quad \forall\ i, i \in k \tag{1}$$

where all users in a subbasin k receive the same allocation proportion P_k of demand u_i, where P_k = decision variable. The subbasin allocation proportion P_k is constrained between zero and one [Eq. (2)], enforcing allocations between zero and normal use

$$0 \le P_k \le 1, \quad \forall\ k \tag{2}$$

The sum of all allocations (net diversions) upstream of a subbasin outlet cannot exceed the total availability of water leaving the subbasin. Total availability is inflows upstream of the subbasin outlet v_k minus environmental outflow flow requirement e_k and buffer outflow b_k [Eq. (3)]. Environmental flows, specified by the user, occur as a constraint. Alternatively, environmental flows could be represented as a water right with a relative priority. Buffer flow is used as a factor of safety to incorporate errors in water availability and actual uses

$$\sum_{i \in k} A_i \le v_k - e_k - b_k, \quad \forall\ k \tag{3}$$

The riparian objective function [Eq. (4)] maximizes total water allocations, with a weighting term to enforce allocation proportionally among water users

$$\text{Minimize } z = \alpha \sum_k w_k P_k - \sum_i A_i \tag{4}$$

In drought, maximizing only total allocations for all riparian users can yield multiple optima. Upstream users could receive zero allocations despite local availability while downstream users receive full allocations. Alternatively, water available in upstream reaches could be allocated entirely to upstream users, with large shortages occurring downstream. Both outcomes fail to distribute water proportionally among riparian users. Therefore, weights are included in the objective function to enforce equitable proportional allocation of shortage among riparian rightholders. The following constraints define how equal proportionality of shortage with full allocation of available water is met.

Upstream users cannot have a lower shortage (higher P_k) than downstream users. If upstream users have less shortage than downstream users, some upstream use could be allocated downstream so both sets of users receive the same proportion of shortage. This constraint is implemented in Eq. (5), where the allocation proportion in any upstream subbasin j cannot exceed the proportion of any downstream subbasin k

$$P_j \leq P_k, \quad \forall\, k, j \in k \tag{5}$$

This constraint would need to change for cases where natural flow decreases downstream from net losses to groundwater or lake and wetland evaporation.

All riparian users with local non-zero availability should receive allocations greater than zero. To prevent upstream users receiving zero allocations despite local availability and downstream users receiving large allocations because of increased availability (from not allocating that same water upstream), a weight is given to increasingly penalize high allocation proportions in downstream basins [Eq. (6)]. The downstream penalty w_k increases with the number of subbasins n_k upstream of subbasin k's outlet

$$w_k = \frac{n_k}{n_{k,\text{system outlet}}} \tag{6}$$

The sum of the products of these weights and allocation proportions is further weighted in the objective function to allocate all available water proportionally. To prioritize allocating all water, the equality terms are given less weight. The weigh α cannot exceed the minimum of all subbasin ratios of unit downstream penalty to total upstream demand [Eq. (7)]

$$\alpha < Min\left(\frac{w_k}{u_k}\right) \quad \forall\, k \tag{7}$$

Eqs. (5)–(7) provide counteracting weights to distribute a shortage equally across a watershed while maximizing total allocations to riparian users.

Riparian Allocation Example

The example watershed in Fig. 2 was created to test and demonstrate the riparian allocation linear program. Each of the eight subbasins (denoted A–H) has local inflows. Available streamflow is given for the outlet of each subbasin, with a fixed fraction for environmental flows. Flow characteristics are given in Table 1 and user demands in Table 2.

Tables 2 and 3 provide user and basin results from the riparian water rights allocation model. Comparing allocations in Subbasins A and B offers insight into the riparian allocation mechanics. Basin A has a total upstream demand of 18 and a local availability of 5.6. If all flow available in A is allocated to users in A, users would receive an allocation proportion of 0.31 (ratio of upstream demand to availability). Basin B has a local availability of 5.6 and upstream demand of 8. If B's availability was completely allocated locally, User 3 would receive an allocation proportion of 0.7, which exceeds downstream ratios of supply to demand. Thus, B is curtailed further to reduce the shortage proportion downstream. No greater shortages occur downstream of Basin A, so all available flow is allocated locally. If unallocated flow is zero, upstream shortage exceeds potential downstream shortages. Availability directly limits upstream allocation and constraint Eq. (3) binds. If unallocated flow exists, water is retained to minimize more severe shortages downstream.

The allocation proportion of 0.67, dictated by binding water availability (no unallocated flow) in Catchment F, is extended upstream to Catchments B, C, D, and E, showing an even allocation of shortage across the larger area. Basins A and G have lower allocation proportions from more severe local shortages. Basin H has a binding water availability that forces an allocation proportion of 0.7, but this does not extend upstream because of still tighter shortages upstream. All available flow was allocated to users, with no nonenvironmental flow leaving the system.

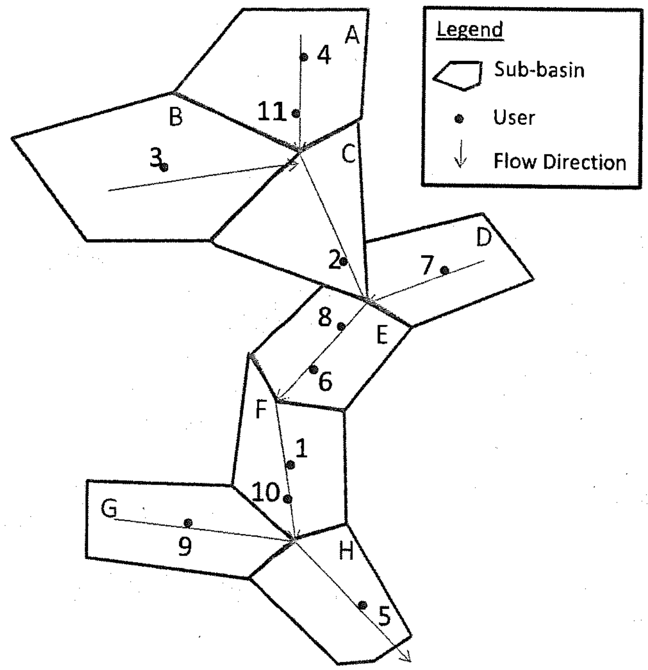

Fig. 2. Example watershed subbasins and users

Table 1. Subbasin Hydrology

Subbasin	Local inflow	Cumulative flow (v)	Environmental flow (e)	Flow available to allocate
A	7	7	1.4	5.6
B	7	7	1.4	5.6
C	7	21	4.2	16.8
D	7	7	1.4	5.6
E	7	35	7	28
F	7	42	8.4	33.6
G	7	7	1.4	5.6
H	7	56	11.2	44.8

Note: Flow units are volume/time.

Table 2. Riparian Model Results by User

User	Demand	Allocation	Proportion
R1	7	4.7	0.67
R2	4	2.7	0.67
R3	8	5.3	0.67
R4	8	2.5	0.31
R5	8	5.6	0.70
R6	4	2.7	0.67
R7	3	2.0	0.67
R8	9	6.0	0.67
R9	9	5.6	0.62
R10	7	4.7	0.67
R11	10	3.1	0.31

Note: Flow units are volume/time.

Table 3. Riparian Model Results by Basin

Basin	Allocation proportion	Availability	Upstream demand sum	Upstream allocation sum	Unallocated flow
A	0.31	5.6	18.0	5.6	0
B	0.67	5.6	8.0	5.3	0.3
C	0.67	16.8	30.0	13.6	3.2
D	0.67	5.6	3.0	2.0	3.6
E	0.67	28.0	46.0	24.2	3.7
F	0.67	33.6	60.0	33.6	0
G	0.62	5.6	9.0	5.6	0
H	0.70	44.8	77.0	44.8	0

Note: Flow units are flow/time.

Appropriative Allocation Formulation

After riparian water rightholders receive allocations, remaining available water is allocated to appropriative rightholders by strict priority. The following mathematical formulation represents the logic of priority-based appropriative water rights, without return flows. Allocation for a user i is given by the decision variable A_i, between a maximum use u_i and a minimum of zero

$$0 \leq A_i \leq u_i, \quad \forall\, i \tag{8}$$

Where a portion of use returns quickly to the subbasin, each use u_i can be adjusted to represent net consumptive diversion. More complex cases have been discussed by Israel and Lund (1999) and Ferreira (2007).

Similar to the mass balance for riparian users [Eq. (3)], the sum of all allocations upstream of a basin outlet cannot exceed the total water availability remaining after riparian allocations

$$\sum_{i\in k} A_i \leq v_k - e_k - b_k - \sum_{i\in k} A_{\text{upstream riparian users } i}, \quad \forall\, k \tag{9}$$

Unlike riparian rights, appropriative water rights are curtailed by strict individual priority. The earliest right in a basin has the highest priority, and the most recent right has the lowest. Priority establishes unit shortage penalties for all users. The unit shortage penalty (p_i) equals the number of users minus priority rank, so the highest priority user has the highest unit shortage penalty. Shortage for a user is the difference between demand u_i and allocation A_i.

The objective function minimizes total shortage penalty for all users [Eq. (10)]. Senior users have more weight in the objective function and are more likely to receive a full allocation. Likewise, junior users are less likely to receive an allocation

$$\text{Minimize } z = \sum_i p_i(u_i - A_i) \tag{10}$$

Appropriative Allocation Example

An appropriative allocation model was developed for the aforementioned example watershed (Fig. 2), with the same user and basin characteristics (Tables 1 and 2). Here, all users have appropriative rights, with User 1 having the highest priority and User 11 the lowest. User and basin results from the appropriative water rights allocation model appear in Tables 4 and 5. User 1, on the main stem and with the highest priority, receives a full allocation, whereas User 3, with a high priority but in the upper watershed, has less flow available. Thus, User 3 receives all flow available in Subcatchment B, but still sees shortage, running out of water before running out of right. User 4 similarly receives all available flow in Catchment A. User 11 in Catchment A has a low priority and receives no water. As demands of senior users are met, remaining available flow is allocated to junior users by priority. All available water was allocated to users, with no nonenvironmental flow leaving the system.

Table 4. Appropriative Model Results by User

User/priority	Demand	Allocation	Shortage
A1	7	7.0	0
A2	4	4.0	0
A3	8	5.6	2.4
A4	8	5.6	2.4
A5	8	8.0	0
A6	4	4.0	0
A7	3	3.0	0
A8	9	4.4	4.6
A9	9	3.2	5.8
A10	7	0	7.0
A11	10	0	10.0

Note: Flow units are volume/time.

Table 5. Appropriative Model Results by Basin

Basin	Availability	Upstream demand sum	Upstream allocation sum	Unallocated flow
A	5.6	18.0	5.6	0
B	5.6	8.0	5.6	0
C	16.8	30.0	15.2	1.6
D	5.6	3.0	3.0	2.6
E	28.0	46.0	26.6	1.4
F	33.6	60.0	33.6	0
G	5.6	9.0	3.2	2.4
H	44.8	77.0	44.8	0

Note: Flow units are volume/time.

Combining Water Allocation Methods

To assess allocations for basins with both riparian and appropriative water rights, the riparian linear program is run first, followed by the appropriative linear program. Riparians, having a higher priority overall, are less likely to be curtailed than appropriators (California has some rare cases of very old appropriative rights with potentially higher priority than riparian users; these can be handled by preallocation of water to such users before riparian allocations in very dry circumstances). Riparian rightholders in upper parts of the watershed are much more vulnerable to curtailment than downstream users. If any riparian is curtailed, all upstream riparians are consequently curtailed. Appropriators in upstream portions of watersheds are also more vulnerable to shortage because of low water availabilities and being curtailed to help meet downstream riparian demands.

Model Limitations

All users within a subcatchment k are assumed to have physical access to all inflow (v_k). But some local inflow will enter downstream of some local users, restricting their access to some flow. This misrepresentation is reduced with increasing the spatial resolution of subcatchments. Ideally, each user would have a defined subbasin, but this would greatly enlarge the problem. Error also could be reduced by restricting each user to the percentage of total subbasin outflow available at the user's point of diversion. Also, some users have multiple points of diversion.

The maximum allocation for each user is their previous use u_i, reported under historical flow conditions. These may be less relevant during drought. Ideally, during drought water users would announce or call diversions for their right before each time period, allowing water right administrators to make more accurate and timely water allocations.

In times of drought, curtailed water users often replace lost surface-water allocations with groundwater. However, DWRAT only includes surface-water allocations and omits groundwater depletion effects on surface-water availability. This may overestimate water availability, especially in longer droughts.

DWRAT currently omits return flows back to surface water. This reduces downstream water availabilities. Water uses such as hydropower and flood irrigation have high return flows to surface water. Israel and Lund (1999), Ferreira (2007), and Chou and Wu (2014) presented methods for developing priority-based penalty coefficients for network flow and linear programming models of water resources systems with return flows and appropriative rights. These algorithms could serve as preprocessors to account for return flows while preserving water rights priorities, or net surface-water diversions could be used, assuming local return flows.

Another limitation is that estimates of water availability, use, and return flows are imperfect. Buffer flow represented in the mass balances [Eqs. (3) and (9)] can provide a factor of safety by modifying availability. Positive buffer flow values decrease availability and increase curtailments, but reduce likelihood of overpromising water. Conversely, negative buffer values reduce curtailments, but are likely to overpromise water and increase likelihood of senior rightholders being deprived of water. Errors cannot be entirely eliminated or even entirely known without extensive monitoring. Higher buffer values increase the likelihood of false curtailments (when water is actually available), whereas lower (or negative) buffer flows increase false promises (when water is not actually available for a noncurtailed rightholder). Effects of uncertainty can be explored by varying the buffer flow to see the range of curtailments generated.

Estimating Water Right Reliability

This section introduces a preliminary approach for estimating water supply reliability for individual water rightholders given hydrologic variability. By varying the flow and conducting probabilistic analysis of results from DWRAT, the reliability of water allocations can be estimated for a set of users. The presented methods estimate the probability of water right curtailment in a basin given an uncertain basin outflow hydrology, with known net diversions and a fixed spatial distribution of water availability.

Any unimpaired outlet flow Q_n with a known distribution of local subbasin inflows has a corresponding legally required set of curtailments $[C_n]$ composed of binary values 0 or 1 for each water rightholder i, calculated by the methods discussed earlier. When $C_i = 1$, user i is curtailed and receives less than their full water allocation. Uncurtailed users ($C_i = 0$) receive full allocations. Monte Carlo analysis and implicit stochastic optimization were used to estimate the probabilities of curtailment for individual users.

In Monte Carlo analysis, model input parameters are sampled from a probability distribution. For each sample, model output is recorded. This process is repeated many times to sample a large range of possible input values with realistic relative frequencies. Frequency analysis on the full set of model outputs can estimate the likelihood of a given curtailment solution over the range of possible input values.

For small or simple basins, water right reliability can be estimated by varying inflow over a probability distribution. For each outlet flow, the optimal curtailment set $[C_n]$ is calculated. The reliability of each right is the probability that there is a corresponding outflow which supplies that right, calculated either by numerical integration or by the ratio of samples where user i is curtailed divided by the total number of Monte Carlo samples.

Operating water systems under uncertainty can be complex and computationally intensive. Numerical estimation of uncertainty can be prohibitively complex. Implicit stochastic optimization (ISO) can reduce these problems by applying deterministic modeling over a representative range of input parameters. Initially, a representative range of model input parameters is generated. For each set of inputs, the model generates a single solution set. The probability of any solution is the probability of its corresponding inputs. Frequency analysis over the set of solutions estimates probabilities of curtailment.

Perhaps more useful, the full solution set can help establish a set of rules for real-time system curtailments. Administrators could observe current conditions and look up the corresponding optimal curtailments from the ISO results without additional model runs. ISO is most often used to identify operating rules for reservoirs with uncertain inflows (Young 1967; Lund and Ferreira 1996). Operations are optimized over a long representative time-series of inflows with perfect foresight using deterministic methods. The results are then used to infer optimal operating rules.

For this application of ISO, stochastic operation of a water rights system is considered from administrator and user perspectives. To estimate water right reliability with ISO, a range of outlet flows Q_n is selected. DWRAT calculates $[C_n]$ for each outlet flow Q_n. The probability of a curtailment occurring is the probability of the lowest Q_n when the curtailment occurs. For simple systems, each user i has a corresponding curtailment threshold flow Q_{ti}. When the outlet flow is below Q_{ti}, user i is curtailed and receives less than a full allocation. By stepping through a range of Q_n values and solving the allocation models, the curtailment threshold flow can be identified for each user. The probability of a user curtailment is the probability of Q_{ti}.

Example Basin

The example watershed in Fig. 2 was extended to test and illustrate these methods with a mix of riparian and appropriative users. The basin has eight subbasins (denoted A–H), with local flow availability v_k equal to the outlet flow (Basin H) multiplied by the ratio of upstream drainage area (a_k) to total basin drainage area [Eq. (11)]

$$v_k = Q_n * \frac{a_k}{a_{k,\text{outlet}}} \tag{11}$$

Outlet flow is normally distributed (for illustration) with a mean of 60 and standard deviation of 30, truncated at zero. Other flow distributions could be used. Local inflows to each subbasin are assumed to be a fixed fraction of unimpaired outlet flow. Users R1 through R5 have riparian rights (equal priority). Users A1 through A11 have appropriative rights and with priority given by their label number (A1 has highest priority). Fig. 3 shows the users' locations and Table 6 provides demand for each user (method results are in lower rows).

Another way to represent the system is to view cumulative demand ranked by priority, as indicated in the second-to-bottom row of Table 6. For a riparian user, cumulative demand is the sum of all riparian demand. For an appropriative user, cumulative demand equals the summed demand of higher priority users.

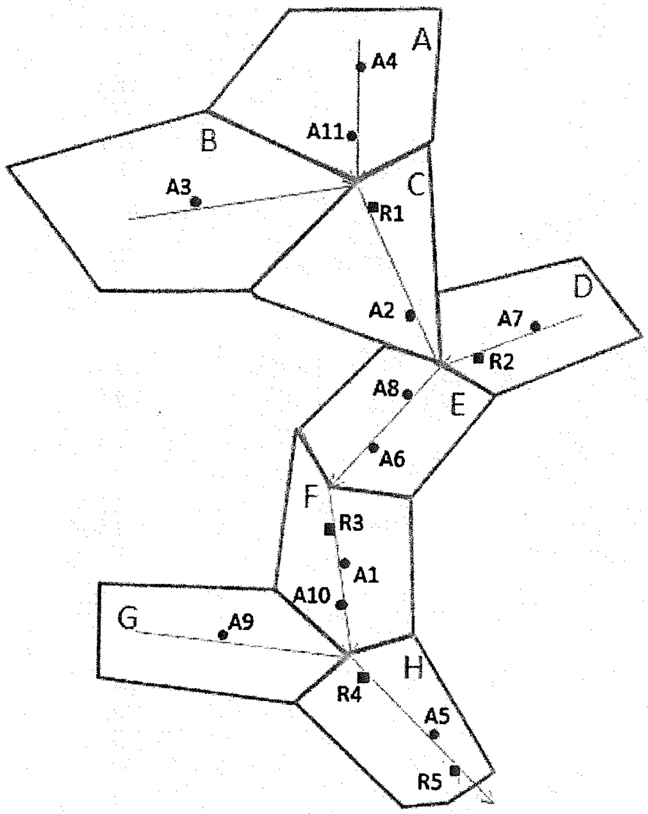

Fig. 3. Example basin with users

If all users had equal access to outlet flow, cumulative demand for user i would be the total amount that must be allocated before user i receives any water. However, the spatial variability of supply disrupts this relationship. This metric is most useful for appropriative rightholders because of their clear relative prioritization.

Monte Carlo Analysis Application

For the Monte Carlo analysis, $[C_n]$ was calculated for a randomly sampled Q_n from the normal error distribution. This process was repeated 500 times to form a statistically representative set. Frequency analysis over all sets of $[C_n]$ determined the reliability of water allocation for each user. The results of the frequency analysis appear in the lowest row of Table 6.

Table 6. Example Users and Demand

User (ordered by priority)	Demand	Cumulative demand	Probability of shortage, Monte Carlo
R1	4	27	0.105
R2	6	27	0.390
R3	8	27	0.105
R4	2	27	0.105
R5	7	27	0.105
A1	7	34	0.190
A2	4	38	0.230
A3	8	46	0.555
A4	8	54	0.555
A5	8	62	0.535
A6	4	66	0.565
A7	3	69	0.630
A8	9	78	0.75
A9	9	87	0.80
A10	7	94	0.875
A11	10	104	0.995

Probability of curtailment increases as priority decreases, with some deviations. Riparian users have the lowest probability of curtailment. However, User R2 is on a tributary branch and is much more likely to face local shortages than other riparian users. Similarly, Users A3 and A4, high in the watershed, have higher probabilities of shortage than A5, with lower priority but on the main stem near the outlet. Users A3 and A4 have the same shortage probability, despite A3's higher priority. Both users are on separate tributaries with independent availabilities, so the availability in Basin A is less affected by water availability or curtailments in Basin B, and vice versa. Users A3 and A4 are limited by availability and location, whereas User A5 is limited by priority.

Implicit Stochastic Optimization Application

To estimate water right reliability with implicit stochastic optimization, $[C_n]$ was calculated for each outlet flow Q_n ranging stepwise from 0 to 150 in increments of 1. As outlet flow increases, fewer users are likely to be curtailed, as shown in Fig. 4. Each step in Fig. 4 corresponds to a user or set of users receiving a full allocation. The flow value corresponding to the step at which a user receives a full allocation is the curtailment threshold flow Q_{ti}. When outlet flow is below Q_{ti}, user i is curtailed. If all users have access to outlet flow, the curtailment threshold would be the cumulative demand for all users. Varying spatial flow availability disrupts this relationship.

Fig. 5 shows the cumulative demand and curtailment threshold for each user, assuming fixed ratios for subbasin inflows to total basin unimpaired outflow. As a user's priority decreases, the corresponding cumulative demand and curtailment threshold increases. Users along the main branch of the river basin (Subcatchments C, E, F, and H) have more access to flow and are less likely to see local supply shortages. Curtailment for these downstream users is generally dictated by priority. In Fig. 5, cumulative demand and curtailment threshold values for these users are nearly equal. Users in the upper portions of the basin (Subcatchments A, B, D, and G) are more likely to face curtailment from local flow shortages. This effect occurs for R2, A3, and A11, whose curtailment threshold significantly exceeds cumulative demand. User R2, despite sharing the highest priority with other riparians, diverts in a subbasin (Basin D) that is more likely to receive shortage. Because local flow availability is proportionate to outlet flow, User R2's curtailment flow threshold is the outflow sufficient in Basin D to meet R2's demand. Their upstream locations make them more vulnerable to curtailment than similar priority users downstream.

The probability of curtailment for a user i is then calculated as the probability that Q_n is less than or equal to Q_{ti}, the cumulative probability distribution function for Q. Fig. 6 shows the probability of curtailment for each user, calculated by the ISO method. The Monte Carlo and ISO methods yield nearly identical curtailments. With more Monte Carlo iterations, the results should converge.

The probability of a individual water right curtailment depends primarily on priority and location in the watershed. The results represent the probability that a water right should be curtailed given the forecast water availability Q and normally distributed error σ. However, actual probabilities of curtailment will differ from errors in estimating water demands, overall water availability, and its spatial distribution.

The presented methods might provide curtailment rules for water right administrators. When flow or forecasted flow at a

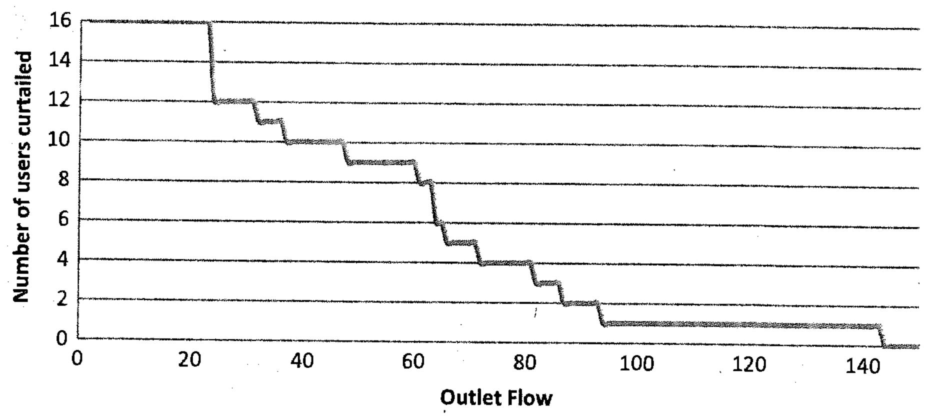

Fig. 4. Total number of curtailed users by outlet flow value

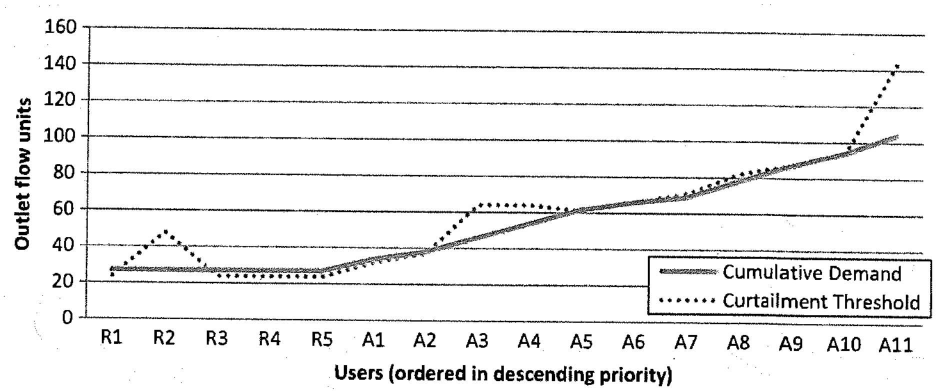

Fig. 5. Cumulative demand and curtailment threshold for all users

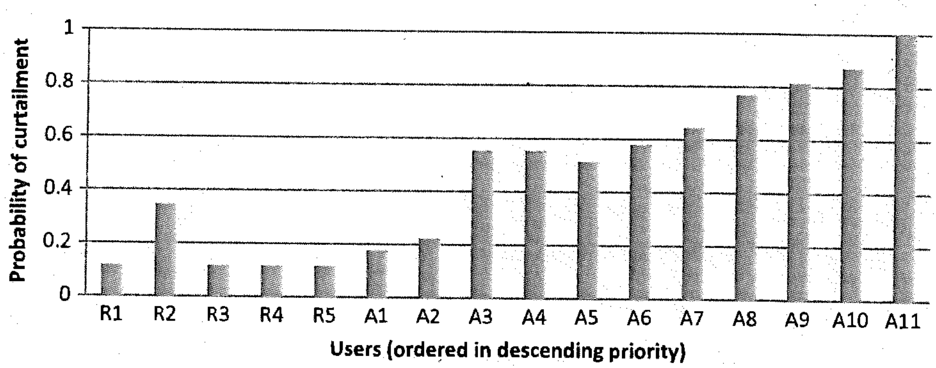

Fig. 6. Probability of curtailment for each user from implicit stochastic optimization method

nearby gauge is below a specified value, some users are not allowed to divert water. This method of assigning curtailments has several advantages. DWRAT would no longer need to be run every time period for an entire basin, given known curtailment thresholds based on flow rates. Users would benefit from knowing the probability of curtailment, allowing for better planning of diversions.

Buffer Flows

Uncertainty in hydrologic forecasting can increase curtailment errors. Curtailments are likely to be calculated in advance based on a forecasted available flow and anticipated user diversions. However, actual flow and diversions may differ significantly, leading to errors in allocations. Including buffer flows can adjust curtailments for forecasting uncertainty by artificially reducing (or increasing) water availability. A higher positive buffer flow is a safety factor for senior rightholders to reduce the chance that water will be unavailable for them or environmental flows. However, this buffer requires additional curtailments for more junior rightholders. The methods discussed next review errors caused by uncertainty and provide a framework for balancing buffer flow values and uncertainties.

False Promises

When actual flow is less than forecasted, some users will be promised a full allocation, but will not have enough water available. Such false promises of water decrease with greater buffer flows. The average number of false promises $E(FP)$ can be defined

$$E(FP) = \int_0^\infty P(Q_{\text{act}})FP(Q_{\text{for}}, Q_{\text{act}}, B)dQ_{\text{act}} \tag{12}$$

where

$$FP(Q_{\text{for}}, Q_{\text{act}}, B) = \text{Maximum}\begin{cases} C(Q_{\text{act}}) - C(Q_{\text{for}} - B) \\ 0 \end{cases} \tag{13}$$

Eq. (12) is the expected number of false promises over possible actual outlet flows Q_{act}, given a forecasted outlet flow Q_{for} and an outlet buffer flow B. False promises for a particular circumstance are defined in Eq. (13) as the difference between number of curtailments with the actual flow and number of curtailments with the forecast flow minus the buffer.

False Curtailments

Buffer flows increase cases when some users suffer curtailments, when the basin had sufficient flow for them to take water. These false curtailments increase with buffer flow values. Given the nomenclature defined earlier, the expected false curtailments $E(FC)$ can be defined

$$E(FC) = \int_0^\infty P(Q_{\text{act}})FC(Q_{\text{for}}, Q_{\text{act}}, B)dQ_{\text{act}} \tag{14}$$

where

$$FC(Q_{\text{for}}, Q_{\text{act}}, B) = \text{Maximum}\begin{cases} C(Q_{\text{for}} - B) - C(Q_{\text{act}}) \\ 0 \end{cases} \tag{15}$$

Eq. (15) defines false curtailments as the difference between forecasted curtailments including buffer flow, and the ideal optimal curtailments with the actual outlet flow. Given uncertainty in water availability, there is always a likelihood of false promises and false curtailments, the balance of which is implicit in water rights administration policies and methods.

Example Basin Application

Eqs. (12) and (14) were applied to the example basin with varying buffer flows and an outlet flow forecast of 60. Fig. 7 illustrates the effect of increasing buffer flows. With no buffer flow, 1.1 false promises and 2.6 false curtailments can be expected. Larger buffer flows make false curtailments more likely and false promises less likely. At a buffer flow exceeding 40, only 20 units of flow are available for allocation and the number of false promises and curtailments stabilizes as all users are curtailed.

Selecting a proper buffer flow may vary with the policy balancing of water rights administrators. If a basin administrator seeks to minimize total falsities, a buffer flow of zero would be optimal. However false promises may be more damaging than false curtailments (or vice versa). In this situation, a buffer flow that would decrease the probabilty of false promises would be optimal, but at the cost of increasing false curtailments.

Here, only positive buffer values are evaluated. Negative buffer values, which would increase supply, would reduce the number of false curtailments and increase the number of false promises. If a water rights administrator seeks to minimize falsities, a range of buffer flow values should be explored. Also, only uncertainty in outflow is examined here. Other sources of uncertainty should be explored, such as subbasin flow distribution and water demand.

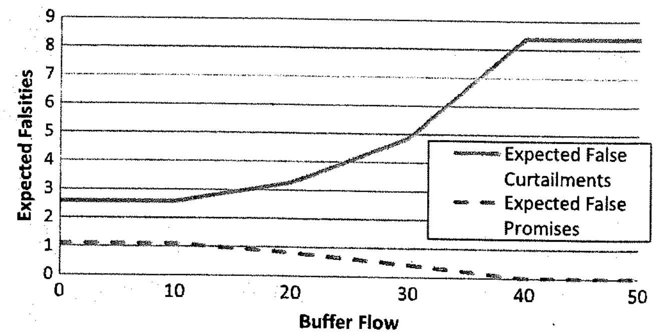

Fig. 7. Expected false promises and curtailments with varying buffer flow

Methods for identifying probability of curtailment could be extended further. Monte Carlo analysis could identify users most likely to face false curtailments or false promises. False promises could result from upstream users withdrawing more than allocated, resulting in a physical absence of water for downstream users.

Applying DWRAT in the Eel River

The Eel River is the first basin for which DWRAT has been developed for application. The Eel River watershed on California's North Coast region has rugged terrain and a low human population density. The basin has an average annual precipitation of 1,524 mm (60 in.), largely from November through March, and is mostly undeveloped. Lake Pillsbury and its forebay, Van Arsdale Reservoir, are the only significant storage projects. At Van Arsdale Reservoir, flow is diverted to the Russian River watershed via the interbasin Potter Valley Project (PVP).

Water Availability and Demands

The USGS operates 11 gauges in the Eel. The lowest elevation gauge, at Scotia, has records dating back to 1911, with a mean annual flow of $35,524,224$ m^3 (28,800 acre/ft/day).

Allocations in DWRAT rely on natural surface-water flow estimates at the 12-degree Hydrologic Unit Code (HUC12) scale. The National Weather Service (NWS) operates flood gauges quantifying natural flow at three locations in the Eel River: Scotia, Fort Seward, and immediately downstream of Lake Pillsbury (ordered from downstream to upstream). A statistical model extrapolates these unimpaired NWS flows to all ungauged HUC12 outlets using ratios of gauged to ungauged flow from a random forest model based on the USGS Gauges-II database that predicts historical monthly flows at ungauged HUC12 locations (Carlisle et al. 2010). A series of scaling factors was calculated using these historical monthly flows. The scaling factors were then used to predict flow at ungauged locations with measured or forecasted flow at gauged locations (Lord 2015).

Water rights information on type of right, date of first use, and 2010–2013 monthly reported withdrawals for the Eel River is available from the SWRCB's Electronic Water Rights Information Management System (2014). The data set contains 206 riparian, 30 pre-1914 appropriative, and 447 post-1914 appropriative rights. Average monthly consumptive water demand is estimated by averaging the 4 years of use data and removing hydropower and other fully nonconsumptive diversions. Daily demand is estimated in DWRAT by dividing the average monthly reported use by the number of days per month. This introduces some error because water

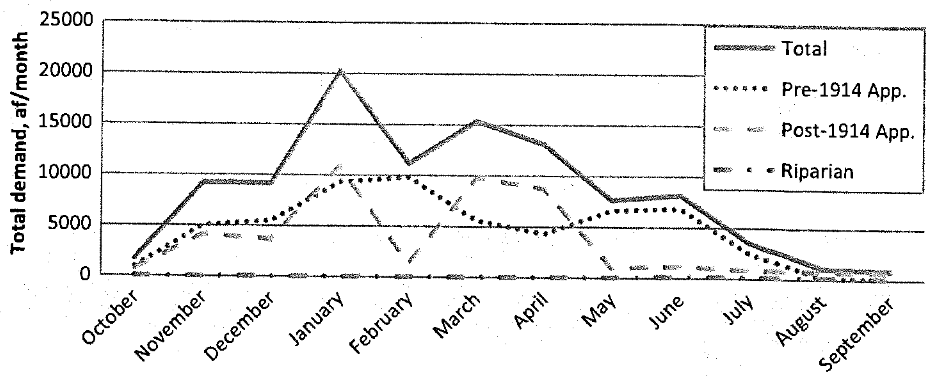

Fig. 8. Monthly water demand in the Eel River Basin according to Howard (2014)

users rarely divert the same amount each day of a month. Fig. 8 shows total average monthly demand for each water right category.

June 30, 2014, Curtailments

On June 30, 2014, the SWRCB announced curtailments for all post-1914 water rights in the North Fork Eel River, Main Stem Eel River, and Van Duzen Tributary, with some exceptions. Curtailments could only be lifted once the SWRCB determined that "water is legally available for diversion under [a user's] priority of right" (SWRCB 2014).

Table 7 summarizes the demand, by user group, for June 30. Of the 683 rights, 419 have non-zero demand for the day and are considered active. The remaining 264 inactive rights have zero demand are excluded from the model. Pre-1914 appropriative rights are most use by volume, followed by post-1914 rights and riparian rights. Fig. 9 shows the June 30 cumulative demand for all rights in the Eel River.

Table 7. Eel River Water Demand, June 30

Right type	Number of active users (% of total)	Demand, af/d (% of total)
Riparian	158 (38%)	4.6 (2%)
Pre-1914 appropriative	25 (6%)	228.0 (84%)
Post-1914 appropriative	236 (56%)	39.5 (14%)
Total	419 (100%)	272.2 (100%)

Water use volume for June 30 in the Eel River is dominated by a few rights owned by the Pacific Gas and Electric Company (PG&E) for the PVP, which transfers water from the Eel's headwaters to the Russian River's East Fork for hydroelectric power. The two largest rights are Applications S001010 (231st in priority, first use in 1905 with June 30 estimated demand of 223.8 acre-ft/day—82% of total demand) and A006594 (249th in priority, first use in 1930 with June 30 estimated demand of 15.5 acre-ft/day).

DWRAT was used to estimate optimal curtailments for June 30, 2014, in the Eel River, with no buffer or environmental flows. A total of 126 rights were curtailed (30% of all users). Curtailments included 46 riparian rights (29% of riparians), 6 pre-1914 rights (24% of pre-1914s), and 74 post-1914 rights (31% of post-1914s). In total, 24.9 acre-ft of water were allocated. Most curtailments were in HUC12 basins where supply is calculated using the NWS gauge at Lake Pillsbury, which had an unimpaired flow of zero. This resulted in zero water available for allocation in all dependent HUC12s. Approximately 75% of curtailed rights are in this part of the watershed, including the large Potter Valley Project diversions.

The SWRCB curtailed diversions for all post-1914 appropriative users, regardless of location in the watershed. The curtailments proposed in DWRAT incorporate spatial variability of flow and limit allocations where supplies are lowest. Many post-1914

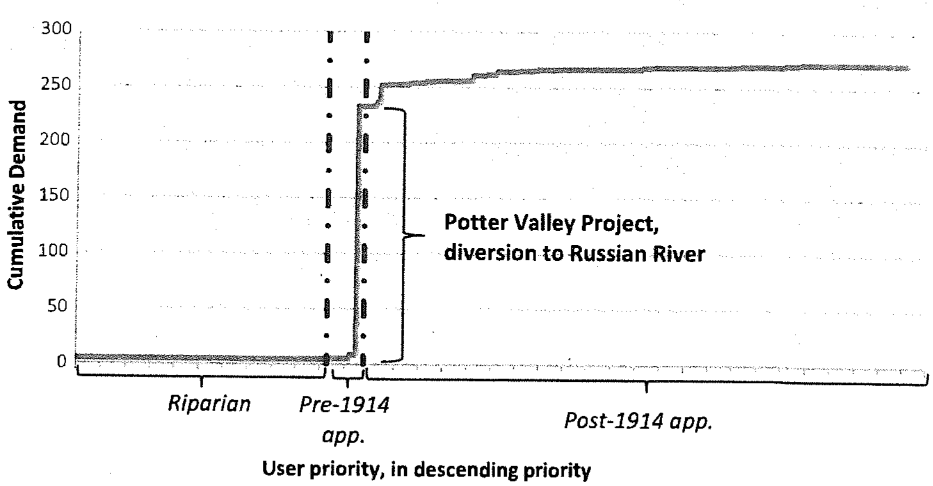

Fig. 9. June 30 cumulative water demand

J. Water Resour. Plann. Manage., 2018, 144(2): 04017082

appropriative users received full allocations using DWRAT, particularly in downstream locations. The shortage was allocated nearly proportionately among user classes and depended more on location than priority of right.

Extended DWRAT Application

DWRAT was used to calculate June 30 curtailments in the Eel River for previous historical years. The NWS only began providing unimpaired gauge flow estimates in 2014, so an alternative source of unimpaired flows was developed. Three USGS impaired flow gauges near the NWS sites were selected. The gauge at Scotia has the longest record, dating to 1911. The other two stations, at Fort Seward and Lake Pillsbury, have much shorter records. Regression analysis was used to develop a trend for the overlapping records between these two stations and the Scotia gauge. The trend was extended over the entire historical record to generate the synthetic impaired flows, with estimated diversions then returned to estimate 102 years of unimpaired flows (Lord 2015). DWRAT was then used to estimate curtailments for June 30 of each year using the synthetic unimpaired flows from 1911 to 2014.

Of the 102-year synthetic unimpaired streamflow record, 88 years would have some curtailments on June 30. By comparison, the SWRCB has only issued curtailments once before 2014. The more frequent curtailments of DWRAT are caused by several factors. DWRAT evaluated curtailments with average 2010–2013 monthly demand over the entire period. Historical water use rates may have been much less. Also, DWRAT omits surface-water return flows, resulting in decreased availability. However, most of the large appropriative rights are fully consumptive to the basin, and most other water use is in the northern part of the basin near the outlet where supplies are plentiful, reducing the potential benefit from return flows. The high frequency of curtailments also is affected by DWRAT's exclusion of water released from storage, underestimating flow availability for appropriative rightholders. Errors also occur in gauge flow estimates and the spatial distribution of flows.

Most curtailments occur in subbasins dependent on the Lake Pillsbury gauge flow for flow extrapolation. It was found that 2014 is the only year with zero flow at this gauge, as well as the only year with a NWS unimpaired flow value. The PVP is in this group of basins. The combination of low predicted flows and a nearby extremely large, senior water right results in consistent curtailments for this part of the watershed. If the highly senior PVP right is curtailed, almost all other appropriative water rights in this region also will be curtailed.

Implicit Stochastic Optimization

The method developed in preceding sections to estimate curtailment thresholds was applied to the Eel River. To simplify analysis, flows at Fort Seward and Lake Pillsbury were calculated as a function of flow at Scotia, using regression equations, and assuming constant proportionality of flow in all subbasins, making flow in all HUC12 subbasins a function of Scotia flow (Lord 2015). Optimal curtailments were calculated for a range of flows at Scotia. Fig. 10 shows the number of users curtailed over the range of flows.

The function shown in Fig. 10 was expected to decrease monotonically, with the total number of curtailed users never increasing with additional supply. Although the curtailments predominantly decrease with increasing unimpaired flow at Scotia, the number of curtailed users increases slightly at 12 points. This behavior occurs at flows ranging from 50 to 100 and 800 to 850. However, the total volume of curtailed water (difference between total demand and total allocations) always decreases monotonically. The cause

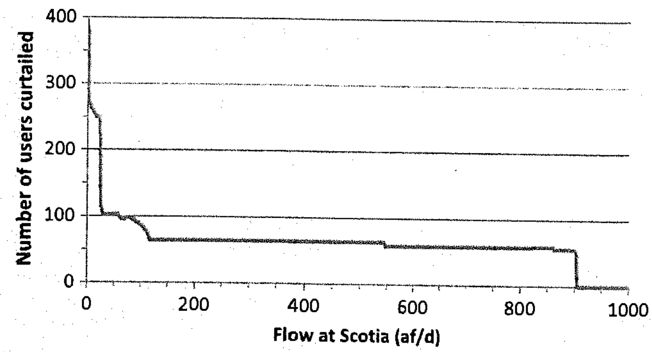

Fig. 10. Number of users curtailed by flow at Scotia, June 30

of the rising curtailments with increased supply is unclear. Rights experiencing this curtailment with increased water availability are mostly appropriative. Further work is needed to determine why curtailment numbers (but not volumes) sometimes increase slightly with increased water availability.

Calculated curtailment thresholds had little correlation with cumulative demand or priority, particularly for appropriative users. Optimal curtailments in the Eel are largely determined by location in the watershed rather than priority of right. Water rights for the PVP dominate allocations. Users downstream of the PVP have low curtailment thresholds and low probabilities of curtailment. Users upstream of the PVP are much more likely to be curtailed to preserve flow for senior downstream users. Basinwide curtailments by priority date will not allocate the most water possible because of spatial variability in water availability, priority, and demand in the Eel. To ensure maximum allocations, curtailments could be issued at a finer spatial scale by priority date. The presented methods could locate areas of large basins likely to face shortage, minimizing the likelihood of downstream false curtailments.

This representation of the Eel River's hydrology is greatly simplified. Flow for the entire river is calculated from availability at Scotia. A better hydrologic model could improve calculations of optimal curtailments and probabilities. Also, return flows should be incorporated. Assuming all use is consumptive artificially reduces availability and increases curtailments. Using past reported water use as a basis for estimated water demands is also a source of error, as found by Grantham and Viers (2014).

Conclusions, Limitations, and Further Research

DWRAT enables precise calculation of water right curtailments during drought by incorporating spatial variability of flow, demand, and priority into a mathematical framework representing the logic of California water law. Although the 2014 drought was significant, more dry years will occur. DWRAT provides an explicit, transparent, mechanistic, and rigorous method for calculating water right curtailments in a mixed water right system using public data and software. It can help support more transparent curtailments and prepare water right administrators for future dry conditions. The curtailment threshold method may be an alternative timely means for issuing curtailments. All users in smaller basins could be told of a specified curtailment threshold value for a nearby gauge. When gauge flow falls below that value, a user will know not to withdraw water to preserve downstream supply.

DWRAT is structured for any temporal or spatial scale large enough where dynamics and hydraulic routing are unimportant. However, curtailments calculated by DWRAT are only as good as the data used. Improvements can be made in both water supply and demand data.

Currently, only monthly withdrawals are available through the SWRCB's databases. Daily demand is estimated in DWRAT by dividing the monthly demand by number of days. This may be reasonable for some users, such as municipalities, but it can be unreliable. Irrigation is rarely distributed evenly across a month. However, asking rightholders to report daily use is unrealistic today. Instead, large users could call use of their rights in advance of an expected curtailment date during extreme dry periods. DWRAT could estimate curtailments based on the updated demand data. Both the SWRCB and users would benefit from this arrangement. Users would benefit from the ability to plan water use in advance and fuller basin water use. The SWRCB would benefit from a transparent and flexible system with explicit and timely water rightholder input.

Limited data exist on return flows. Rights associated with in-stream hydropower uses have zero consumptive demand in DWRAT, but nonconsumptive use from other sources is not yet considered. For rights with return flows rejoining the basin near the point of diversion, allocations could be based on consumptive use rather than total withdrawal. Rights where return flows return to supply far from the point of diversion, such as interbasin transfers through hydropower, present a larger challenge, but might just be considered as fully consumptive from surface-water availability. Several studies (Israel and Lund 1999; Ferriera 2007; Chou and Wu 2014) have presented methods for adjusting penalty coefficients for appropriative users to address this problem, but the method may be too complex for large systems, and data on return flow locations may be difficult to acquire.

Water availability is estimated statistically, using discrete NWS full natural flow forecasts and a spatial extrapolation model. DWRAT does not include water released from reservoirs, which is available for appropriative rightholders. In large systems with multiple reservoirs, such as the Sacramento River, this can be an important supply source. Current versions of DWRAT lack this capability, but reservoir releases could be added to appropriative availability.

DWRAT is an algorithm for implementation of water rights law in California. By accounting for spatial variability in demand, supply, and priority, curtailments can be suggested with greater precision. Given that California faces future droughts, tighter water rights administration will be necessary. Tools such as DWRAT can add transparency, rigor, and accuracy to better address the needs in future dry years.

Acknowledgments

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PRU and R-GPCD Calculation

September 22, 2020

This document contains suggested methods for estimating Percentage Residential Use (PRU), and explains how daily residential per capita water use (R-GPCD) is calculated by Water Board staff. As of October 1st, 2020, the R-GPCD is automatically calculated in the reporting tool. The methodology outlined here has not changed since the initial guidance was developed for the emergency conservation regulations.

When estimating PRU, we recommend using billing data to determine the volume of water provided to residential customers as a percentage of Total Monthly Potable Water Production. In cases where billing periods are not based on calendar month, the urban water supplier should use discretion in selecting the most comparable and appropriate billing period. PRU, rather than residential use volume, is requested in the monthly conservation report because it can be calculated using the previous year's data if current billing data is not available.

Example PRU Calculation: Using recent billing data to estimate PRU

Total Production (T): 1543.98 Acre-feet (AF)

Commercial Agriculture (C): 20 AF

Residential Use (R)[1]: 1001.42 AF

1. Subtract Commercial Agriculture (if any) from Total Production

$$Total\ Production, minus\ Agriculture\ (TPA) = T - C$$

$$TPA = 1543.98 - 20 = 1523.98\,AF$$

2. Divide Residential Use by (Total Production – Commercial Agriculture)

$$PRU = \frac{R}{TPA} \times 100$$

$$PRU = \frac{1001.42}{1523.98} \times 100 = 65.71\%$$

If you do not have billing data for the current reporting month, use last year's data (**BOTH** residential use and total potable production) for the month that corresponds to the reporting month. For example, if you do not currently have October 2020 billing data available, use October 2019 data. **This calculated PRU using last year's data should be entered in the "Preliminary" column when submitting a report.**

[1] When estimating "Residential Use," we recommend using billing data to determine the volume of water provided to residential customers. In cases where billing periods are not based on calendar month, the urban water supplier should use discretion in selecting the most comparable and appropriate billing period.

Once you have current billing data, re-calculate the PRU using current numbers and enter the new value in the "Final" column of the edited report.

Example PRU Calculation: Bi-Monthly Billing Cycle Initial Estimate

Total Production (T) Over Billing Cycle: 3002.15 AF

Commercial Agriculture (C) Over Billing Cycle: 35 AF

Residential Use (R) Over Billing Cycle: 1900.23 AF

Length of Billing Cycle: 61 days

Reporting Month: May

Days in May: 31 days

1. Subtract Commercial Agriculture (if any) from total production

$$Total\ Production, minus\ Agriculture\ (TPA) = T - C$$
$$TPA = 3002.15 - 35 = 2967.15\ AF$$

2. Calculate Residential Use for Reporting Month (RM) and Total Production for Reporting Month (TPM)

$$TPA\ for\ May\ (TPM) = \frac{TPA \times days\ in\ May}{days\ in\ billing\ cycle}$$
$$TPM = \frac{2967.15 \times 31}{61} = 1507.90\ AF$$
$$R\ for\ May\ (RM) = \frac{R \times days\ in\ May}{days\ in\ billing\ cycle}$$
$$RM = \frac{1900.23 \times 31}{61} = 965.69\ AF$$

3. Divide Residential Use for Reporting Month by (Total Production – Commercial Agriculture) for Reporting Month

$$PRU = \frac{RM}{TPM} \times 100$$

$$PRU = \frac{965.69}{1507.90} \times 100 = 64.04\%$$

Please note in the "Qualification" box that the billing data is bi-monthly. As with the previous PRU calculation example, if you do not have billing data that encompasses the current reporting month, please use billing data from the previous year to estimate PRU and enter the value in the "Preliminary" column.

Example Residential Gallons Per Capita Daily (R-GPCD) Calculation

The updated reporting tool automatically calculates the monthly R-GPCD value. The calculation methodology is outlined below.

Original Units	Conversion Factor (CF) from Original Units to Gallons
Gallons (G)	1
Million Gallons (MG)	1000000
Hundred Cubic Feet (CCF)	748.052
Acre Feet (AF)	325851

Total Production (T): 1543.98 AF

Commercial Agriculture (C): 20 AF

Percentage Residential Use (PRU): 65.71%

Population (P): 69078 people

Month: May

Days in Month: 31 days

Conversion Factor (CF): 325851

1. Subtract Commercial Agriculture (if any) from Total Production
$$Total\ Production, minus\ Agriculture\ (TPA) = T - C$$
$$TPA = 1543.98 - 20 = 1523.98\ AF$$
2. Convert (Total Production-Commercial Agriculture) to Gallons, using the Conversion Factor
$$TPA\ in\ Gallons\ (TG) = TPA \times CF$$
$$TG = 1523.98 \times 325851 = 496590407\ G$$
3. Multiply the Total Production Gallons by Percentage Residential Use to get Residential Use in Gallons
$$Residential\ Use\ in\ Gallons\ (RG) = TG \times \frac{PRU}{100}$$
$$RG = 496590407 \times \frac{65.71}{100} = 326313708\ G$$
4. Divide Residential Use by (Population x Days in Month) to get R-GPCD
$$R - GPCD\ for\ May = \frac{RG}{P \times days\ in\ May}$$
$$R - GPCD\ for\ May = \frac{326313708}{690798 \times 31} = 152.38\ GPCD$$

Appendix D

November 12, 2021 Memorandum
Backfeeding Russian River Water to Stafford Lake

Item #9

MEMORANDUM

To: Board of Directors

From: Drew McIntyre, General Manager

Subject: Stafford Lake Backfeeding – 2022 Water Year

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November 12, 2021

RECOMMENDED ACTION: Approve Backfeeding Russian River Water to Stafford Lake

FINANCIAL IMPACT: Up to ~$400 Per Acre-Foot

The District has been backfeeding Stafford Lake during dry year periods dating back to the 1976-1977 drought. In the early years, the District incurred the extra costs for this operation. In more recent years during 2009-2018, MMWD paid the costs for backfeeding as it benefited their operations. A summary of previous backfeeding events over the last 30 years is provided as follows:

Year	Back-Fed Amount (acre-feet)
2021	1100
2018	130
2014	359
2009	348
1991	1000
1989	782
1988	200

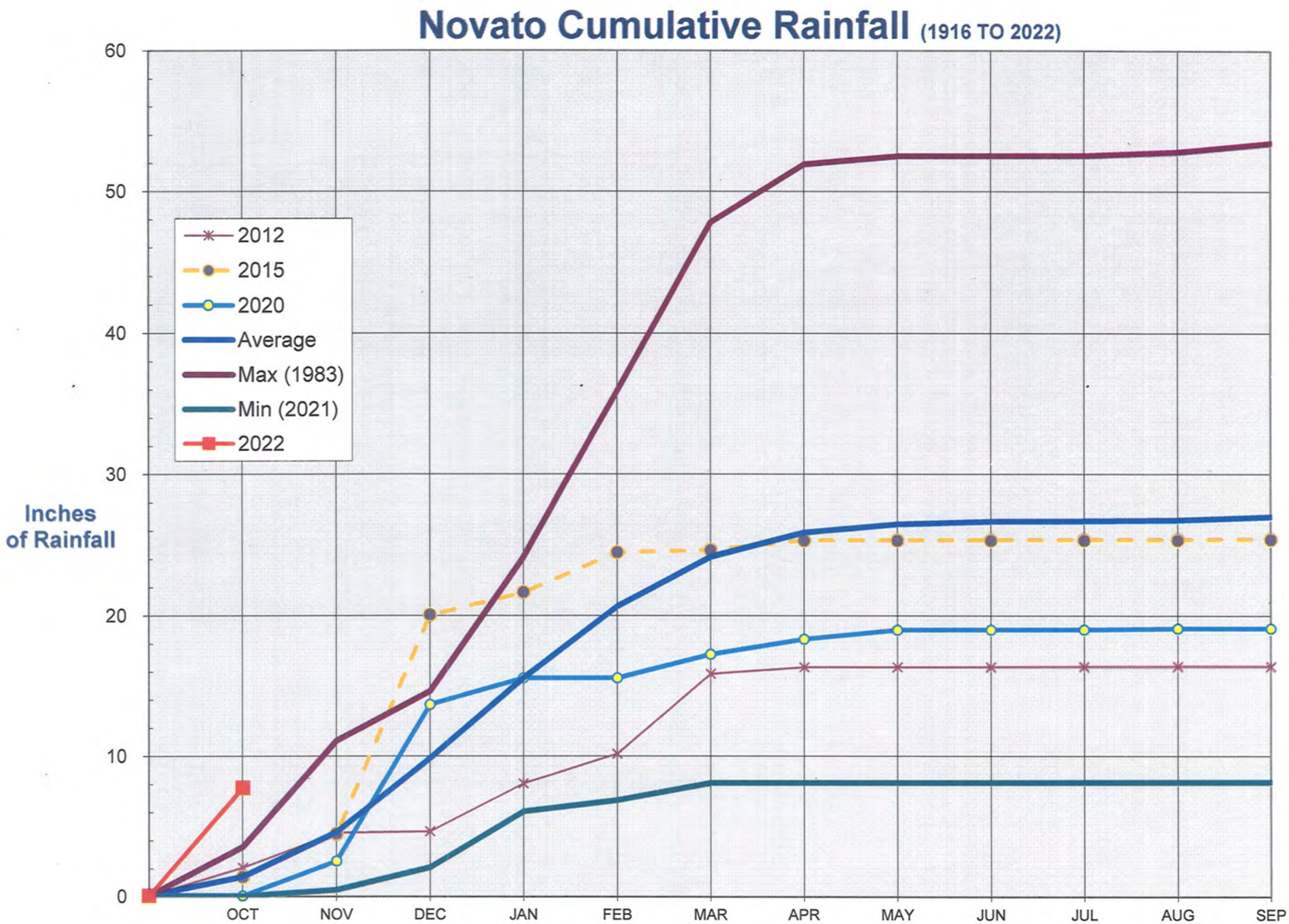
Historical cumulative rainfall in Novato is graphed in Attachment 1. As we know, the 2021 water year (October 1- September 30) was the lowest rainfall year on record since 1916. Water year 2022 rainfall to-date is off to a good start with October 2021 rainfall of 8.6 inches equaling the total rainfall recorded last winter. However, we have no guarantees on how much additional rainfall will occur this winter. Reservoir storage levels are low in both Stafford (Attachment 2) and Lake Sonoma (Attachment 3). Lake Sonoma is particularly concerning as it closely hovering above 100,000 acre-feet which is the lowest level recorded since construction of Warm Springs Dam in 1983. It is estimated that we need at least another 10+ inches of rainfall to fill Stafford Lake and SCWA staff estimate they need at least 24 inches of rain to fill Lake Sonoma. Given the recent two-year epic drought and low reservoir storage levels, it is recommended that we proceed to backfed

Stafford Lake on or about December 1 to take advantage of natural flows in the Russian River (when they are available).

The backfeeding cost of approximately $400 per acre-foot is derived from the cost to pump SCWA water into Stafford Lake plus the marginal cost to re-treat SCWA water stored in Stafford Lake. Obviously, there is a risk that the benefit of backfeeding water into Stafford Lake could be negated if more winter rains result in filling and overflow at Stafford Lake. To minimize this risk, we will try to manage backfeeding operation in concert with actual rainfall events. In the end, it is my belief that it is prudent to move forward with backfeeding now rather than waiting a couple of months in the "hope" that more rainfall will come.

RECOMMENDATION

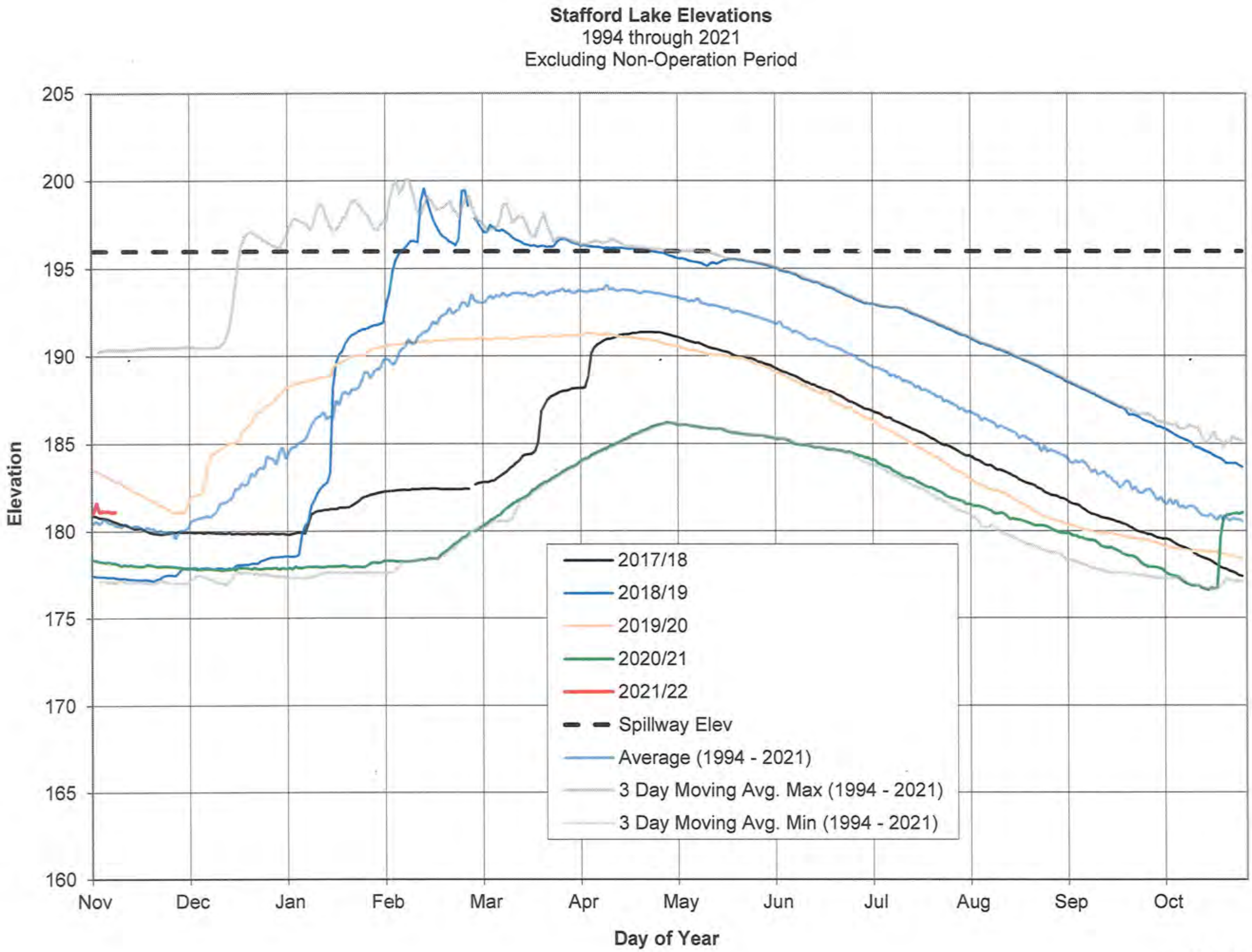
Board authorize backfeeding of Russian River water into Stafford Lake on or about December 1, 2021.



ATTACHMENT 1

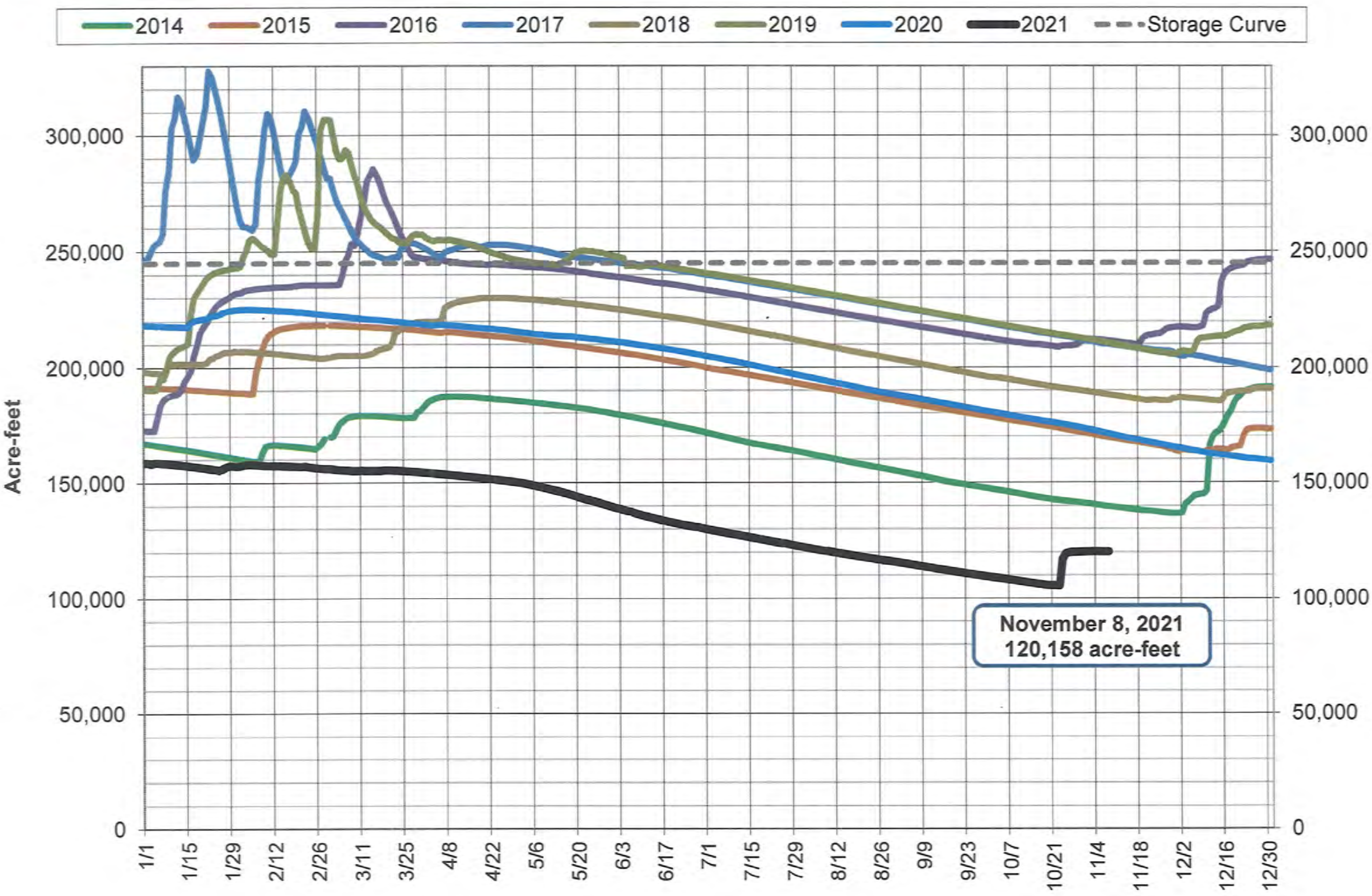
\\nmwdserver1\ops\Water Production\Rainfall\Stafford Rain 1916-Present 21

11/12/2021



ATTACHMENT 2

Lake Sonoma Storage



ATTACHMENT 3

Appendix E

2019 Stafford Treatment Plant Process Efficiency Improvements Study

WEST YOST ASSOCIATES

TECHNICAL MEMORANDUM

DATE: June 21, 2019

Project No.: 861-50-18-01
SENT VIA: EMAIL

REGISTERED PROFESSIONAL ENGINEER
AILEEN N.L. KONDO
No. C74367
Exp. 6-30-21
CIVIL
STATE OF CALIFORNIA

TO: Robert Clark, North Marin Water District
Operations/Maintenance Superintendent

FROM: Aileen Kondo, PE, RCE# 74367
Ryninta Anatrya, PE, RCE# 87270

REVIEWED BY: Craig Thompson, PE, BCEE, RCE# 44224
Robert Ward, PE, RCE# 58810

SUBJECT: Stafford Treatment Plant Process Efficiency Improvements Study

1.0 PROJECT BACKGROUND

The North Marin Water District (District) treats water from Stafford Lake through the Stafford Treatment Plant (STP) to supplement its purchased water supply from the Sonoma County Water Agency (SCWA). Approximately 20 percent of the District's water supply comes from Stafford Lake.

The STP has a nominal production capacity of six million gallons per day (mgd). The STP treatment process is shown in the process flow diagram in Attachment A, and the water treatment processes are described below:

- Oxidation with chlorine dioxide, augmented with up to 2 milligram per liter (mg/L) of chlorine
- Coagulation using polyaluminum chloride and ferric chloride as the primary coagulant and a coagulant aid polymer
- Pretreatment clarification and filtration through three nominal 2 million gallon per day (mgd) Actifloc® clarifier and granular media filter modular, steel treatment units (Actifloc unit)
- Filtration through granular activated carbon (GAC) contactor-filter units for enhanced removal of both taste and odor compounds and disinfection byproduct precursors
- Chlorine addition for final disinfection
- Sodium hydroxide addition for pH and corrosion control

The STP facilities also include handling facilities for liquid waste streams from the treatment processes and sludge solids management facilities for dewatering of solids. These facilities are also shown in the process flow diagram in Attachment A.

Although purchasing water from SCWA has historically been more economical than treating the available Stafford Lake source water, the cost of SCWA water has been steadily climbing. The SCWA water cost has generally been increasing by 3 to 7 percent each year for the last 10 years and has increased from $1,878 per million gallon (MG) in 2010 to $2,877 per MG in 2019. In comparison, the historical cost of treating Stafford Lake water has fluctuated based on the STP production. In the last decade, the cost of STP production has ranged between $2,618 per MG to $4,171 per MG. Generally, the higher the STP production, the lower the STP production cost. If the cost of SCWA water continues to rise, water produced from the STP has the potential to be as or more economical than water purchased from the SCWA, when the STP annual water production goal of 750 MG is met or exceeded. Additionally, one of the District's 2018 Strategic Plan goals is to increase local control and long-term water supply reliability. Therefore, it is desirable to maximize the flexibility and capability to produce water at the STP.

The STP operation and treated water production is often constrained by the District's wastewater discharge permit restrictions and the Novato Sanitary District's (NSD) collection system capacity, especially during and immediately following major storm events. The NSD discharge permit for the STP includes the following flow rate and daily volume restrictions for liquid waste streams discharged into NSD's collection system:

- Flows shall not exceed 40,000 gallons per day (gpd) during December through April.
- Flows shall not exceed 150,000 gpd during May through November.
- Discharge shall occur at a flow rate of 100 gallons per minute (gpm) or less.
- Discharge shall cease when any significant rainfall event commences. (Significant rainfall events are not defined in the discharge permit.)

Current STP operations generate more wastewater that can be discharged to NSD's collection system. As a result, the STP must regularly stop water production and associated waste stream production to stay within its wastewater discharge limits.

The District's use of its locally-available water is maximized when the STP can operate while the Stafford Lake is spilling (i.e., the lake is full, and water is overflowing into the spillway). Lake spilling normally occurs in the late winter and early spring, during and following significant rainfall events. Since STP's discharge of liquid wastes into NSD'S collection system must cease during these events, the STP often cannot operate, and the available water spilling from the lake is lost.

Additionally, the lake's source water quality is frequently better and costs less to treat during the winter and early spring. Due to better source water quality, chemical dosages are typically lower, and filter run times are often longer when treating water during this period compared to during the summer months. However, since the wastewater discharge rate and daily limit restrictions are more stringent during the winter and early spring, water production is constrained during the period when source water quality is better for treatment. When the STP is operated in early spring, the STP can only produce about 1.5 million gallons in a day, and operation must cease daily to avoid generating more wastewater (>40,000 gpd) than can be discharged to the sewer in a day.

The STP Process Efficiency Improvements Study goals include identifying five alternative treatment or operating improvements that could permit the District to increase its use of its locally available lake water supply. Eliminating or reducing the current operational constraints resulting from the NSD discharge restrictions would provide the greatest benefit to STP operational flexibility and production. Therefore, the Process Efficiency Improvements alternatives focus on reducing and/or reclaiming greater portions of the process waste streams that are currently discharged to the sewer.

This report summarizes the five alternatives developed and evaluated as a part of the study and includes an opinion of probable construction cost (OPCC) for the alternatives, as well as recommendations for implementing the recommended improvements.

2.0 CURRENT STP OPERATIONS

2.1 Seasonal Operations

The STP normally operates between late spring (March/April) and early fall, treating source water accumulated and stored in Stafford Lake. Occasionally, the STP may begin operating earlier during some years when the lake is full or nearly full and the current weather forecast indicates that the lake will likely begin spilling (prior to a rain event). Operating the STP when the lake is spilling or just prior to its spilling maximizes the District's local water use. The water drawn from Stafford Lake for treatment during these periods will be replenished by the predicted storm and does not reduce the accumulated lake volume held in reserve for treatment later in the year. Unfortunately, the STP often does not start operating until March or April during most years, even though the lake may be full, due to NSD's more stringent discharge volume restrictions during the winter and spring months and during and immediately after significant rain events.

The District has set a minimum operational water level in Stafford Lake (at 177 feet elevation). The minimum water elevation permits the District to maintain an emergency supply in case it loses its SCWA aqueduct supply. The STP is shut down when the water level in Stafford Lake drops to the District's minimum operating water level to provide its "emergency reserve." An early season shutdown of the STP may occur before the lake's water level is at the minimum level to provide additional source water reserves in the lake to buffer against a possible, subsequent drought (drier-than-normal) year. An early wintertime shutdown of the STP provides additional time for Stafford Lake to fill. District staff routinely perform planned annual maintenance activities during the four- to five-month period between shutting down the STP in October or November and restarting it in early spring.

2.2 Daily STP Operations

During the earlier months of the STP operating season (March or April), when NSD's more stringent discharge restrictions are in effect, the STP typically operates at near full plant capacity (6 mgd) for approximately four to eight hours during each day. The STP is then shut down and remains offline for the remainder of the day. The STP shuts down daily to avoid generating waste liquids in excess of NSD's seasonal sewer discharge limits. As the liquid waste sludge and water accumulate in the solid's thickener, the accumulated liquid requires extending the STP shut down period to permit discharging the accumulated liquid waste fluid to sewer. During the summer months, when NSD's higher sewer discharge flow rate is allowed, the STP can be operated between two-thirds and full capacity without having to schedule a daily treatment process shutdown.

3.0 STP WASTE STREAMS AND WASHWATER RECOVERY ANALYSIS

Table 1 lists the STP water treatment processes' waste streams that currently are discharged to NSD's sewer and those that are recycled to the head of the treatment process. These waste streams are further described below.

Table 1. STP Treatment Process Waste Streams

Waste Stream	Volume/Flow Rate	Frequency/Duration	Percent of Total Sewer Discharge or Reclaimed Water[(a)]
Liquid discharged to NSD's sewer collection system			
Hydrocyclone Waste Stream	37 gpm per Actifloc Unit (110 gpm total for all three units)	Continuous during startup and normal operation, plus for 10 minutes after treatment unit shuts down	80 – 90%
Centrifuge Centrate	15-20 gpm	Mostly continuous during plant operation	5 – 10%[(b)]
Centrifuge Area Washdown	15-25 gpm	Varies	<5%
Reclamation Pond Cleaning	160,000 gallons	Normally once per month	5 – 10%
Reclaimed water recycled to head of STP			
Actifloc Unit Spent Backwash Water	30,000 gallons per filter unit backwash	Spring: After 20 to 40 hours of accumulated filter run time Summer: After 10 to 20 hours of accumulated filter run time	80 – 90%
Actifloc Unit Filter-to-Waste (FTW)	Up to 1,400 gpm per unit filter	During daily treatment unit start-up period (10-minutes), after each filter backwash, and if filtered water turbidity is not acceptable	N/A[(c)]
GAC Contactor Spent Backwash Water	18,000 gallons per GAC contactor unit backwash; 72,000 gallons for all four GAC contactors	After 200 hours of cumulative GAC-contactor-filter operation	5 – 10%
pH Analyzer and Lab Sink Sample Drain	1-5 gpm	Continuous during plant operation	~5%

(a) Percentages are based on daily average volumes.
(b) Plant water is used to process the sludge solids sent to the centrifuge, and the centrate returned to the solids thickener includes the plant water used for solids processing. The plant water use for sludge processing is about 4,000 to 5,000 gpd during the wet season and about 12,000 to 14,000 gpd during the dry season.
(c) The FTW volume does not count towards the reclaimed water volume that is limited to 10 percent of the STP production flow rate and is not counted in the total reclaimed water.

3.1 Waste Streams Disposed to Sewer

The waste streams that are discharged into NSD's sewer are collected (accumulate) in the 260,000-gallon solids thickener tank. The accumulated liquid waste water is metered into NSD's sewer collection system. These waste streams include:

- **Hydrocyclone Liquid/Sludge Waste Stream**: Each Actifloc unit includes two pumps that continuously withdraw settled microsand-sludge slurry from the bottom of each pretreatment unit's two hoppers. The pumps send the sand-sludge slurry to two hydrocyclones on each Actifloc unit. There is a dedicated pump and hydrocyclone for each hopper. The hydrocyclones separate the microsand from the sludge solids. The microsand is returned to the Actifloc unit's injection tank, and the sludge solids waste stream is discharged to the 500-gallon hydrocyclone waste collection tank and pumped from this tank to the solids thickener for settling of solids. Clarified water from the solids thickener is discharged at a controlled rate to NSD's collection system.

  When in operation, each Actifloc unit currently generates a relatively constant 37 gpm sludge waste stream. Each treatment unit's sand pumps and hydrocyclones continue to operate when an Actifloc unit is stopped for a filter backwash and subsequent fiter-to-waste (FTW) period, which is a 35 to 40 minute process. When an Actifloc unit is shut down (e.g., at the end of each daily operating period), the unit's sand pumps and hydrocyclones continue to operate for another 10 minutes until most of the microsand has settled in and been transferred from the hoppers to each Actifloc unit's injection compartment. These standard operating protocols continue to generate liquid (sludge) waste without concurrent production of clarified water. The hydrocyclone is the largest source of non-recycled liquid waste, accounting for 80 to 90 percent of the liquid waste sent to the NSD sewer connection.

- **Centrate from the Centrifuge**: Settled sludge from the solid's thickener tank is withdrawn from the bottom of the tank and sent to the centrifuge for dewatering. The settled sludge solids liquid stream is delivered to the centrifuge at about a 30 gpm flow rate. The centrate from the centrifuge is collected in a below grade wet well and is returned to the solids thickener tank at a flow rate between approximately 15 and 20 gpm. Plant water is used in the processing of the sludge solids and is sent with the centrate to the NSD sewer connection via the solid's thickener. The amount of plant water used for sludge processing is typically between 4,000 and 5,000 gpd during the wet season and between 12,000 and 14,000 gpd during the dry season.

- **Centrifuge Area Washdown**: A catch basin at the centrifuge washdown area collects washdown water and rainwater that flows into the area. The water accumulates in a below-grade sump and is pumped to the solids thickener tank at an approximate flow rate of 15 to 25 gpm. The occurrences of rain and area washdown are intermittent and irregular. The volume of waste pumped to the solid's thickener varies but is typically several hundred gallons or less per event.

- **Water from Reclamation Pond Cleanings**: There are two 445,000-gallon reclamation ponds (990,000 gallons total) that receive spent filter backwash water and other recyclable treatment process waste streams. The ponds are normally cleaned monthly. Wastewater from the pond cleaning is pumped directly to the solid's thickener. The pond cleaning generates about 160,000 gallons waste volume that is discharged to the NSD collection system each month.

3.2 Recycled Waste Streams

The waste streams recycled to the head of the STP, other than FTW, are first sent to one of the two reclamation ponds. The clarified water in each pond is returned at a rate that is limited to 10 percent of the STP production flow rate. The recycled waste streams include the following:

- **Actifloc Units Spent Filter Backwash Water**: There are three Actifloc units. Two or all three of the treatment units are normally operated whenever the STP is operating. The filters' cumulative run times between backwashes depend on season variation in source water quality. As noted above, during the winter and spring, the filter run time between backwashes is about 20 to 40 hours. In the summer, when the source water quality can be more challenging due to algal blooms and other lake conditions, the filter run times are often between 10 and 20 hours between backwashes. Each filter backwash generates about 30,000 gallons of spent backwash water. The spent filter backwash water from each Actifloc unit's backwash is sent to the reclamation ponds and returned to the head of the STP after a period of settling and clarification in the pond.
- **Actifloc Unit FTW**: When each Actifloc unit is started (following either a filter backwash or shutdown period), the filtered water is initially discharged to waste until the filtered water turbidity is below the filtered water turbidity setpoint value. The FTW water is typically returned directly to the head of the plant. The FTW is sent to the reclamation pond only if the filtered water turbidity exceeds the return water turbidity setpoint value. The FTW flow rate can be up to 1,400 gpm per filter, and the duration varies depending on how long it takes for the filtered water turbidity to reach acceptable levels.
- **GAC Contactor Spent Backwash Water**: There are four GAC contactors that polish the filtered water. Normally all four GAC contactors are in service when the STP is operating. The GAC contactors are typically backwashed after 200 hours of cumulative operating time. Each GAC contactor backwash generates approximately 18,000 gallons of spent backwash water. The GAC contactors' spent backwash water is sent to the reclamation ponds and returned to the head of the STP after a period of settling and clarification.
- **pH Analyzer and Lab Sink Sample Drain**: The pH analyzer waste sample water does not contain any added reagents and is sent to the reclamation pond for recycling. Sample water from various points in the treatment process is continuously supplied to the lab sink. The drain water from the lab sink is also sent to the reclamation pond for recycling. The total sample drain flow rates range between 1 and 5 gpm and are continuous when the STP is operating.

3.3 Washwater Recovery Analysis

To comply with the requirements and guidelines in both the Filter Backwash Recycling Rule (FBRR) and California Cryptosporidium Action Plan (CCAP), the clarified water from the reclamation pond is returned to the head of the water treatment process at a flow rate that does not exceed 10 percent of the STP total flow rate. Additionally, the return water turbidity is monitored, and the spent backwash water is recycled only if the return water turbidity is less than 2 NTU.

Under current STP operations, spent backwash water is generated at a rate that is less than the rate at which it can be returned, even during winter when the STP treatment process flow rate and associated allowable daily recycled water return flow rate are lower. If the waste streams that are currently discharged to NSD's sewer are also recycled to the head of the STP, the required return rate would be greater than five percent but less than 10 percent of the STP's total flow rate during most operating conditions.

Table 2 below summarizes waste volumes under typical STP operating conditions. The operating conditions labeled as "Proposed" assume that some of the waste streams currently discharged to the sewer (including the Actifloc hydrocyclone waste stream and pond cleanings) will be returned.

The Total Average Daily Waste Volume was computed for each waste stream assumed to be returned. The "Total Average Daily Waste Volume" is the total waste volume generated from the occurrence of the activity divided by the interval (in days) at which the activity occurs. For example, if the Actifloc units are backwashed after a filter run time of 36 hours and the units are operated for six hours a day, the units are backwashed every six days (= 36 hours ÷ 6 hours/day). The backwashes from all three units generates a total waste volume of 90,000 gallons (= 3 units x 30,000 gallons/unit). The average daily waste volume, or total waste volume averaged over the six days, is 15,000 gallons (= 90,000 gallons ÷ 6 days).

The Total Average Daily Waste Volume from each process with return waste was summed, and this sum was compared to the total water production for each scenario to determine the average return rate for that scenario.

It should be noted that the supernatant from the solids thickener historically had high iron and manganese concentration that presented an oxidant demand. When the supernatant was recycled, the required chlorine dioxide dose increased. The higher dose was beyond the capacity of the existing chlorine dioxide generator. Therefore, the solids thickener supernatant is currently sent to the sewer rather than recycled.

Iron and manganese are typically removed by filtration through the granular media filters following oxidation. The iron and manganese in the filters are dislodged during a filter backwash and transferred to the reclamation ponds with the spent backwash water. The iron and manganese settle into the sludge layer in the reclamation ponds, and therefore, are most likely to be present in the pond cleaning waste stream. This can be verified by measuring the iron and manganese concentrations in the pond cleaning waste stream. If the pond cleaning waste stream is confirmed to be the source of the iron and manganese, this waste stream can be excluded from recycle. Or an oxidant can be added to treat the waste stream prior to recycling. Managing the iron and manganese in the waste stream must be considered when considering recycling the waste streams.

Table 2. Washwater Recovery under Varying Conditions

Parameter	Units	Current		Proposed	
		Winter	Summer	Winter	Summer
Plant Production Flow Rate	gpm	4,167	4,167	1,042	4,167
Hours of Operation per Day	hrs	6	18	24	24
Production Volume per Day	gallons	1,500,000	4,500,000	6,000,000	6,000,000
Allowed Percent Recycle	percent	10%	10%	10%	10%
Allowed Recycle Flow Rate	gpm	417	417	417	417
Allowed Recycle Volume per Day	gallons	150,000	450,000	60,000	600,000
Actifloc Filter Backwash					
No. of Filter Units Online	no	3	3	3	3
Filter Run Time	hrs	36	12	36	12
Waste Volume per Unit Backwash	gallons	30,000	30,000	30,000	30,000
Total Average Daily Waste Volume(a)	**gallons**	**15,000**	**135,000**	**60,000**	**180,000**
GAC Contactor Backwash					
No. of Filter Units Online	no	4	4	4	4
Filter Run Time	hrs	200	200	200	200
Waste Volume per Unit Backwash	gallons	18,000	18,000	18,000	18,000
Total Average Daily Waste Volume(a)	**gallons**	**2,160**	**6,480**	**2,160**	**8,640**
Sample Drain					
Total Sample Drain Flow Rate	**gpm**	**5**	**5**	**5**	**5**
Hours of Operation per Day	hrs	6	18	24	24
Total Average Daily Waste Volume	**gallons**	**1,800**	**5,400**	**7,200**	**7,200**
Actifloc Hydrocyclone Waste					
Waste Flow Rate per Unit	gpm	-	-	37	37
Minutes of Operation per Day	mins	-	-	1,440	1,440
Total Average Daily Waste Volume	**gallons**	**-**	**-**	**159,840**	**159,840**
Pond Cleanings					
Interval Between Cleanings	days	-	-	30	30
Volume per Cleaning	gallons	-	-	160,000	160,000
Average Daily Waste Volume	gallons	-	-	5,333	5,333
Total Average Daily Waste Volume to be Returned	**gallons**	**18,960**	**146,880**	**241,013**	**361,013**
Average Return Rate(b)	%	1.3%	3.3%	4.0%	6.0%

(a) The total average daily waste volume from filter backwashes is computed as the number for filter units online times the waste volume per unit backwash times the filter run time divided by the hours of operation.

(b) The average return rate is reported as a percent of the daily water production. It is computed as the total average daily waste volume divided by the total daily water production.

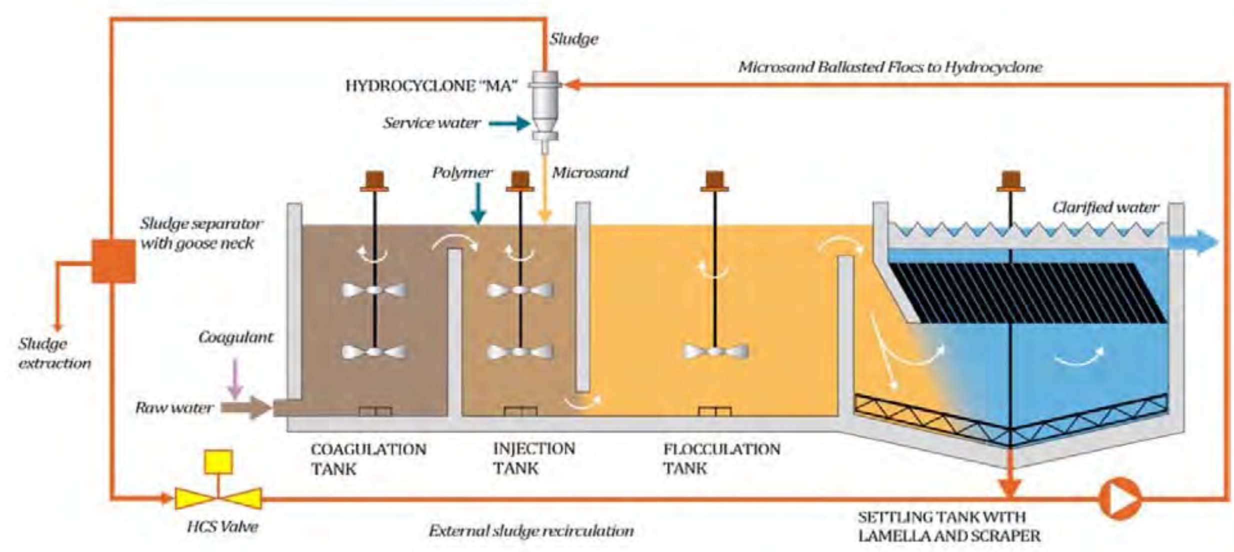
4.0 PROCESS EFFICIENCY IMPROVEMENT ALTERNATIVES

Five process efficiency improvement alternatives were identified and evaluated. These alternatives involve reducing and/or reclaiming a portion of the water treatment processes' waste streams that are currently discharged to the NSD sewer. These five process efficiency alternatives are discussed below.

4.1 Actifloc Unit Hydrocyclone Waste Reduction

Veolia offers an Actiflo® treatment unit with a High Concentration Sludge (HCS) system, which includes a sludge separator unit, HCS valve, and an external recycling loop to reduces the volume of the sludge waste stream (or increase the sludge concentration of the waste stream) by retaining sludge in the recirculation loop. The HCS system is shown schematically in Figure 1. A variation on Veolia's HCS concept is proposed for reducing the volume of waste produced by each STP Actifloc unit.

Figure 1. Diagram of the Actiflo® HCS system



4.1.1 Existing Actifloc Unit Hydrocyclone Configuration

The STP has three Actifloc units. Each modular treatment unit has two sludge collection hoppers where the microsand-ballasted floc-sludge settles and accumulates. Each hopper is connected to a sand pump that withdraws the settled sand-sludge slurry and sends it to a hydrocyclone. The microsand and floc-sludge are separated in the hydrocyclone. The sand is recycled (discharged) into the Actifloc unit's injection compartment, and the sludge is discharged from each hydrocyclone at a flow rate between an 18 and 19 gpm. Each Actifloc unit that is in service will have both of its sand pumps and hydrocyclones running continuously, generating a relatively constant 37 gpm wet sludge waste stream.

A photo of one of the Actifloc unit's two hydrocyclones is shown in Figure 2. The sand-sludge slurry is pumped through the tan-colored hose and enters the hydrocyclone from the side. The sand exits the hydrocyclone through the nozzle at its base. The waste sludge exits the hydrocyclone through its top outlet, passes through an elbow and a vented tee, and down the gray pipeline to a collection header that sends the wet sludge to the hydrocyclone waste collection tank.

Figure 2. Hydrocyclone Pair on the Deck of an Actifloc Unit

4.1.2 Returning Hydrocylcone Waste Stream

Reduction of the hydrocyclone sludge waste stream could be achieved by returning a portion of the hydrocyclones' waste sludge stream to the Actifloc unit's injection chamber where the microsand is currently reintroduced and/or added. The current Actiflo® system supplier, Veolia, indicated that this has been done at a number of other facilities that have Actiflo® pretreatment units. The objective of recycling a portion of the hydrocyclones' waste sludge at the other facilities includes reducing chemical use by returning some of the chemical in the settled microsand-sludge slurry ahead of the Actiflo® maturation zone. Returning the waste stream from one of the two hydrocyclone units would provide a 50 percent reduction in both the liquid waste flow rate and daily sludge volume from the Actifloc units.

Based on discussions with the Veolia, concerns with returning the hydrocyclone sludge waste stream back into the Actifloc unit pretreatment process include the following:

- Building up of solids within the Actifloc unit and potentially impacting the effluent (clarified water) quality.
- Increasing the percent solids of the sludge-microsand slurry to be processed by the hydrocyclone, which may result in reduced sand separation efficiency (i.e., increased microsand loss).

Buildup of solids within the Actifloc unit pretreatment process would be a pertinent concern when treating water with high solids concentration. It should be noted that the original Actiflo® treatment process was developed to clarify secondary wastewater effluent that typically has a higher solids concentration than WTP source water. Most of the time, the STP is treating water with relatively low turbidity (< 10 NTU). Because the STP raw water turbidities are typically very low, returning a portion of the sludge waste stream may improve floc formation in the Actifloc unit by reintroducing more and larger pre-formed floc solids that enhance particle collisions and agglomeration.

Veolia indicated that the solids concentration in the sand-sludge slurry fed to the hydrocyclone should not exceed than 12 to 15 percent (including the microsand) to avoid impacting the hydrocyclone efficiency. The sludge waste stream has very low concentration of dry solids (typically between 0.1 and 0.3 percent) and is a small fraction of the dry solids in the sand-sludge slurry. Doubling the sludge solids concentration by returning 50 percent of the waste stream back into the Actiflo process should not significantly increase the sand-sludge slurry's dry solids concentration. Additionally, since the hydrocyclones' wet sludge would be recirculated to the Actifloc unit, the microsand enmeshed in the wet sludge slurry would be returned and would not be "lost."

4.1.3 Hydrocyclone Waste Reduction Implementation

Returning 50 percent of the two hydrocyclones' sludge waste stream (100 percent of one of the two hydrocyclone's sludge discharge stream) back into the Actifloc unit's injection chamber requires modification and reconfiguration of the hydrocyclone's discharge pipeline. The modifications could be implemented by District staff for a relatively minor cost. The sand pumps are configured to operate within a specific back pressure range that provides the desired microsand-sludge slurry flow rate that is recommended to keep the settling microsand from settling, accumulating, and impairing the sludge hopper's outlet connection. Therefore, the temporary modifications to the hydrocyclone's sludge discharge pipeline should be configured to provide a similar backpressure on the sand pumps that the current configuration provides. The recommended piping reconfiguration to return 50 percent of the hydrocyclone liquid waste stream into the Actifloc unit's injection chamber is as follows:

- On one of the two hydrocyclone units, disconnect the stainless-steel vent assembly where it connects to the hydrocyclone liquid waste pipeline (by disconnecting the flanged connection adjacent to the increaser and loosening the Victaulic connection at the top of the hydrocyclone)
- Rotate the vent assembly 180 degrees and install Unistrut or a similar support system to support the vent assembly's new location

- Reconnect the sludge discharge assembly to the hydrocyclone at the Victaulic connection
- Connect piping to vent assembly at the flange connection to direct the hydrocyclone liquid waste stream back into the Actifloc unit's injection chamber

The hydrocyclone's original sludge discharge pipeline configuration can be restored if the modified hydrocyclone's sludge waste stream return has an undesirable impact on either the pretreatment or filtration processes. If the evaluation of the return of one of the hydrocyclone's waste stream (approximately 50 percent of the total sludge) to the Actifloc unit's injection chamber indicates no adverse impact on either the Actifloc unit pretreatment or filtration process, a follow-up evaluation could be conducted to determine how much of the other hydrocyclone's sludge can also be recycled without causing an adverse impact on the Actifloc unit performance.

Additional piping and valving could be added to allow readily switching between returning and wasting the sludge or returning only a portion of the sludge on the second hydrocyclone. On this unit, the reconfigured sludge discharge pipeline should provide similar backpressure that was provided by the unit's original configuration. Since a portion of the hydrocyclone waste stream would be sent to waste, maintaining similar back pressure on the hydrocyclone waste connection provided in the unit's original configuration is necessary to maintain the hydrocyclone's efficiency (i.e., to minimize the amount of sand in the waste stream). The return pipe should be configured similar (in size and elevation) to the existing waste pipe to maintain similar back pressures on the hydrocyclone waste connection. Sand concentrations from the hydrocyclone can be measured before and after the reconfiguration to confirm that the reconfigured piping has not adversely affected the hydrocyclone efficiency.

4.1.4 Hydrocyclone Waste Reduction Performance Testing

Testing should be performed to determine the impacts of returning 50 percent of the hydrocyclone sludge waste stream on the Actifloc unit pretreatment process. During the testing period, two or all three Actifloc units should be operated, with the test condition of returning 50 percent of the sludge on only one of the two or three Actifloc units. The other unit(s) would operate normally to serve as an evaluation test control and provide operating data for comparison with the test unit's data.

The parameters that should be monitored on both the test unit and control unit(s) during the test period are listed below. Data collection should occur hourly or at shorter intervals where on-line instruments provide data. The data collection interval can be adjusted as appropriate based on the observed results.

- Raw water turbidity and pH
- Clarified water turbidity and pH
- TSS in the maturation tank
- Sand concentration (either into or out of the hydrocyclone)
- Sample and determine each Actifloc unit's microsand concentration prior to starting the test period

- Where necessary, add microsand and resample each Actifloc unit until each unit's microsand concentration is within five percent of the other Actifloc units
- Continue monitoring and recording both the microsand concentration and the amount of microsand that is added to each Actifloc unit each day during the test period
- Filtered water turbidity (record at 15 minute or shorter intervals during test period)
- Headloss through the filter media
- Filter run hours between backwashes during test period

If the test results are favorable, one of the two hydrocyclones on each of the two other Actiflo pretreatment units should be modified to return both the microsand and the sludge to the injection chamber ahead of the Actifloc unit maturation tanks.

A follow-up test could be performed to determine whether the return of the hydrocylone waste could be increased beyond 50 percent. The un-modified hydrocyclone waste discharge pipeline could be reconfigured by replacing its vertical-to-horizontal elbow with a tee and a diaphragm type valve to permit returning a portion of its waste sludge to the injection chamber.

Depending on this additional test's results, either the original elbow should be re-installed on the test Actifloc units' hydrocyclone, or the two other Actiflo pretreatment units should be modified to return a similar portion of the hydrocyclone's sludge to the injection chamber to optimize the amounts of wet sludge that is recirculated and discharged to waste.

4.2 STP Operating Strategy Optimization

4.2.1 Wet Season Operations (December – April)

The current operating strategy that includes daily start-up and shutdown sequences results in waste stream production from each online Actifloc units' hydrocyclone without a corresponding or off-setting benefit of treated water production. During the startup period, each Actifloc unit operates in an FTW mode for between 15 and 30 minutes until the target operating filtered water turbidity level is achieved. When each Actifloc unit is being shut down, the sand pumps and hydrocyclones continue to operate for an additional 10 minutes to transfer most of the sand-sludge slurry out of the settling zone. The daily disruptions to filter operation during each start-up and shut down cycle also contribute to shortening of the filters' run time. The filters flow rate changes tend to create conditions that cause particles to move deeper into (or through) the filter media, thereby increasing both the risk of filter breakthrough and high headloss through the filter media.

Operating with fewer Actifloc units in service for longer periods (instead of all three trains for a shorter operating period) could reduce operating inefficiencies by reducing the number of treatment unit startup/shutdown cycles per day. Table 3 summarizes the duration that STP can be operated and the associated daily production, when operating one, two, and three Actifloc units, while staying within the wet season NSD daily sewer discharge limit of 40,000 gpd.

Table 3. Wet Season Production Volume (with no Actiflo® Waste Reduction)				
Parameter	Units	3 Units	2 Units	1 Unit
No. of Actifloc Units in Operation	no	3	2	1
Production Flow Rate per Actifloc Unit	mgd	2	2	2
Hours of Operation	hours	4.8	7.5	15.5
Total Daily Production Volume	**MG**	**1.21**	**1.25**	**1.29**
Actifloc Hydrocyclone Waste				
Hydrocyclone Waste Flow Rate per Unit	gpm	37	37	37
Startup FTW Duration	minutes	20	20	20
Startup Hydrocyclone Waste Volume	gallons	2,220	1,480	740
Production Hydrocyclone Waste Volume	gallons	32,170	33,280	34,390
Shutdown Hydrocyclone Waste Duration	minutes	10	10	10
Shutdown Hydrocyclone Waste Volume	gallons	1,110	740	370
Total Hydrocyclone Waste Volume	**gallons**	**35,500**	**35,500**	**35,500**
Other Waste				
Daily Waste from Centrifuge Operation	gallons	4,500	4,500	4,500
Total Waste Volume to Sewer	**gallons**	**40,000**	**40,000**	**40,000**
Actifloc Filter Backwash				
Filter Backwash Interval	days	3	3	2
Filter Run Hours	hours	16.7	25.8	35.4
Washwater Supply Volume per Filter Backwash	gallons	30,000	30,000	30,000
Average Daily Water Use for Filter Backwash[(a)]	**gallons**	**30,000**	**20,000**	**15,000**
Average Daily Water Use[(b)]	**gallons**	**34,500**	**24,500**	**19,500**
Net Average Daily Production Volume[(c)]	**MG**	**1.17**	**1.22**	**1.27**

(a) The average daily washwater use for filter backwash is the total washwater supply volume for all units in service averaged over the filter backwash interval.

(b) The average daily water use includes water used for filter backwash and for centrifuge operation.

(c) The net average daily production volume is the total daily production less the average daily water use for filter backwash and centrifuge operation. This volume does not account for other treatment process water uses and is not a true net production volume, but it is provided for comparison.

Based on a 20-minute FTW duration at startup and a 10-minute hydrocyclone waste duration at shutdown, operating the STP with just one Actifloc unit can yield an additional hour of production at 2 mgd (or 83,333 gallons in a day) when compared to operating three units. Operating the STP with two Actifloc units can yield an additional 0.25 hours of production at 4 mgd (or 41,667 gallons in a day) when compared to operating three units. Also, the more frequent daily start-up and shutdown cycles per Actifloc unit when operating all three units result in shorter total filter run hours between backwashes and greater amounts of filtered water consumption for the more frequent filter backwashes. It is estimated that operating three Actifloc units uses on average an additional 10,000 to 15,000 gallons of filtered water per day for backwash over the amount used when operating just two or one unit.

If 50 percent reduction in the Actifloc units' hydrocyclone waste streams can be achieved (as described in Section 4.1), then the Actifloc units can be operated for a longer duration before reaching the 40,000 gpd wet season NSD daily sewer discharge limit. Table 4 lists the duration that STP can be operated and the associated daily production, when one, two, and three Actifloc units are operated with 50 percent hydrocyclone waste reduction while maintaining the Actifloc unit waste stream volume below the wet season NSD daily sewer discharge limit. In this case, the highest daily production is achieved with two Actifloc units in operation. It is estimated that an additional 40,000 to 60,000 gallons of water can be yielded from operating two Actifloc units for a longer duration (instead of three Actifloc units for a shorter duration).

Table 4. Wet Season Production Volume (with 50% Actifloc Unit Waste Reduction)

Parameter	Units	3 Units	2 Units	1 Unit
No. of Actifloc Units in Operation	no.	3	2	1
Production Flow Rate per Actifloc Unit	mgd	2	2	2
Hours of Operation	hours	10.2	15.5	24.0
Total Daily Production	**MG**	**2.54**	**2.58**	**2.00**
Actiflo Hydrocyclone Waste				
Hydrocyclone Waste Flow Rate per Unit	gpm	18.5	18.5	18.5
Startup FTW Duration	minutes	20	20	20
Startup Hydrocyclone Waste Volume	gallons	1,110	740	370
Production Hydrocyclone Waste Volume	gallons	33,835	34,390	26,640
Shutdown Hydrocyclone Waste Duration	minutes	10	10	10
Shutdown Hydrocyclone Waste Volume	gallons	555	370	185
Total Hydrocyclone Waste Volume	**gallons**	**35,500**	**35,500**	**27,195**
Other Waste				
Daily Waste from Centrifuge Operation	gallons	4,500	4,500	4,500
Total Waste Volume to Sewer	**gallons**	**40,000**	**40,000**	**31,695**
Actiflo Filter Backwash				
Filter Backwash Interval	days	2	2	1
Filter Run Hours	hours	23.2	35.4	24.0
Washwater Supply Volume per Filter Backwash	gallons	30,000	30,000	30,000
Average Daily Washwater Use for Filter Backwash[a]	**gallons**	**45,000**	**30,000**	**30,000**
Average Daily Water Use[b]	**gallons**	**49,500**	**34,500**	**34,500**
Net Average Daily Production Volume[c]	**MG**	**2.49**	**2.55**	**1.97**

(a) The average daily washwater use for filter backwash is the total washwater supply volume for all units in service averaged over the filter backwash interval.

(b) The net average daily production volume is the total daily production less the average daily washwater use for filter backwash. This volume does not account for other treatment process water uses and is not a true net production volume, but it is provided for comparison.

The accounting of waste volumes in Tables 3 and 4 above do not include FTW volumes since 100 percent of the FTW volume is typically returned to the head of the treatment process. However, it should be noted that a lower volume of FTW water will be generated, and less energy used to return the FTW water when fewer Actifloc units are operated. The GAC contactor backwash volumes, pond cleaning volumes, and centrifuge area washdown volumes are also not included in Tables 3 and 4, as these volumes occur less frequently and are not expected to differ significantly for the three operating conditions shown in Table 3 and 4.

It should be noted that the STP cannot currently operate with just one Actifloc unit online, due to limitations in the chemical feed pump and high service pump turndown capacities. The STP can be operated with two Actifloc units online, which still provides a benefit of greater water production efficiency (higher daily water production for the same amount of water wastage) over operating all three Actifloc units during the wet season.

4.2.2 Dry Season Operations (May – October)

The dry season NSD daily sewer discharge limit is 150,000 gpd. However, there is also a maximum sewer discharge flow rate restriction of 100 gpm, which limits the daily sewer discharge to 144,000 gpd. One or two Actifloc units can be operated continuously without generating more wastewater that can be discharged to the sewer in a day. However, three Actifloc units in service produces a combined hydrocyclone waste stream flow rate of 110 gpm, and the waste in excess of the sewer discharge limit accumulates in the solid thickener. Three Actifloc units can be operated for about 19 hours each day, after which the total liquid waste produced is more than the amount that can be discharged each day.

The highest daily water production is achieved with three Actifloc units in service, even with the daily down time to avoid generating more wastewater than the dry season NSD sewer discharge limit. To minimize the Actifloc unit startup and shutdown frequencies and associated waste generation without water production, the stoppage of Actifloc unit operation to allow the solids thickener to drain should coincide with the Actiflo filter backwashes. After a filter backwash, the Actifloc unit should remain offline for a period to allow drawing down the solid’s thickener.

If 50 percent or greater reduction in the Actifloc unit’s hydrocyclone waste stream can be achieved (as described in Section 4.1), then the three Actifloc units can be operated continuously without requiring that the solids thickener be shutdown daily to drain the “excess” accumulated waste sludge. Water production from the STP can be maximized under this condition without additional operational optimizations to reduce down time resulting from NSD discharge restrictions.

4.3 Waste Stream Treatment and Recovery with Densadeg® Unit

4.3.1 Densadeg Unit Treatment Alternative Description

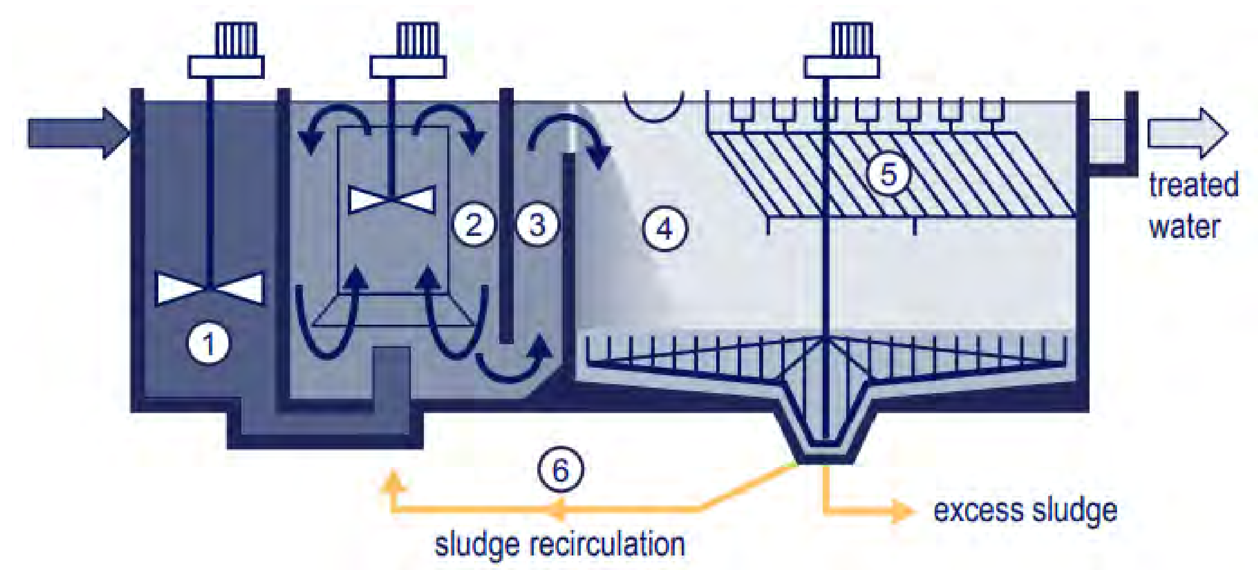
The Densadeg® clarifier/thickener unit (Densadeg unit) is a high-rate water clarification-sludge thickening treatment unit manufactured by Suez that recirculates a portion of the sludge to optimize the flocculation and clarification process in a manner similar to a reactor-clarifier. A Densadeg unit could be used at the STP to clarify the water fraction in the sludge waste stream and further thicken the settleable sludge solids in the liquid waste currently sent to the solids thickener and disposed of to the NSD’s sewer. This would both reduce the amount of waste sludge discharged to sewer and increase the dry solids content in the sludge sent to the centrifuge for dewatering.

The Densadeg unit should be able to reduce the turbidity of the liquid waste streams sent to the unit to less than 2 NTU so that the clarified water from the Densadeg unit can be recycled back to the head of the STP treatment process. The sludge generated by the Densadeg unit and sent to the centrifuge would have a higher dry solids content and a lower water fraction, which should improve the centrifuge's dewatering efficiency and reduce the volume of centrate sent to NSD's collection system.

4.3.2 Densadeg Unit Treatment Steps

Densadeg unit treatment steps are depicted in Figure 3 and described below. A catalog cutsheet of the Densadeg unit is included in Attachment B.

Figure 3. Schematic of the Densadeg Unit Treatment Process



- The liquid waste to be treated enters a rapid mix zone where a coagulant and/or coagulant aid is added.
- The coagulated water enters a reaction zone where an axial-flow turbine helps recirculate and blend the coagulated water and recycled sludge to form dense particles. Polymer can be added in this process step to enhance particle formation.
- The flocculated water, containing dense particles flows to the settling and separation zone through an upflow transition zone identified by Suez as the "piston" zone, where additional flocculation can occur.
- In the settling and separation zone, thickened sludge solids settle to the bottom of the tank while the clarified water rises upward toward the tube settlers near the top of the tank. A rotating scraper at the bottom of the tank helps thicken the settled sludge solids.
- Clarified water flows through tube settlers where further water/solids separation occurs. Troughs above the tube settlers collect the clarified water.

- A portion of the thickened sludge is recirculated back to the reaction zone to enhance flocculation and help form dense particles. Excess sludge is discharged to waste from the Densadeg unit.

4.3.3 Densadeg Unit Sizing

The Densadeg unit would be used to treat the recoverable liquid waste streams at the STP, which potentially include waste streams from the Actifloc unit hydrocyclones and reclamation pond cleanings. The centrate from the centrifuge and the centrifuge area washdown would continue to be disposed of to the NSD sewer. Table 5 lists the flow rates of the liquid waste streams that will be sent to the Densadeg unit. The Densadeg unit would be sized to provide a treatment capacity of 135 gpm, but the unit could be operated at a lower flow rate when there are fewer than three Actifloc units in operation.

Table 5. Estimated Flow Rates of Waste Streams Sent to Densadeg Unit

Parameter	Flow (gpm)
Actifloc Unit Hydrocyclone Waste (all three units online)	110
Pond Cleaning	25
Total	**135**

4.3.4 Densadeg Unit Installation Description

A process flow diagram, showing the integration of the Densadeg unit into the STP secondary treatment process, is included in Attachment B. The recoverable liquid waste streams currently sent to the solid's thickener would also be routed to the Densadeg unit for treatment. The clarified water from the Densadeg unit would be pumped to the head of the STP treatment process ahead of the raw water pumps for recycling. The excess sludge would be sent to the centrifuge by routing a sludge pipeline that ties into the sludge pipeline from the solid's thickener to the centrifuge.

A potential location for the Densadeg unit is adjacent to the solids thickener to minimize amount of new yard piping. A Densadeg unit installation at the STP would include the following components:

- Densadeg unit mounted on concrete pad
- Yard piping to divert the hydrocyclone and pond cleaning waste streams to the Densadeg unit
- Yard piping tying into the solids thickener sludge pipeline to send excess sludge from the Densadeg unit to the centrifuge
- Sludge return pump to recirculate a portion of the thickened sludge back to the Densadeg unit's reaction zone
- Recycled water transfer pump and pipeline to return the clarified water upstream of the raw water pumps
- Chemical storage and feed system for coagulant and/or coagulant aid addition

- Electrical service to the Densadeg unit, recycled water pump, and chemical feed equipment
- Instrumentation and controls for operation and control of the Densadeg unit

A preliminary layout for the Densadeg unit alternative is included in Attachment B.

4.4 Waste Stream Treatment and Recovery with Roughing Filters

4.4.1 Roughing Filter Treatment Alternative Description

A roughing filter is a filtration process that uses course granular media, arranged from coarse to fine in the direction of flow, to remove solids. A roughing filter can reduce turbidity levels to less than one NTU and can be used to treat the STP waste streams so that they can be recycled to the head of the treatment process. Accumulated solids in the filter are removed by performing a filter backwash cycle at approximately at eight-hour to 40-hour filter run intervals. The filter backwash cycle involves agitating the media to dislodge captured floc and flushing the loosened floc particles from the media with water and supplemental air. One advantage of the roughing filters is that the influent (untreated) water can be used for the backwash water supply, thereby reducing use of filtered water.

Past general discussions with State Water Resource Control Board's (SWRCB) Division of Drinking Water (DDW) staff indicate that recycling liquid waste streams with turbidity significantly lower than the California Cryptosporidium Action Plan (CAP) goal at two NTU could potentially permit increasing the recycle water flow rate as a fraction of the total water treatment plant flow rate from the recommended 10 percent limit to a higher percentage. When the recycle-water-turbidity is significantly less than two NTU, the number of microorganism (especially regulated pathogens) is likely to be lower.

As shown in Table 2 above, if all of STP's waste streams, excluding the centrate from the centrifuge, are recycled back to the head of the treatment process, the recycle flow rate would be less than 10 percent of the total plant flow rate during the winter. This would comply with both the FBRR requirements and the CAP guidelines. The recyclable waste water streams' flow rate could be greater than 10 percent of the total STP flow rate if filter run times are shorter than expected during the winter, due to unusual water quality conditions or issues with the filters, and all the recyclable waste streams are being recycled. The ability to recycle a higher portion of the liquid waste stream could be beneficial under this condition.

4.4.2 Roughing Filter Components

A vertical, pressurized roughing filter would be used to treat the STP waste streams to be recycled. The roughing filter system would include the following components:

- A pressure vessel with media and support screens, water and air distribution systems, and control valves

- A pump to deliver the recycle water from the solid's thickener through the roughing filter pressure vessel to the head of the STP treatment process; the same pump would be used to deliver water from the solid's thickener to the roughing filter for its wash cycle
- A blower to supply air for the wash cycle; depending on the roughing filter's air wash rate, one of the existing filters' air wash supply blowers could be used for this purpose
- A polymer feed system to add polymer to the roughing filter influent to optimize the solids removal process

Manufacturers of the roughing filter system package include Water Remediation Technology's Loprest Water Treatment Division and Roberts Water Technologies, Inc. A cutsheet of the roughing filter is included in Attachment C.

4.4.3 Roughing Filter Sizing

In addition to treating the recoverable liquid waste streams at the STP, which include waste streams from the Actifloc unit hydrocyclones and reclamation pond cleanings, the roughing filter could also be used to treat the water collected in the existing reclamation ponds if it is needed to reduce its turbidity to less than two NTU. Table 6 below lists the estimated average daily flow rates for recycle water treatment by roughing filters when the STP is operated at its maximum treatment capacity during summer time conditions. Similar to the Densadeg unit alternative, the centrifuge centrate and centrifuge area washdown would not be recycled and would continue to be discharged to the sewer. The roughing filter would be sized to provide a treatment capacity of at least 435,000 gpd, or 302 gpm.

Table 6. Estimated Waste Stream Flows for Treatment by Roughing Filters

Parameter	Flow (gpd)
Actiflo Hydrocyclone Waste (all three units online)	160,000
Pond Cleaning	6,000
Actiflo Filter Backwash (all three units online)	252,000
GAC Contactor Backwash (all four units online)	9,000
Sample Drain	8,000
Total	**435,000**

4.4.4 Roughing Filter Installation Description

A process flow diagram, showing the integration of the roughing filter into the STP secondary treatment process, is included in Attachment C. The recoverable liquid waste streams, currently collected in the solid's thickener, would be sent through the roughing filter for treatment and return to the head of the STP treatment process, upstream of the raw water pumps. Return water from the reclamation pond could be diverted to the solid's thickener for treatment through the roughing filter, if needed. The centrifuge centrate and centrifuge area washdown that are currently sent to the solid's thickener would be diverted to the existing adjacent centrate tank (also called export tank) for disposal to the sewer. Spent washwater from the roughing filter would be returned to the solids thickener or could be sent to the centrate tank for disposal to the sewer. Sludge transfer from the solids thickener to the centrifuge would be unchanged from the current configuration.

The roughing filter could be located next to the solid's thickener, and its installation at the STP would include the following components:

- Vertical roughing filter pressure vessel, influent pump, and air-wash blower mounted on a concrete pad
- Yard piping and valves to allow sending the return water from the reclamation ponds to the solid's thickener for treatment through the roughing filter
- Pipelines from the solid's thickener to the influent pump; from the pump to the roughing filter pressure vessel; and from the roughing filter pressure vessel to the recycled water tie-in point on the raw water pipeline, upstream of the raw water pumps
- Pipeline to convey spent washwater from the roughing filter pressure vessel back to the solid's thickener or to the centrate tank
- Reconfiguration of influent pipelines at the solids thickener to send the centrate and centrifuge area washdown into the centrate tank
- Chemical storage and feed system for polymer addition
- Electrical service to the roughing filter control panel, influent pump, and air-wash blower
- Instrumentation and controls for operation of the roughing filter system

A preliminary layout of the roughing filter system is included in Attachment C.

4.5 Waste Stream Recovery with Refurbished Reactor Clarifier

4.5.1 Refurbished Reactor Clarifier Unit Treatment Alternative Description

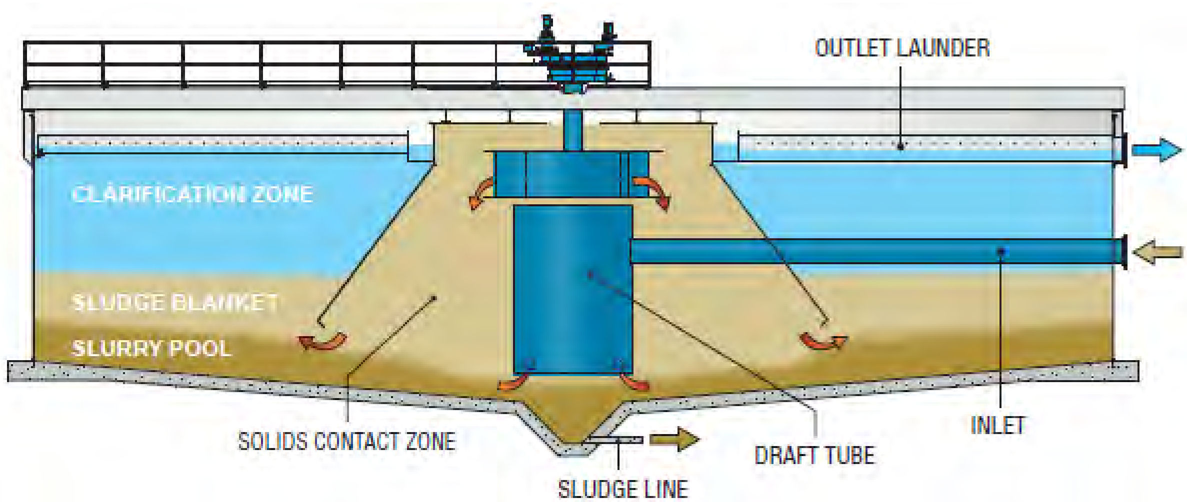
The existing solids thickener is presently operated as an EQ basin/thickener; it serves as a holding tank for the waste streams that are metered into the NSD sewer connection, and a gravity thickener thickens the solids that settle to the bottom of the structure. The solids thickener can be retrofitted to restore its original function as a reactor clarifier. A reactor clarifier uses similar processes as the Densadeg unit for clarifying the water fraction and thickening the settleable solids in the waste stream. The reactor clarifier should be able to produce clarified water with a turbidity less than two NTU for recycle to the head of the STP treatment process. The reactor clarifier should also produce sludge with higher solids content, which would improve the centrifuge dewatering efficiency.

4.5.2 Reactor Clarifier Treatment Steps

Figure 4 shows a schematic of a reactor clarifier. The treatment steps are described below. Additional product information is included in Attachment D.

- The liquid waste enters the center of the reactor clarifier.
- Concentrated solids at the bottom of the reactor clarifier is drawn up into the draft tube and mixed with the inlet flow.
- Flocculation occurs in the solids contact zone. The velocity of the flow decreases as it moves down the conical shaped curtain and the flow cross-sectional area increases, resulting in tapered flocculation.
- Clarification occurs as the water flows under the bottom of the curtain and through the sludge blanket; finer particles can come in contact and agglomerate with larger particles. As the agglomeration becomes larger, it may settle.
- The clarified water rises up the sides of the clarifier, spills over the weir into a collection launder, and is recycled to the head of the plant.

Figure 4. Schematic of a Reactor Clarifier Unit



4.5.3 Reactor Clarifier Sizing

Similar to the Densadeg unit, the reactor clarifier would treat the waste streams from the Actifloc unit hydrocyclones and reclamation pond cleanings and could have a total influent flow rate of up to 135 gpm. A reactor clarifier mechanism would be installed in the existing solids thickener basin, which has an inside diameter of 55 feet.

4.5.4 Reactor Clarifier Installation Description

A process flow diagram, showing reconfiguration of the existing solids thickener as a reactor clarifier to permit recovery of the recoverable liquid waste streams, is shown in Attachment D. The recoverable liquid waste streams, which include the Actifloc unit hydrocyclone waste stream and pond cleanings, would continue to be routed to the reactor clarifier (existing solids thickener), and the influent pipelines would be extended to the feed well at the center of the reactor clarifier. The non-recoverable liquid waste streams, which include the centrifuge centrate and centrifuge area washdown, would be re-routed to the centrate tank for sewer disposal. The clarified water from the reactor clarifier would be sent to the existing reclamation ponds for recovery via the existing solids thickener overflow pipeline.

Converting the existing solids thickener into a reactor clarifier would involve the following:

- Demolition of the existing thickener unit in the existing solids thickener
- Repair of the existing solids thickener structure, as needed
- Installation of a reactor clarifier unit in the existing solids thickener structure
- Reconfiguration of the following pipelines:
  - Combine and extend the Actifloc unit hydrocyclone and pond cleaning solids thickener influent pipelines to the rector clarifier center feed well
  - Reroute the centrifuge centrate and centrifuge are washdown solids thickener influent pipelines to the centrate tank
  - Route the clarified water from the reactor clarifier to the existing reclamation ponds via the existing solids thickener overflow pipeline.
- Installation of a chemical storage and feed system for coagulant and/or coagulant aid addition
- Installation of instrumentation and implementation of controls for operation of the reactor clarifier

A preliminary layout of the reactor clarifier system is included in Attachment D.

5.0 OPCC AND ESTIMATE OF OPERATION AND MAINTENANCE (O&M) COSTS

5.1.1 Engineer's OPCC

An engineer's OPCC was developed for Alternatives 3, 4, and 5. No cost estimates were developed for Alternatives 1 and 2, as the cost of implementing these two alternatives are expected to be minimal and/or included in the STP's current operation and maintenance (O&M) costs.

The Association for the Advancement of Cost Engineering (AACE) International publishes guidelines for classes of cost estimates and their expected accuracy ranges. Based on these guidelines, the preliminary OPCC summarized below is a Class 5 Estimate. Class 5 estimates are based on limited information and are generally prepared for strategic planning purposes, assessment of initial viability, evaluation of alternate schemes, and project screening. Typical accuracy ranges for Class 5 estimates are (-)20 to (-)50 percent on the low side and (+)30 to (+)50 percent on the high side.

The OPCC for Alternatives 3, 4, and 5 were developed using budgetary quotes from vendors, cost data from similar projects, and R.S. Means Data Online. The cost estimate summarized in Table 7 below applies the following contingencies and markups:

- 8.5 percent taxes on materials
- 25 percent indirect project cost (general conditions, contractor overhead and profit)
- 40 percent estimating contingency
- 2.5 percent inflation rate to midpoint of construction; assumes 30 months to midpoint of construction (January 2022) for alternatives 3, 4, and 5

Table 7. Conceptual Level OPCC for STP Process Efficiency Improvements Project

Element	Element Cost, $		
	Alternative 3 Densadeg	Alternative 4 Roughing Filter	Alternative 5 Reactor Clarifier
Site Work and Yard Piping	134,000	159,000	183,000
Treatment System	720,000	669,000	429,000
Electrical & Instrumentation	256,000	248,000	184,000
Subtotal Project Cost	**1,111,000**	**1,076,000**	**796,000**
Taxes on Materials (8.5%)	68,000	57,000	46,000
Subtotal	**1,179,000**	**1,133,000**	**842,000**
General Conditions, Overhead & Profit (25%)	295,000	283,000	210,000
Subtotal	**1,474,000**	**1,416,000**	**1,052,000**
Estimating Contingency (40%)	590,000	567,000	421,000
Current Construction Cost	**2,064,000**	**1,983,000**	**1,473,000**
Inflation to Construction Midpoint (2.5%)	133,000	128,000	95,000
Total Future Construction Cost	**2,197,000**	**2,111,000**	**1,568,000**

5.1.2 O&M Cost Estimate

Estimates of annual O&M costs were developed for Alternatives 3, 4 and 5 are summarized in Table 8. For the comparative purposes, the Alternative 4 annual O&M cost was developed based on treating the recoverable liquid waste streams that are currently discharged into the sewer and does not account for treatment of the currently recycled water from the reclamation pond. The annual O&M costs were developed applying the following assumptions:

- 250 days of treatment unit operation in a year
- 30 mg/L of ferric chloride and 3 mg/L of polymer addition to the Densadeg unit and reactor clarifier influent
- 1.5 mg/L of polymer addition to the roughing filter influent

The O&M cost estimates apply the following unit cost assumptions:

- \$75/hr for labor (including benefits)
- \$0.14/kWh energy rate
- \$0.35/lb for ferric chloride
- \$2.00/lb for polymer

The labor cost is estimated to be greater for the Densadeg unit because it requires more frequent chemical feed adjustment and monitoring to maintain treatment performance. The Densadeg unit also uses more chemical than the roughing filter for treatment.

Table 8. Estimate of Annual O&M Cost for STP Process Efficiency Improvements Project

O&M Cost Component	Component Cost, $		
	Alternative 3 Densadeg	Alternative 4 Roughing Filter	Alternative 5 Reactor Clarifier
Labor	21,500	13,800	15,900
Chemical Use	6,700	1,000	6,700
Energy Use	2,700	2,000	1,000
Total Annual O&M Cost	**30,900**	**16,800**	**23,600**

6.0 RECOMMENDATIONS

Based on the objective of eliminating or reducing current STP operational constraints resulting from the NSD discharge restrictions, five alternatives were developed to reduce and/or reclaiming greater portions of the process waste streams that are currently discharged to the sewer. The alternatives include:

- **Alternative 1**: Actifloc unit hydrocyclone waste reduction by returning a portion of the waste stream into the Actifloc units' injection chamber
- **Alternative 2**: Optimizing the STP operation to increase water production by reducing the number of Actifloc units that operate during each day to minimize startup and shutdown cycles and associated waste generation without treated water production benefits
- **Alternative 3**: Waste stream treatment and recovery using a Densadeg unit to both reduce recycle water turbidity and thicken settled sludge solids
- **Alternative 4**: Waste stream treatment and recovery using a roughing filter to reduce recycle water turbidity
- **Alternative 5**: Waste stream treatment and recovery using the existing solids thickener, retrofitted to restore its original function as a reactor clarifier, to both reduce recycle water turbidity and thicken settled sludge solids

The recommended sequence of implementation is as follows.

- Implement Alternative 1 (Actifloc Unit Waste Reduction) as soon as practical.
- Implement Alternative 2 (Water Production Increase through STP Operational Optimization) if additional production from STP is desired.

- Implement Alternative 3 (Densadeg), Alternative 4 (Roughing Filter), or Alternative 5 (Reactor Clarifier) if additional waste stream reduction and water recovery is desired. Alternative 5 (Reactor Clarifier) is preferred to Alternatives 3 (Densadeg) and 4 (Roughing Filter).

Alternatives 1 and 2 are recommended for initial consideration. Depending on the results, Alternative 5 would be recommended as the next strongest candidate over Alternatives 3 and 4. Additional discussion of the alternatives is provided in the sections below.

6.1.1 Alternative 1 – Actifloc Unit Waste Reduction

Performing the Alternative 1 test described in Section 4.1.4 is recommended to determine the impacts that returning a portion of the Actifloc unit's hydrocyclone liquid waste stream to Actifloc unit may have on the Actifloc unit performance. If the test results are favorable, reconfiguration of the hydrocyclone waste pipeline should be implemented on the other two Actifloc units. To maximize the waste reduction, additional testing could also be performed to determine whether the return of the hydrocylone waste could be increased beyond 50 percent and to determine the amount the maximum practical return rate that could be achieved without negatively impacting the Actifloc units' performance.

It should be noted that the FBRR requires spent filter backwash, thickener supernatant, and liquids from dewatering processes that are recycled be returned ahead of the first water treatment process to receive optimum treatment, or a report must be submitted to the primacy (regulatory) agency explaining why the location where recycle stream is added to the water treatment process does not have an adverse impact on the treatment process performance. Although the Actifloc units' hydrocyclone waste would be categorized an as non-regulated residual stream and is not regulated by the FBRR, it would be prudent for the District to consult with the DDW on the acceptability of returning the hydrocyclone waste sludge to the Actifloc units' injection chambers.

If Alternative 1 proves to be viable and more than 50 percent of the Actifloc units' hydrocyclone waste stream can be returned to the Actifloc units' injection chambers without a measurable adverse impact on performance, this could eliminate the STP operational constraints resulting from the NSD's discharge restrictions during dry season operation. At least 75 percent reduction of the Actifloc units' hydrocyclone waste stream is needed to eliminate the STP operational constraints from the NSD's discharge restrictions during wet season operation. If these waste reduction rates can be achieved, the total waste generated requiring sewer disposal would be less than the amount that can be discharged to the NSD sewer connection. The STP would not need to shut down to drain accumulated waste, and consideration of the other proposed alternatives would not be necessary.

6.1.2 Alternative 2 – Water Production Increase through STP Operational Optimization

If Alternative 1 is not viable or only a 50 percent Actifloc unit waste reduction can be achieved, then Alternative 2 should be considered for implementation. Alternative 2 is also a "nearly no-cost" alternative, as it only requires operational changes and some control strategy improvements. Alternative 2 includes operating fewer Actifloc units during the winter and early spring, when the more stringent NSD discharge restrictions are in effect, to reduce waste generation without associated water production during unit startup and shutdown cycles. It is estimated that an addition 83,000 gallons can be produced during each day, if one Actifloc unit were operated for 17.5 hours instead of operating three Actifloc units for 4.8 hours. However, reducing the STP plant flow rate to 2 mgd is not currently feasible due to pump and chemical feed turndown capacity limitations. Operating with two Actifloc units for 7.5 hours can still yield an additional 42,000 gpd. If 50 percent Actifloc unit waste reduction can be achieved, then operating two Actifloc units for 17.7 hours should be considered to provide the greatest daily net water production.

During the late spring and summer months, when the less restrictive NSD discharge requirements are in effect, highest daily water production would be achieved with all three Actifloc units in service. However, at the current rate of waste generation for sewer disposal, the STP would still require shutdown after 19 hours of operation to avoid accumulating waste in the solids thickener. To minimize the frequency of Actifloc unit startup and shutdown events (and associated waste generation without treated water production), the stoppage of Actifloc unit operation to allow the solids thickener to drain should, when possible, be scheduled to coincide with the Actiflo filter backwashes. After a filter backwash, the Actifloc unit should remain offline for a period to allow drawing down the amount of sludge in the solid's thickener. This optimization uses the storage volume in the solids thickener to reduce waste generation and to extend the water production period. If 50 percent reduction in the Actifloc unit's hydrocyclone waste stream can be achieved, then all three Actifloc units can be operated continuously without regular shutdown for draining the solids thickener.

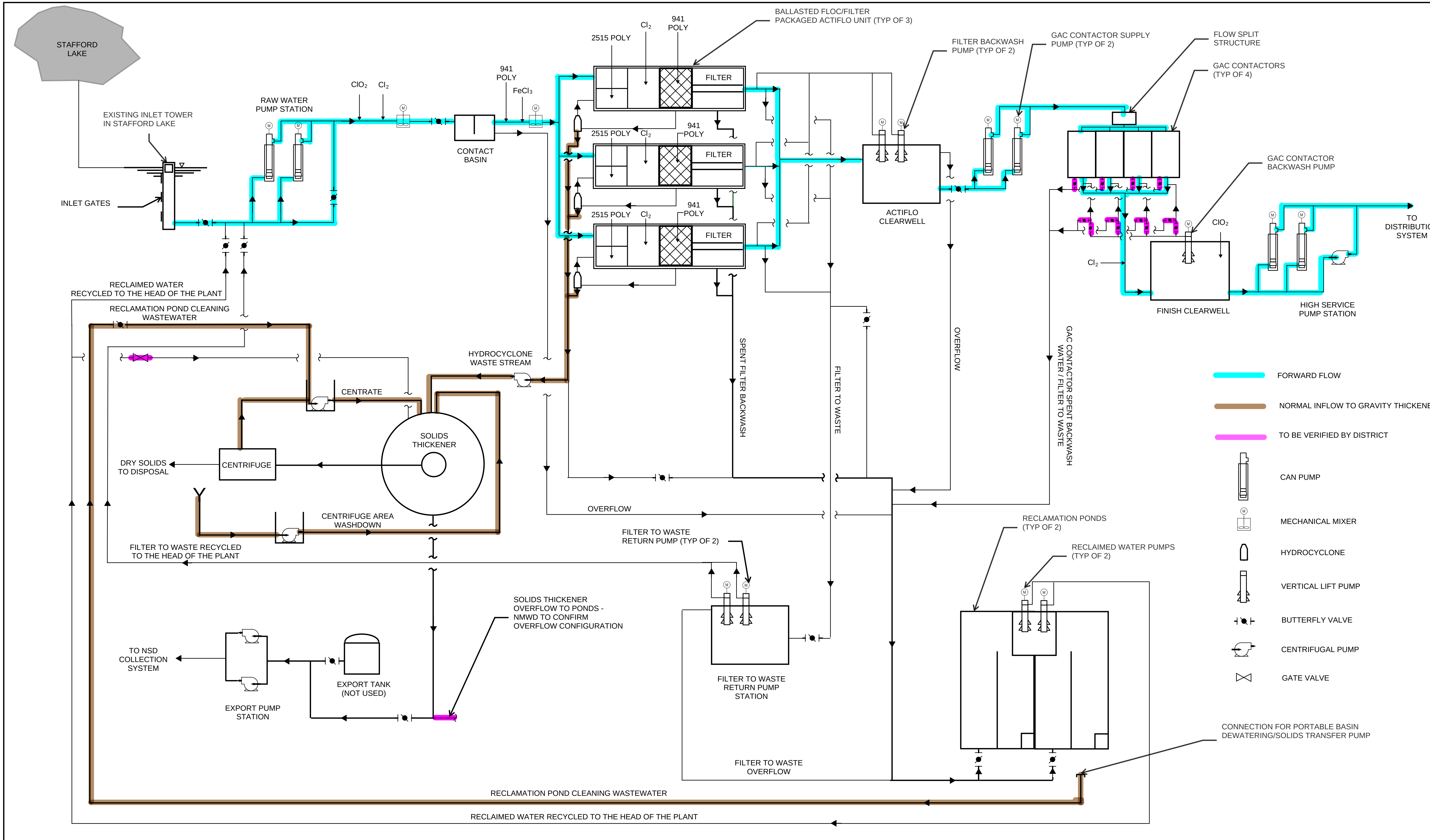
6.1.3 Alternatives 3, 4, and 5 – Waste Stream Treatment and Recovery

Consideration should be given to Alternatives 3, 4, and 5 if Alternative 1 is not successful or if additional recovery of the liquid waste stream discharged to sewer is desired. Alternative 3 involves treatment using a Densadeg unit, which is a reactor-clarifier-thickener process. Alternative 4 uses a roughing filter for treatment for turbidity reduction. Alternative 5 involves retrofitting the existing solids thickener to restore its original function as a reactor clarifier. Comparison of the three alternatives is provided in Table 9.

Table 9. Comparison of Alternatives 3, 4, and 5			
	Alternative 3 - Densadeg	Alternative 4 - Roughing Filter	Alternative 5 - Reactor Clarifier
Advantages	• Produces sludge with higher solids concentration for more efficient centrifuge operation • Potentially greater water recovery than Alternative 4 (no wash cycle, less concentrate from centrifuge)	• Can achieve treated effluent with lower turbidity, potentially enabling >10 percent recycle rate, if needed[(a)] • Can be used to treat water from reclamation pond, if needed • Lowest chemical use • Lowest operating cost	• Produces sludge with higher solids concentration for more efficient centrifuge operation • Potentially greater water recovery than Alternative 4 (no wash cycle, less concentrate from centrifuge) • Reuses and improves upon existing treatment process • Does not require much additional space • Lowest power consumption • Lowest capital cost
Disadvantages	• New treatment process to operate and maintain • Requires chemical dose adjustment • Higher chemical use • Highest power consumption • Highest capital cost	• New treatment process to operate and maintain • Potentially greater water wastage (if spent washwater from roughing filter wash cycle is discharged to sewer)	• Requires chemical dose adjustment • Higher chemical use
(a) Require discussion with DDW for approval.			

Based on cost and other factors, Alternative 5 would be recommended over Alternative 3 and 4. The reactor clarifier retrofit is 35- to 40-percent lower in capital cost compared to the other two alternatives. It reuses an existing structure and thus requires less space to implement. It involves restoring an original treatment process and does not introduce a new treatment unit to operate and maintain. While it would not produce as high-quality treated effluent as the roughing filter in Alternative 4, its performance should be comparable to the Densadeg unit in Alternative 3, which should be adequate for recycle.

ATTACHMENT A
Stafford WTP Process Flow Diagram



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NORTH MARIN WATER DISTRICT

NORTH MARIN WATER DISTRICT
STAFFORD TREATMENT PLANT
PROCESS EFFICIENCY IMPROVEMENT STUDY

PROCESS FLOW DIAGRAM

JOB NUMBER --
DRAWING NUMBER --
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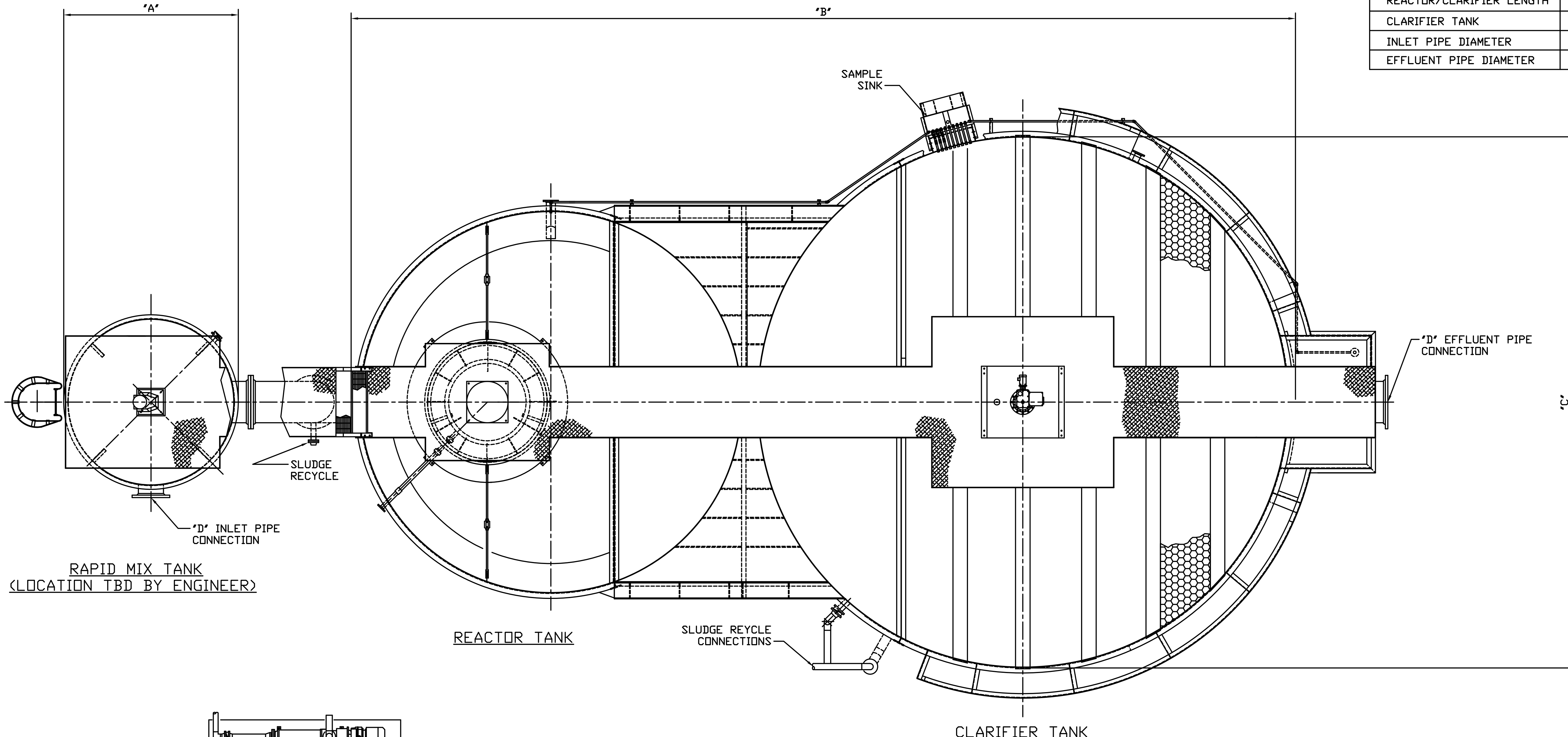
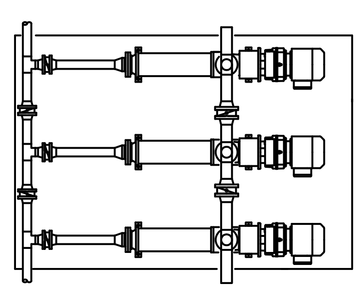
REVISION

ATTACHMENT B
Densadeg Drawings

- Densadeg Catalog Cutsheet
- Modified Process Flow Diagram with Densadeg
- Densadeg Alternative Preliminary Layout

GENERAL LEGEND	SYMBOL	VALUE	UNITS
RAPID MIX TANK	A	2.0	FT
REACTOR/CLARIFIER LENGTH	B	11.0	FT
CLARIFIER TANK	C	6.0	FT
INLET PIPE DIAMETER	D	3.0	IN
EFFLUENT PIPE DIAMETER	E	8.0	IN





SLUDGE RECYCLE PUMPS
(LOCATION TBD)

PLAN VIEW

NOTES:

1. THIS DRAWING IS PRELIMINARY & NOT FOR CONSTRUCTION
2. DESIGN OF CONCRETE SLABS IS BY OTHERS
3. RECYCLE PUMPS TO BE LOCATED BY ENGINEER
4. ORIENTATION OF PIPE CONNECTONS TBD BY ENGINEER

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REV	REVISION DESCRIPTION	DRAWN	CHECKED	APP	DATE
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TEL: 804-756-7600

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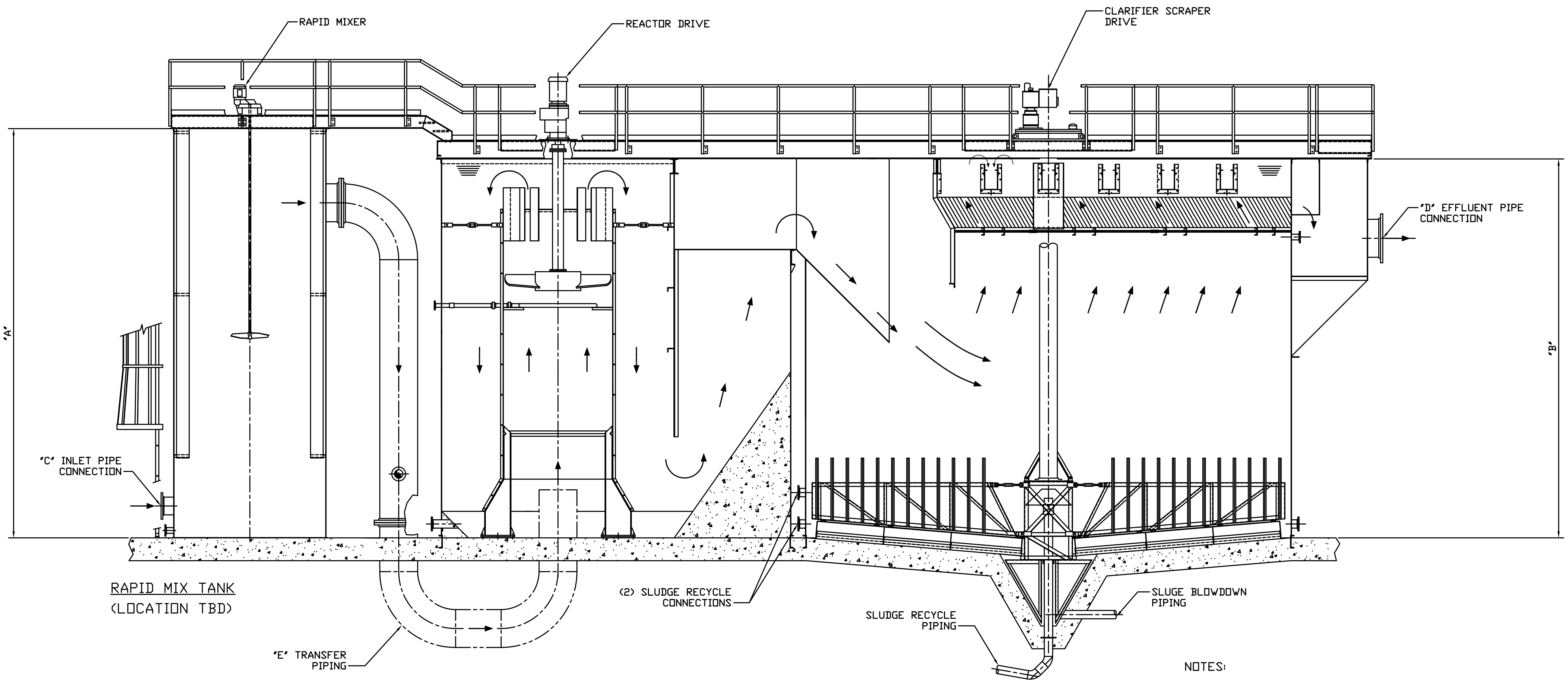
LAYOUT
MECHANICAL PLAN
STEEL DENSADEG -- MODEL 1

SIZE D | DWG. NO. -001 | REV.

GENERAL LEGEND	SYMBOL	VALUE	UNITS
RAPID MIX TANK HEIGHT	A	17.75	FT
CLARIFIER TANK HEIGHT	B	16.0	FT
INLET PIPE DIAMETER	C	3.0	IN
EFFLUENT PIPE DIAMETER	D	8.0	IN
TRANSFER PIPE DIAMETER	E	4.0	IN



SECTIONAL ELEVATION VIEW
(SEE PLAN VIEW FOR TRUE ORIENTATIONS)

NOTES:

1. THIS DRAWING IS PRELIMINARY & NOT FOR CONSTRUCTION
2. DESIGN OF CONCRETE SLABS IS BY OTHERS
3. RECYCLE PUMPS TO BE LOCATED BY ENGINEER
4. ORIENTATION OF PIPE CONNECTONS TBD BY ENGINEER

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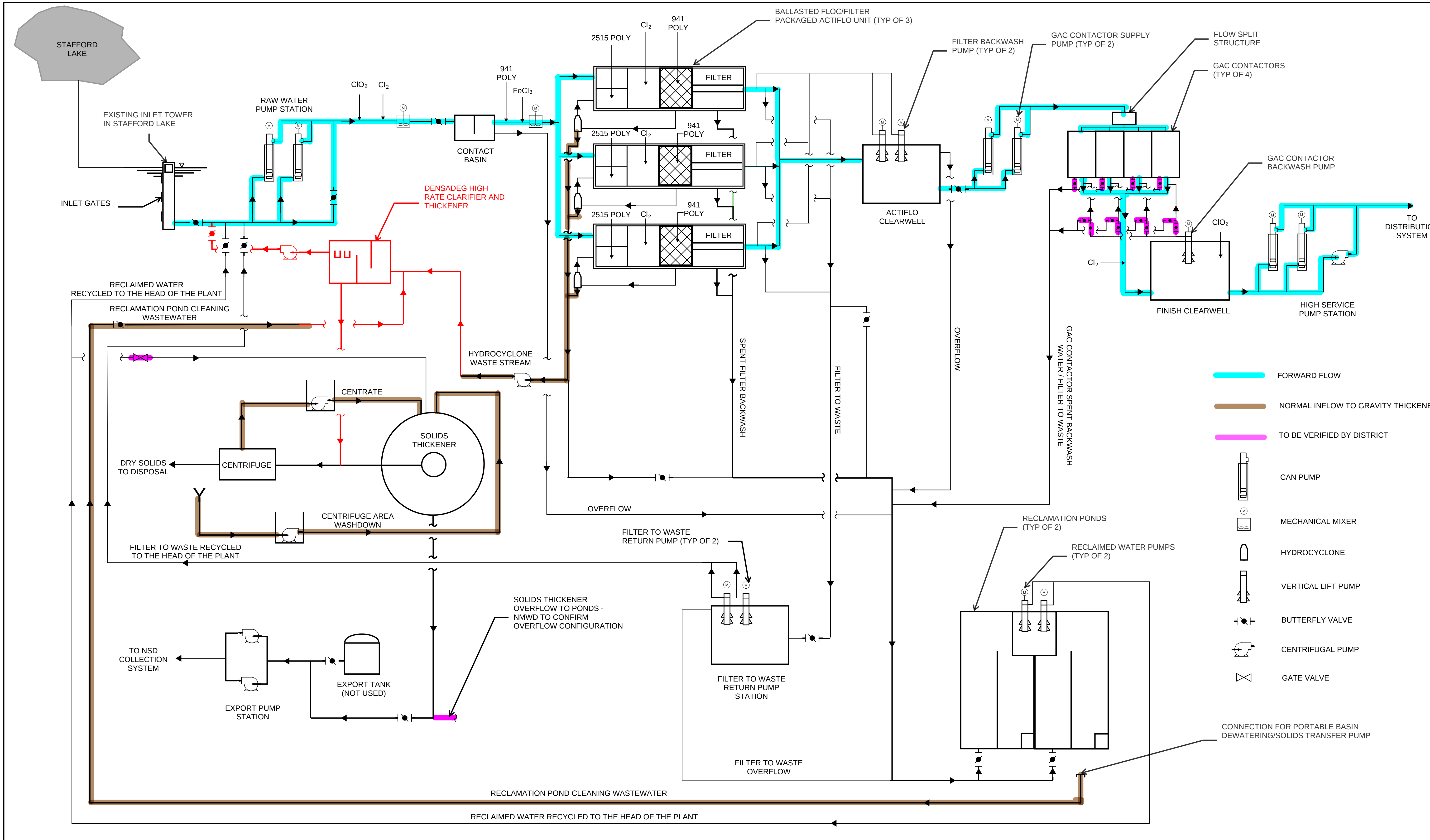
LAYOUT
MECHANICAL SECTION
STEEL DENSADEG -- MODEL 1

SIZE D DWG. NO. -002 REV.



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PROCESS FLOW DIAGRAM
MODIFIED WITH DENSADEG

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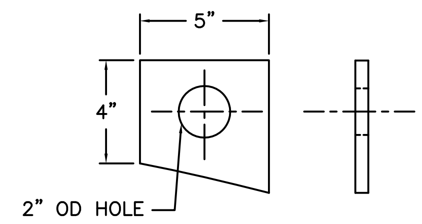
DENSADEG ALTERNATIVE PRELIMINARY LAYOUT

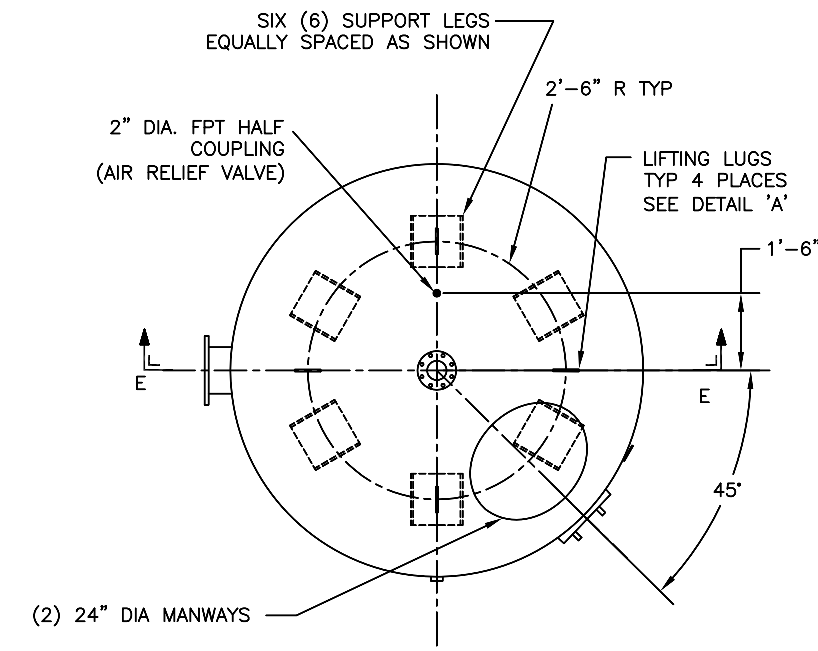
ATTACHMENT C
Roughing Filter Drawings

- Roughing Filter Catalog Cutsheet
- Modified Process Flow Diagram with Roughing Filter
- Roughing Filter Alternative Preliminary Layout

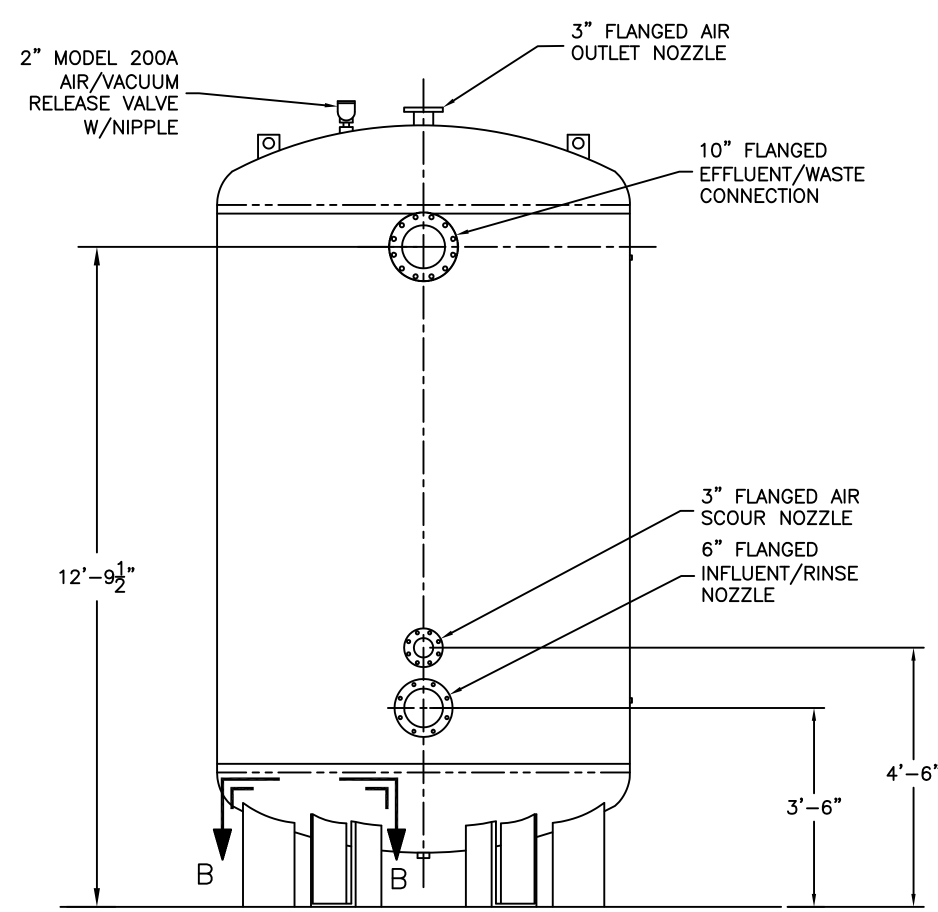
NOTES:
1) 7'-0" DIA. X 10'-0" STRAIGHT SIDE VPF WITH FLANGED AND DISHED TOP AND BOTTOM HEADS REQUIRED.
2) ALL FLANGES FLAT-FACE, F+D 150# STD, BOLT HOLES STRADDLE CENTERLINES.
3) INTERIOR OF TANK TO BE WHITE METAL SAND BLASTED TO SSPC-SP10 AND PRIMED WITH ONE COAT OF TNEMEC FC-140-1255 PRIMER TO A DRY COAT THICKNESS OF 3-5 MDFT FOLLOWED BY TWO COATS OF TNEMEC FC-140-15BL (5 MDFT EACH COAT).
4) EXTERIOR OF TANK TO BE FREE OF GREASE & SCALE AND COMMERICAL SAND BLASTED TO SSPC-SP6 AND TO RECEIVE TWO COATS TNEMEC SERIES 37-77 CHEM PRIME, TO A DRY COAT THICKNESS OF 3-5 MDFT EACH COAT. FINISH COATS TO BE APPLIED IN THE FIELD BY CONTRACTOR.
5) TANK TO BE FABRICATED FROM SA-516-GR70 STEEL OR EQUAL.
6) SEE DRAWING 190218-M2 FOR SECTION E-E.
7) - CLARIFIER MAXIMUM LOADING RATE (UP-FLOW OPERATIONAL MODE):
   10 GPM/SQFT = 350 GPM
   - CLARIFIER RINSE RATE:
   10 GPM/SQFT = 350 GPM IN COMBINATION WITH AN AIR FLOW RATE OF 6 SCFM/SQFT = 227 SCFM



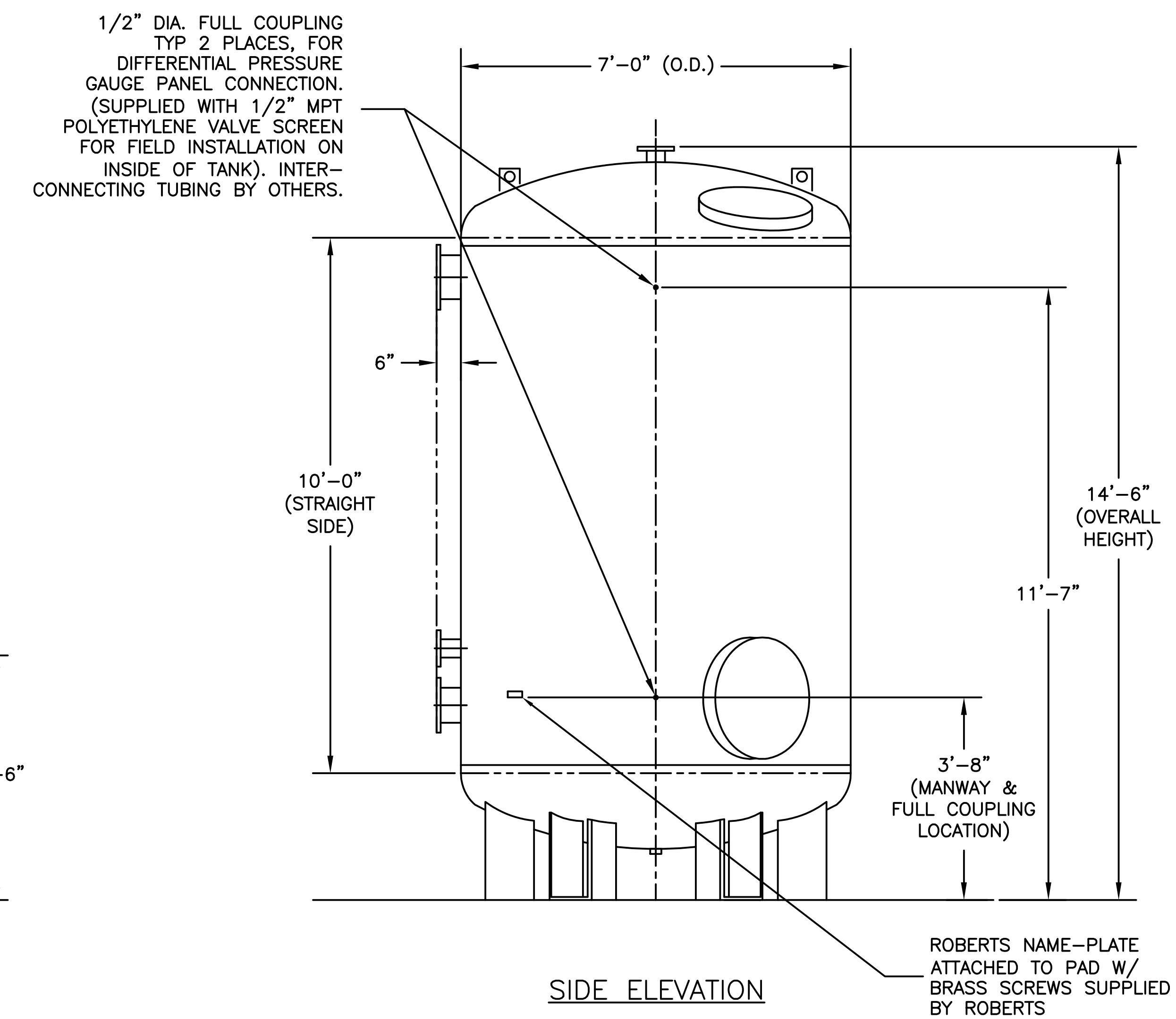
DETAIL 'A'
SCALE: 3"=1'



PLAN VIEW



FRONT ELEVATION



SIDE ELEVATION

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CHECKED GDR DATE 2-19-19

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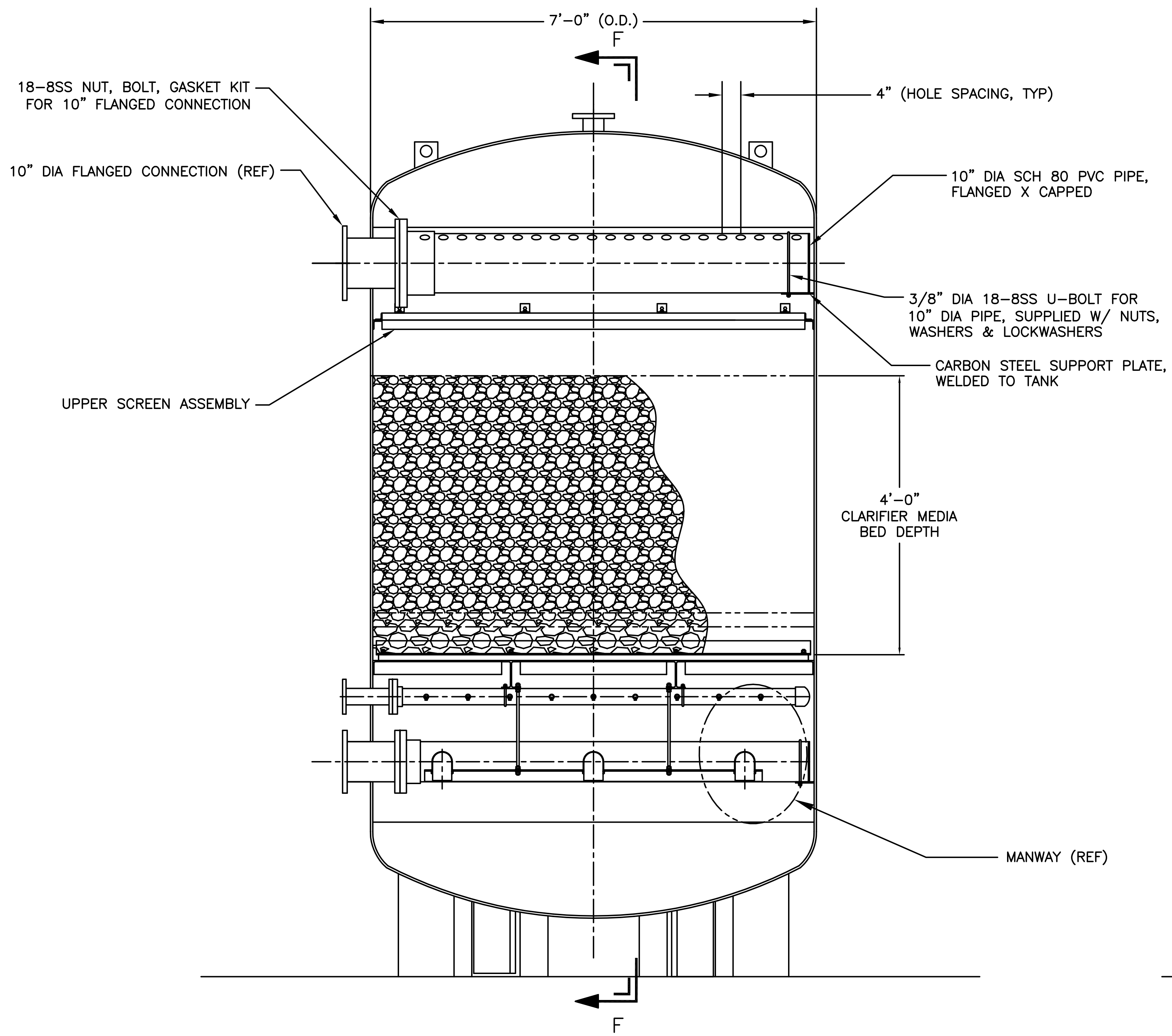
6TH STREET AND COLUMBIA AVE.
DARBY PENNSYLVANIA 19023

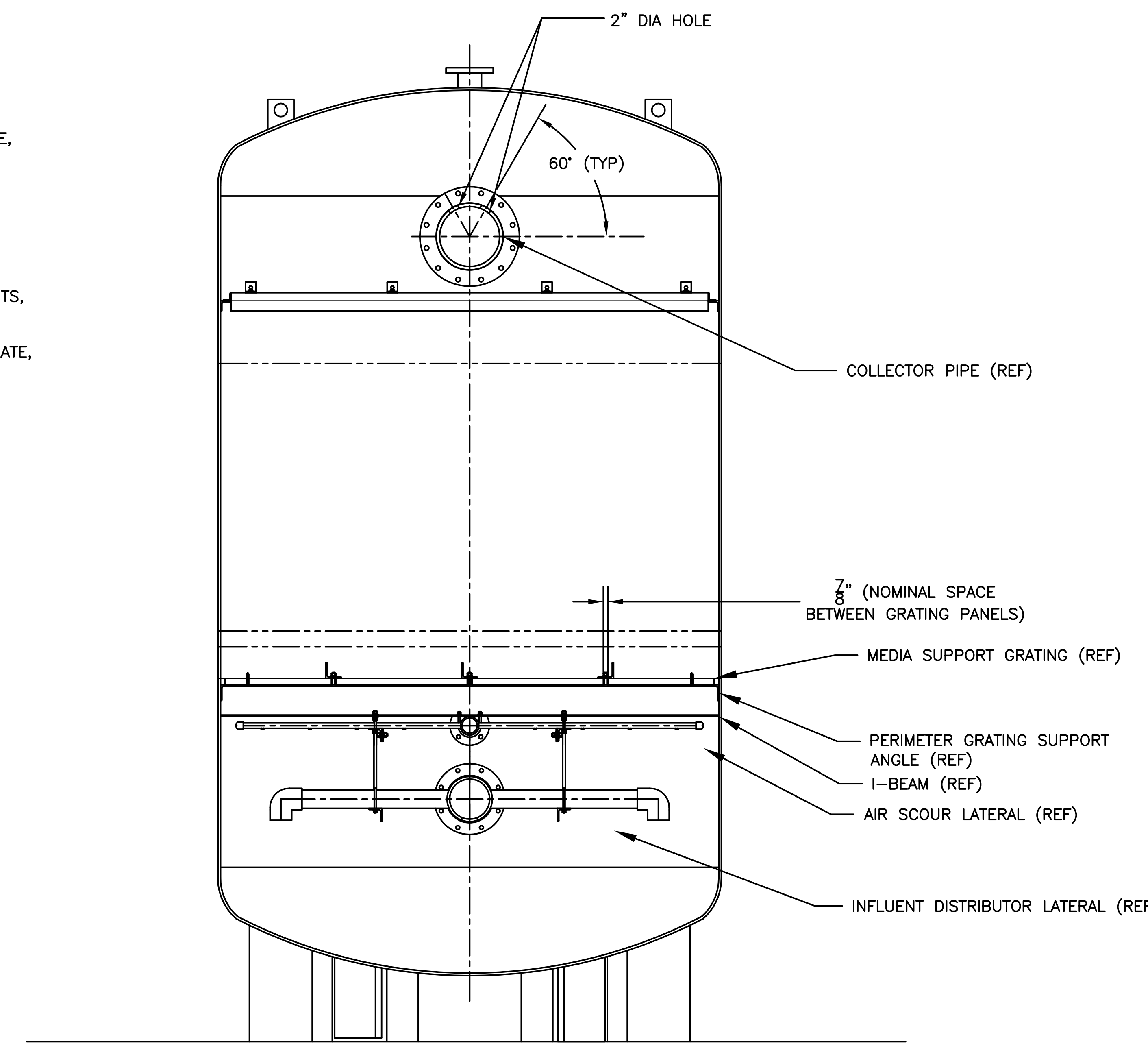
7'-0" OD X 10'-0" STRAIGHT SIDE VERTICAL CONTACLARIFIER PRESSURE VESSEL FOR NORTH MARIN, CA

SCALE NTS
CONTRACT RO19-0218T
SECTION P
DWG. NO. 190218-M1



ELEVATION SECTION E-E

(REFERENCE DRAWING 190218-M1)



ELEVATION SECTION F-F

NO.	REVISION	DATE	BY

DRAWN	DATE	CHECKED	DATE
TAH	2/19/19	GDR	2/19/19

ROBERTS WATER TECHNOLOGIES, INC.
6TH STREET AND COLUMBIA AVE.
DARBY PENNSYLVANIA 19023

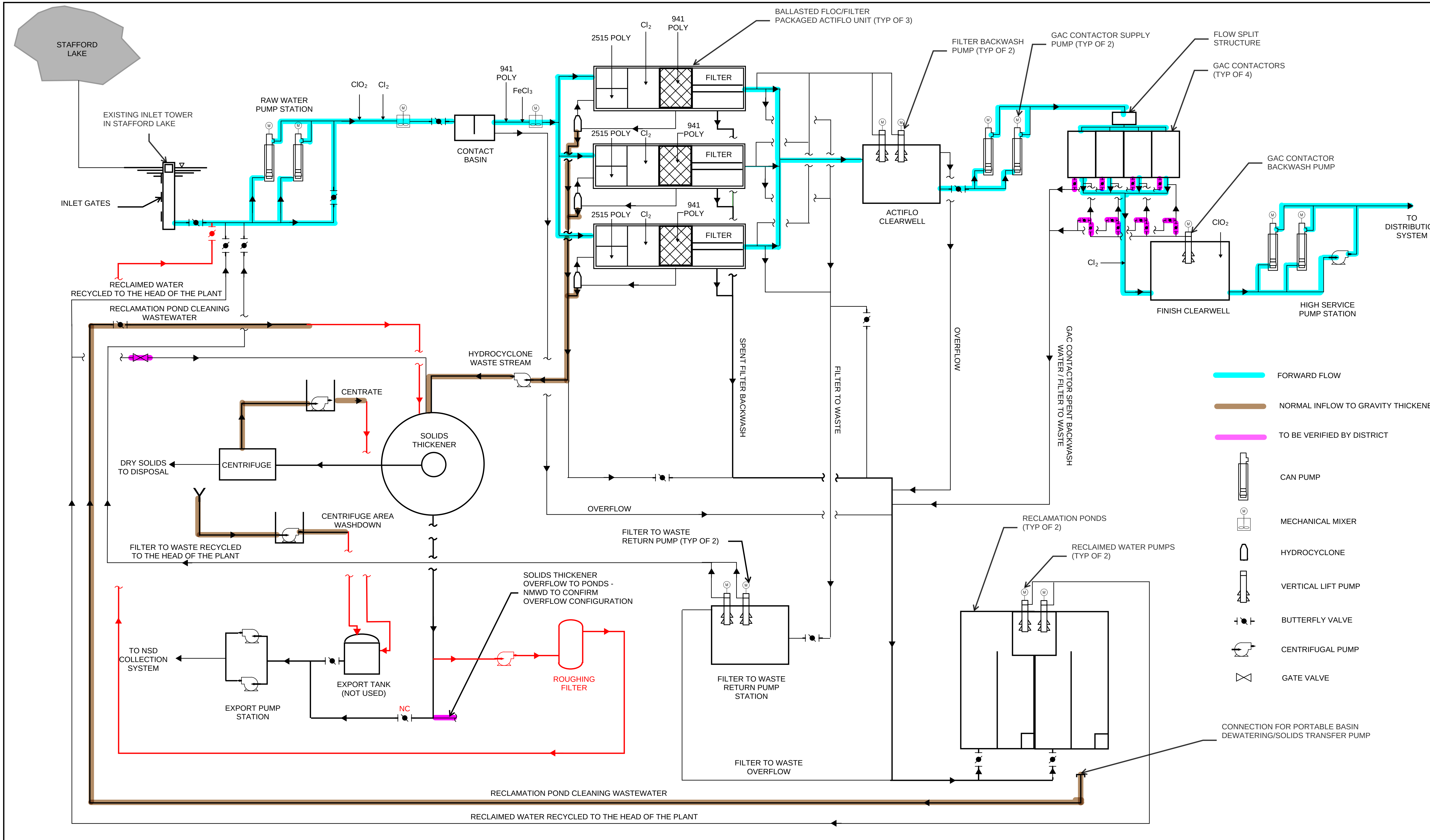
ELEVATION SECTION E-E & F-F FOR 7'-0" OD X 10'-0" STRAIGHT SIDE VERTICAL CONTACLARIFIER PRESSURE VESSEL

SCALE NTS

CONTRACT RO-19-0218T

SECTION P

DWG NO. 190218-M2



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NORTH MARIN WATER DISTRICT
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PROCESS FLOW DIAGRAM
MODIFIED WITH ROUGHING FILTER

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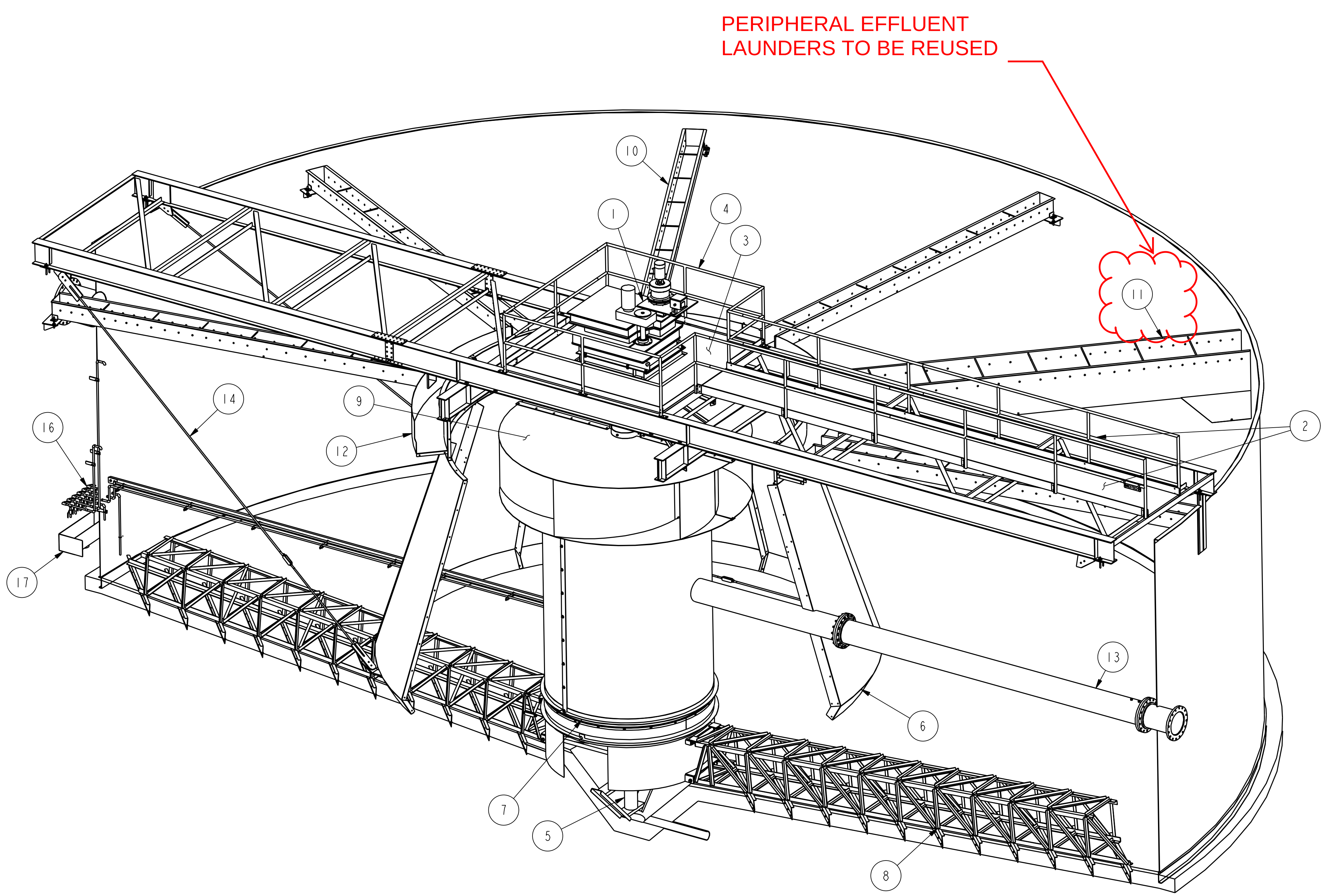
ROUGHING FILTER ALTERNATIVE PRELIMINARY LAYOUT

ATTACHMENT D
Reactor Clarifier Drawings

- Reactor Clarifier Catalog Cutsheet
- Modified Process Flow Diagram with Reactor Clarifier
- Reactor Clarifier Alternative Preliminary Layout

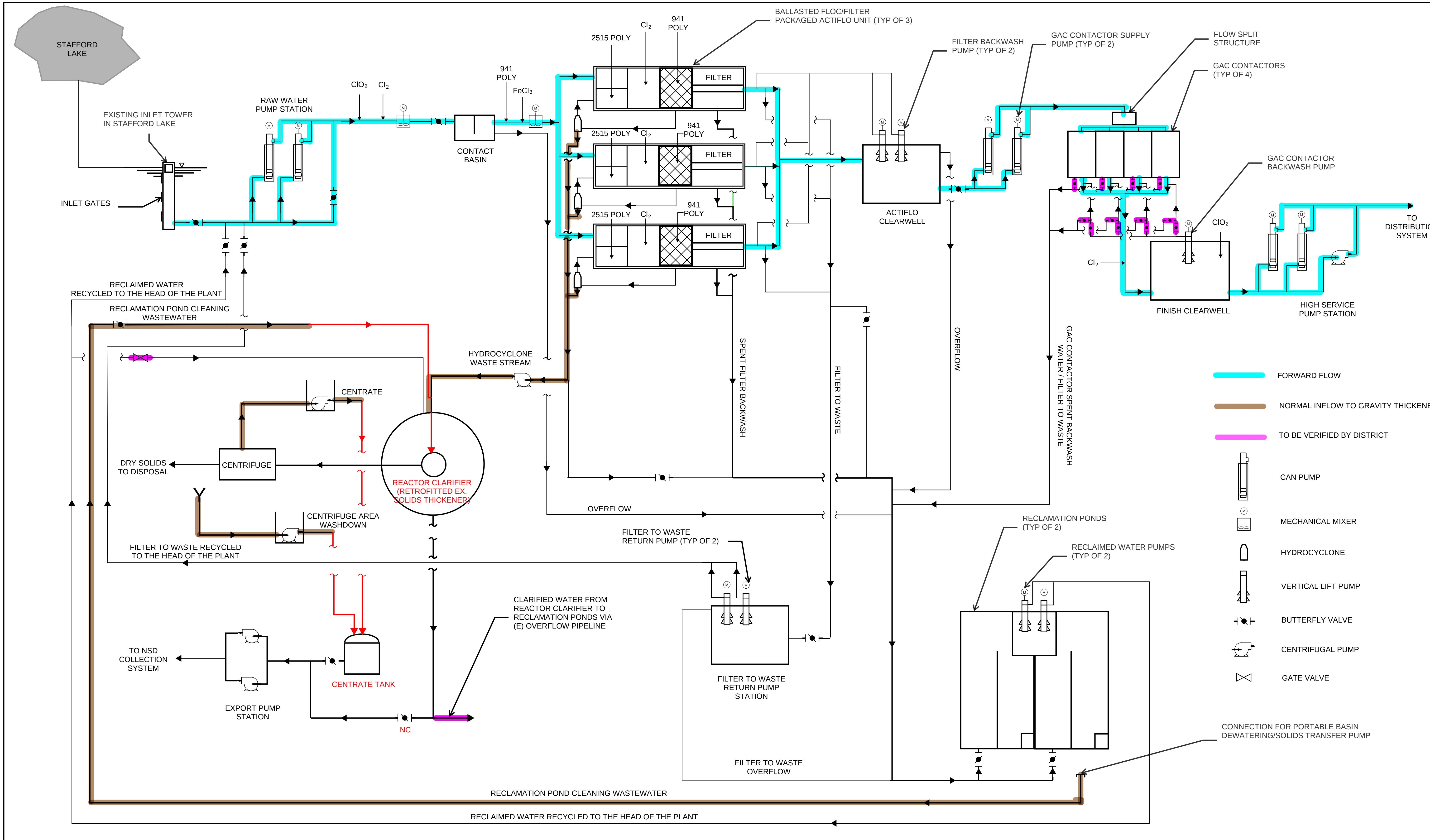


EQUIPMENT LIST

ITEM	DESCRIPTION/REMARKS
1	DUAL DRIVE UNIT W/ TORQUE CONTROL DEVICE.
2	BRIDGE
3	PLATFORM
4	HANDRAIL
5	CENTER SHAFT W/ TROUGH SCRAPER.
6	REACTION WELL W/ BAFFLES.
7	DRAFT TUBE W/ SUPPORTS.
8	(2) RAKE ARMS W/ SCRAPER BLADES AND ADJ. 304SS SQUEEGEES (RAKE TWICE PER REVOLUTION)
9	RADIAL IMPELLER
10	RADIAL LAUNDERS W/ EFFLUENT ORIFICES.
~~11~~	~~RADIAL EFFLUENT LAUNDER W/ EFFLUENT ORIFICES.~~
12	COLLECTION TROUGH
13	INFLUENT PIPE
14	REACTION WELL TIE ROD SUPPORTS
15	EFFLUENT PIPE
16	(6) SAMPLE LINES
17	SAMPLE SINK W/ 2" FLANGED DRAIN

WESTECH

SOLIDS CONTACT CLARIFIER



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PROCESS FLOW DIAGRAM
MODIFIED WITH REACTOR CLARIFIER

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THICKENER RETROFIT ALTERNATIVE PRELIMINARY LAYOUT

Appendix F

Cost Estimates

Appendix F

Cost Estimating Methods and Assumptions

PREPARED FOR

North Marin Water District

NORTH MARIN WATER DISTRICT

PREPARED BY

WEST YOST
Water. Engineered.

Table of Contents

LIST OF TABLES

Table of Contents

LIST OF ACRONYMS AND ABBREVIATIONS

AACE	Association for the Advancement of Cost Engineering
AF	Acre Feet
AFY	Acre Feet Per Year
ASR	Aquifer Storage and Recovery
CCI	Construction Cost Index
CY	Cubic Yard
ENR	Engineering News Record
IPR	Indirect Potable Reuse
MCE	Marin Clean Energy
NPV	Net Present Value
O&M	Operations and Maintenance
RO	Reverse Osmosis
STP	Stafford Treatment Plant
Study	Local Water Supply Enhancement Study

Appendix F – Cost Estimating Methods and Assumptions

1.0 OVERVIEW

This appendix describes the methods and assumptions used by West Yost to estimate the capital costs, replacement costs, and operation and maintenance (O&M) costs, associated with the design and construction of each water supply alternative evaluated as part of NMWD's Local Water Supply Enhancement Study (Study). A 30-year operational cycle was used to calculate the total cost of each alternative.

The cost estimates prepared for this Study were developed in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International for a Class 5 Estimate. AACE International defines a Class 5 Estimate in the following manner:

> *Class 5 Estimate: This estimate is prepared based on limited information, where little more than proposed plant type, its location, and the capacity are known. Strategic planning purposes include, but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, little time is expended in the development of this estimate. The expected accuracy ranges for this class estimate are –20 to – 50 percent on the low side and +30 to +100 percent on the high side.*

Except where noted, unit costs for estimating the capital cost are based on a combination of data supplied by manufacturers, published industry standard cost data and curves and construction costs for similar facilities and/or other public agencies with similar construction cost indices. All construction costs have been adjusted to reflect November 2021 costs at an Engineering News Record (ENR) San Francisco construction cost index of 14,421.03. These costs are to be used for conceptual cost estimates only.

The costs presented in this Study are not intended to represent the lowest prices in the industry for each type of construction; rather they are representative of average or typical construction costs. These planning level cost estimates have been prepared for guidance in evaluating various facility improvement options, and are intended for budgetary purposes only, within the context of this study effort. Cost estimates at this level of planning are necessarily preliminary in nature, with appropriate consideration for the potential variability in project scope and economic factors. Preliminary and detailed design will be necessary to refine and confirm the estimates presented herein.

The following sections of this appendix describe the methods and assumptions used to estimate the costs for the design and construction of the water supply alternatives:

- Contingencies and Allowances
- Operations and Maintenance Costs

Costs for each water supply alternative are discussed in their respective chapters and summarized in Chapter 12 and this appendix.

2.0 CONTINGENCIES AND ALLOWANCES

To assist NMWD staff with budgeting for the water supply alternatives, the following percentages are applied to the base construction costs.

- Estimating and Construction Contingency: 40 percent
- Project Allowances: Varied based on water supply alternative

Because of the variation in the local water supply enhancement projects, all contingencies and allowances were reviewed on a case-by-case basis, as they may vary considerably with each construction project.

The construction costs presented in the subsequent sections of this appendix are representative of water system facilities construction under normal conditions and schedules; consequently, it is appropriate to include allowances for both estimating and construction contingencies appropriate for the conceptual planning phase. Factors such as unexpected construction conditions, the need for unforeseen mechanical items, and variations in final quantities are only a few of the items that can increase project costs. The 40 percent contingency is intended to account for these factors.

Project allowances such as engineering, administrative, and permitting services associated with new facilities include preliminary investigations and reports, subsurface investigations, preparation of design drawings and specifications, surveying and staking, sampling, and testing of materials, start-up services, and construction management and inspection services. For this Study, such costs varied based on the water supply alternative due to the differences between each alternative. Table F-1 summarizes the project allowance for each alternative.

Table F-1. Alternative Specific Project Allowances – Capital Cost

Alternative	Project Allowance, percent
Aquifer Storage Recovery in the Novato Basin	35
Recycled Water System Expansion	30
Indirect Potable Reuse[(a)]	-
Improve STP Process Water Recapture Efficiency	
Pretreatment Modifications	25
Raw Water Intake Modifications[(b)]	-
Wastewater Discharge Pipeline Replacement	25
Diver Captured Water into Stafford Lake	
Option 1 – Leveroni Canyon	20
Option 2 – Bowman Canyon	20
Option 3 – Novato Creek	20
Option 4 – Dam at Leveroni Canyon	60
Option 5 Dam at Bowman Canyon	60
Increase Stafford Lake Storage Capacity	
Spillway Notch Slide Gate	45

Table F-1. Alternative Specific Project Allowances – Capital Cost	
Alternative	Project Allowance, percent
Sediment Removal	10
Desalination[c]	-

Notes:
(a) Cost estimate is based on industry standards scaled to NMWD required demand.
(b) High level cost estimate for equipment and installation of the raw water intake modification provided by manufacturer. No construction contingency or project allowance applied to the cost estimate.
(c) No cost estimate prepared for the desalination alternative since it is not feasible at the local level.

The above contingencies/allowances were applied to the base construction cost as follows:

(Base Construction Cost) x (Construction Contingencies [1.40]) = Construction Cost

(Construction Cost) x (Project Allowances [1.25]) = Capital Cost

The total cost increase of the contingencies/allowances totals approximately 66 percent of the estimated base construction cost. An example application of these standard mark-ups to a project with an assumed base construction cost of $1.0 million is shown in Table F-2.

Table F-2. Example Application of Contingencies and Allowances	
Cost Component	Cost, dollars
Estimated Base Construction Cost[a]	1,000,000
Construction Contingencies = 40 percent	400,000
Estimated Project Cost after Construction Contingencies (Construction Cost)	1,400,000
Project Allowances: Engineering, Administration, and Permitting = 25 percent	350,000
Estimated Total Project Capital Cost	**$1,750,000**

Notes:
(a) Assumed cost of an example project.

3.0 REPLACEMENT COSTS

In addition to the construction and capital cost estimates, replacement costs for various alternatives were included in the total cost estimate. Replacement components, the timing and replacement frequency were determined for each alternative. The same construction contingency and project allowance was applied to the replacement cost that was applied to the capital cost.

A net present value (NPV) analysis was performed to calculate the total cost of replacement for each alternative. The future value of the replacement costs was calculated using the inflation rates provided in Table F-3 and the frequency of replacement over the 30-year operational cycle. The future replacement costs were discounted using a discount rate of 3.5 percent and summed up over the 30-year operational cycle to calculate the total NPV replacement cost.

Table F-3. Inflation Rates for NPV Analysis	
Cost Component	Inflation Rate, percent
Material	3
Chemicals	5
Energy	3
Labor	3
Other	3

Some alternatives may not account for any replacement costs if the life span of the evaluated infrastructure is more than the 30-year operational cycle. Table F-4 summarizes the expected life span of various infrastructure. Other alternatives may include replacement timing and costs for infrastructure that is more detailed compared to what is summarized in Table F-4. The life expectancy and replacement timing is based on engineering judgement for those alternatives.

Table F-4. Facility and Infrastructure Life Expectancy	
Cost Component	Life Expectancy[(a)], Years
Aqueduct	150
Dam	100
Distribution Mains	50
Pumping Equipment	25
Water Treatment Equipment	20
Storage and Transmission (16” Diameter +) Facilities	50
Distribution Facilities (includes pump stations)	50

Notes:
(a) Source: North Marin Water District. Financial Statement Notes. Note 5 – Depreciation.

4.0 ANNUAL OPERATION AND MAINTENANCE COSTS

In addition to construction and capital cost estimates and replacement cost estimates, annual O&M costs were developed for the purposes of evaluating the various water supply alternatives. O&M costs were estimated for the recommended new facilities and generally include materials, labor, energy, chemicals, and other (i.e., disposal and general maintenance of physical facilities (i.e., re-coating or replacement of ancillary appurtenances)). The O&M costs include an operating contingency that varies with each water supply alternative. Data on O&M costs for existing facilities was not used in this Study, so the O&M costs presented in this Study do not account for O&M costs for existing facilities, nor the possible reduction in O&M costs for facilities recommended to be decommissioned.

A NPV analysis was performed to calculate the total O&M cost over the 30-year operational cycle for each alternative. The future value of the annual O&M costs was calculated using the inflation rates provided in

Table F-3. The future annual O&M costs were discounted using a discount rate of 3.5 percent and summed up over the 30-year operational cycle to calculate the total NPV O&M cost.

5.0 UNIT COST OVER 30 YEARS

A unit cost for each alternative was calculated to objectively compare each alternative. The unit cost over 30-years is calculating by dividing the NPV total cost by the by the total water supply yield over the 30-year operational cycle. The NPV total cost is equal to the sum of the total capital cost, total NPV replacement cost, total NPV O&M cost.

6.0 COST ESTIMATE

The following sections detail the cost estimating assumptions applied to each water supply alternative evaluated as part of this Study. November 2021 costs at an ENR San Francisco construction cost index of 14,421.03.

6.1 Aquifer Storage Recovery in Novato Basin

The local aquifer storage and recovery (ASR) alternative evaluates using ASR wells to inject treated surface water from NMWD’s distribution system into the Novato Valley Groundwater Basin. The same wells would be used to withdraw the storage water from the aquifer when treated surface water supplies are limited or not available. The cost estimate, detailed in Table F-4, is on a per well basis.

The base capital cost for one ASR well, including the well, facilities and appurtenances was assumed to be $1.8 million. The base capital cost includes construction of above and below ground facilities or site work, ASR well facilities, and associated pipelines. This includes earthwork, drainage, construction of a driveway and sidewalk, pilot hole drilling, mechanical well development, pumping well development, and piping to tie into the distribution system. The total capital cost is estimated to be $3.4 million and includes a 35 percent project allowance. The total capital cost for a local ASR project is only for the construction and operation of one ASR well. The cost estimate does not include costs, such as well siting or property acquisition, to illustrate that an ASR program is cost prohibitive for NMWD to pursue at a local level within the Novato Valley Basin without the other added costs. Including these costs would increase the unit cost per ASR well over the 30-year operational cycle.

The 30-year NPV replacement cost was estimated to be $0.6 million. An inflation rate of 3 percent and discount rate of 3.5 percent was applied to all equipment that was assumed to be replaced to determine the total net present value over the 30-year operational cycle. The ASR replacement cost project allowance is 35 percent.

The 30-year NPV O&M cost is estimated to be $1.0 million. Based on engineering judgement and experience, the annual O&M base cost was estimated to be $26,000 based on the size of ASR well that could serve NMWD. The annual O&M cost with a 35 percent operating contingency is $35,000. The annual O&M cost includes the cost of materials, labor, and energy. Because a local ASR program in the Novato Valley Groundwater Basin is not feasible for NMWD, a detailed O&M cost estimate was not prepared. An inflation rate of 3 percent and discount rate of 3.5 percent was applied to the annual O&M cost over 30 years to determine the O&M net present value.

The total cost (total capital cost plus NPV costs) for the local ASR alternative is estimated to be $5.05million per ASR well. Assuming seasonal injection and recover of approximately 15 acre feet per year (AFY), the additional yield over a 30-year period is estimated to be approximately 450 acre feet (AF). The unit cost per ASR well is estimated to be approximately $11,200 per AF over a 30-year operational cycle.

Table F-4. ASR - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, percent per Unit	Cost, dollars
Capital Cost				
ASR Wells, Facilities, and Appurtenances	1	Lump Sum	$1,800,000.00	1,800,000.00
			Base Construction Cost	1,800,000.00
			Construction Contingency (40 percent)	720,000.00
			Construction Cost with Contingency	2,520,000.00
			Project Allowances (35 percent)	882,000.00
			Total Capital Cost	**$3,402,000.00**
Capital Cost - Replacement				
Cl2 Injection System	1	Lump Sum	$1,000.00	1,000.00
			Year of Replacement/Frequency	1
			Total Future Cost of Replacement	**$51,000**
			NPV Base Construction Cost	29,000
Chemical Pumps	1	Lump Sum	$600.00	600.00
			Year of Replacement/Frequency	2
			Total Future Cost of Replacement	**$16,000**
			NPV Base Construction Cost	9,000
Water Level Transducer	1	Lump Sum	$2,150.00	2,150.00
			Year of Replacement/Frequency	3
			Total Future Cost of Replacement	**$39,000**
			NPV Base Construction Cost	23,000
Column Tube, Foot Valve, FCV Hydraulic Pump, Air-Vacuum Release Valve	1	Lump Sum	$5,650.00	5,650.00
			Year of Replacement/Frequency	5
			Total Future Cost of Replacement	**$65,000**
			NPV Base Construction Cost	37,000
Well Rehab, Pump Bowls, Motor Valves, Globe Valves	1	Lump Sum	$48,510.00	48,510.00
			Year of Replacement/Frequency	10

Table F-4. ASR - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, percent per Unit	Cost, dollars
			Total Future Cost of Replacement	**$232,000**
			NPV Base Construction Cost	137,000
Flow Meters	1	Lump Sum	$10,000.00	10,000.00
			Year of Replacement/Frequency	12
			Total Future Cost of Replacement	**$45,000**
			NPV Base Construction Cost	29,000
Injection Flow Control Valve	1	Lump Sum	$17,000.00	17,000.00
			Year of Replacement/Frequency	15
			Total Future Cost of Replacement	**$85,000**
			NPV Base Construction Cost	48,000
			Total Net Present Value Base Construction Cost	**$312,000**
			Construction Contingency (40 percent)	125,000
			Construction Cost with Contingency	437,000
			Project Allowances (35 percent)	153,000
			NPV Total Replacement Cost	**$ 590,000**
Annual Operation and Maintenance Cost				
Operations and Maintenance	1	Lump Sum	$26,000.00	26,000
			Base O&M Cost	26,000
			Contingency (35%)	9,100
			Annual O&M Cost	**$35,100**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$1,013,000**
			NPV Total Cost	**$5,005,000**
			Annual ASR Supply, ASR	15
			Total ASR Supply over 30 Years, AF	450
			NPV of Total Cost per Acre-Foot, $/AF	**$11,200**

6.2 Recycled Water System Expansion

The recycled water system expansion alternative considered the expansion of the recycled water system to offset current and future potable water demand used for non-potable application. Four different pipeline segments were identified as part of this Study.

Only capital costs and O&M costs have been prepared for each pipeline segment. The project allowance applied was 30 percent. It was assumed that a pipeline has an approximate life span of 50 years. Since this the operational cycle is less than 50 years, no replacements were assumed to be required. For the capital cost estimate, all pipeline segments were assumed to be 8 inches in diameter. The pipeline unit cost is $260 per linear foot and accounts for the cost of pipeline materials, trenching, placing, and jointing pipeline, valves, fittings, service connections, placing imported pipeline bedding, native backfill material, and asphalt pavement replacement, if required. Pipeline unit cost is based on the Feasibility Study of West Ignacio Recycled Water Extension (September 2017). The pipeline unit cost was scaled from September 2017 to January 2022 using the ENR Construction Cost Index (CCI) for San Francisco of 14301.

For the O&M cost estimate, NMWD estimated that for every one-hundred recycled water customers, it takes approximately one-quarter of the standard hours worked in a year for one NMWD staff member to complete recycled water O&M tasks such as required reporting, inspection, and maintenance. The following assumptions were made for estimating the O&M cost:

- Standard Hours Worked per Year = 2,080 hours per year
- NMWD Staff Effort Cost = $210 per hour
- Annual Hours per 100 Recycled Water Customers (2,080 hours * 0.25) = 520 hours per year
- Annual Hours per 50 Recycled Water Customers (520 hours per year / 2) = 260 hours per year
- Annual O&M Cost for Recycled Water Expansion (260 hours per year * $210 per hour) = $54,600 per year
- An operating allowance was not included since the annual O&M cost is based off of the historical level of effort NMWD has experience with operating its recycled water system.

The four segments identified would serve approximately 50 additional recycled water customers. The total O&M cost was allocated proportionally to each segment based on the recycled water customer percentage. Table F-5 summarizes the annual O&M cost estimate per pipeline segment.

Table F-5. Recycled Water Expansion – Annual O&M

Segment	Number of Future Customers	Percent Allocated	Annual O&M Cost per Segment, dollars
Segment N-1	20	42	22,750
Segment N-2	13	27	14,790
Segment C-1	3	6	3,410
Segment C-2	12	25	13,650
Total	**48**	**100%**	**$54,600**

The total cost (total capital cost plus NPV costs) for constructing all recycled water pipeline segments is estimated to be $14.7 million. The total capital cost is estimated to be $13.1 million and the 30-year NPV O&M cost is estimated to be $1.6 million. Expanding NMWD's recycled water system could provide a potable water offset of up to 63 AFY if all proposed extension projects were constructed. This equates to a total potable water offset of 1,881 AF over 30 years. The unit cost over 30 years is $7,900 per AF if all four pipeline extensions are constructed.

The cost estimate for each identified pipeline segments are detailed in Table F 6 through F-9.

Table F-6. Segment N-1 – Cost Estimate

Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost				
8-inch Diameter Pipeline	4,230	LF	$260.00	1,099,800
			Base Construction Cost	1,099,800
			Construction Contingency (40 percent)	440,000
			Construction Cost with Contingency	1,539,800
			Project Allowances (30 percent)	462,000
			Total Capital Cost	**$2,002,000**
Capital Cost - Replacement				
-	-	-	-	-
Annual Operation and Maintenance Cost				
Labor	1	Lump Sum	$22,750.00	22,750
			Base O&M Cost	22,750
			Contingency (0 percent)	-
			Annual O&M Cost	**$22,750**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$657,000**
			NPV Total Cost	**$2,659,000**
			Annual Recycled Water Demand, AFY	17.0
			Total Recycled Water Demand Served over 30 Years, AF	**510**
			NPV of Total Cost per Acre-Foot, dollar/AF	**$5,300**

Table F-7. Segment N-2 – Cost Estimate				
Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost				
8-inch Diameter Pipeline	8,525	LF	$260.00	2,216,500
			Base Construction Cost	2,216,500
			Construction Contingency (40 percent)	887,000
			Construction Cost with Contingency	3,103,500
			Project Allowances (30 percent)	932,000
			Total Capital Cost	**$4,036,000**
Capital Cost - Replacement				
-	-	-	-	-
Annual Operation and Maintenance Cost				
Labor	1	Lump Sum	$14,790.00	14,790
			Base O&M Cost	14,790
			Contingency (0%)	-
			Annual O&M Cost	**$14,790**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$427,000**
			NPV Total Cost	**$4,463,000**
			Annual Recycled Water Demand, AFY	22.6
			Total Recycled Water Demand Served over 30 Years, AF	**678**
			NPV of Total Cost per Acre-Foot, dollar/AF	**$6,600**

Table F-8. Segment C-1 – Cost Estimate				
Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost				
8-inch Diameter Pipeline	5,500	LF	$260.00	1,430,000
			Base Construction Cost	1,430,000
			Construction Contingency (40 percent)	572,000
			Construction Cost with Contingency	2,002,000
			Project Allowances (30 percent)	601,000
			Total Capital Cost	**$2,603,000**
Capital Cost - Replacement				
-	-	-	-	-
Annual Operation and Maintenance Cost				
Labor	1	Lump Sum	$3,420.00	3,420
Base O&M Cost				3,420
			Contingency (0 percent)	-
			Annual O&M Cost	**$3,420**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$99,000**
			NPV Total Cost	**$2,702,000**
			Annual Recycled Water Demand, AFY	4.1
			Total Recycled Water Demand Served over 30 Years, AF	**123**
			NPV of Total Cost per Acre-Foot, dollar/AF	**$22,000**

Table F-9. Segment C-2 – Cost Estimate				
Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost				
8-inch Diameter Pipeline	9,425	LF	$260.00	2,450,500
			Base Construction Cost	2,450,500
			Construction Contingency (40 percent)	981,000
			Construction Cost with Contingency	3,431,500
			Project Allowances (30 percent)	1,030,000
			Total Capital Cost	**$4,462,000**
Capital Cost - Replacement				
-	-	-	-	-
Annual Operation and Maintenance Cost				
Labor	1	Lump Sum	$13,650.00	13,650
			Base O&M Cost	13,650
			Contingency (0 percent)	-
			Annual O&M Cost	**$13,650**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$394,000**
			NPV Total Cost	**$4,856,000**
			Annual Recycled Water Demand, AFY	19.0
			Total Recycled Water Demand Served over 30 Years, AF	**570**
			NPV of Total Cost per Acre-Foot, dollar/AF	**$8,600**

6.3 Indirect Potable Reuse

Potable reuse involves producing potable water from wastewater that has been processed through an advanced treatment process. Potable reuse thus requires a source of available wastewater, as well as dedicated treatment process equipment. Groundwater replenishment and surface water augmentation are often referred to as “indirect potable reuse” (IPR). Both IPR methods were determined to be infeasible due to the limited storage of the Novato Valley Groundwater Basin and Stafford Lake.

Because indirect potable reuse was determined to not be viable, a planning level cost estimate was not prepared. Based on industry standards and the size of NMWD, a potable reuse project would be able to provide between 1,000 to 3,100 AFY. The unit cost is estimated to be $3,000 per AF. This cost estimate accounts for constructing and operating an advanced treatment facility over a 30-year period but does not account for reverse osmosis (RO) reject brine stream. Additional study would be needed to determine feasible RO reject bring management alternatives and their costs. The costs associated with RO reject bring management system may be cost prohibitive given the possible disposal options. In addition, the cost estimate is for the treatment facility only and does not include costs for groundwater injection or extraction or a pipeline system that would transport advanced treated water to wells, nor pipelines that transport extracted water back into the water system.

6.4 Improve Stafford Treatment Plan Process Water Recapture Efficiency

This alternative evaluated the potential to produce additional potable water from NMWD's Stafford Treatment Plant (STP) by making efficiency improvements to the recapture of process water and related raw water intake and wastewater discharge modifications. During the course of this Study, the following separate items have been identified to enhance NMWD's water supply:

- pretreatment unit modifications
- raw water intake modifications
- replacement of wastewater discharge pipeline

The raw water intake modifications and replacement of the wastewater discharge pipeline are ancillary improvements identified during this Study. These two improvements would not specifically increase the yield of the STP but would improve the reliability of the STP water supply yield. Two separate cost estimates have been prepared. The first cost estimate, summarized in Table F-10, is only for the pretreatment modifications since this is the only identified improvement that would increase local water supply at the STP. The second cost estimate, summarized in Table F-13, is for the pretreatment modifications and the ancillary improvements.

6.4.1 Pretreatment Modifications

The total capital cost of the pretreatment modifications includes installation for small piping and valving as well as performance testing and is estimated to be $70,000. The estimated capital cost for the small piping and valving equipment is $10,000 including a 40 percent construction contingency and a 25 percent project allowance. The performance testing is estimated to be approximately $60,000 and assumes the performance testing would be led by an engineering consultant with assistance and supervision from NMWD staff. The engineering consultant would work with NMWD staff and the manufacturer to develop a work plan, collect data, among other efforts. No contingencies were associated with the performance testing.

The 30-year NPV replacement cost for the pretreatment modification is estimated to be $70,000. It is assumed that the small piping and valving would need to be replaced every five years over the 30-year operational cycle. An inflation rate of 3 percent and discount rate of 3.5 percent was applied to all equipment that was assumed to be replaced to determine the total net present value over the 30-year operational cycle. The replacement cost estimate assumes a project allowance of 25 percent.

Overall, O&M costs are likely to be similar or slightly lower after implementation of the pretreatment unit modifications, but whether they would be significantly lower and by how much cannot be determined without additional information that is not readily available at this time. For purposes of determining a unit cost, no changes to operational costs are assumed associated with this component.

Table F-10 provides the detailed cost estimate for the pretreatment modification.

Table F-10. Pretreatment Modifications - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost - Stafford TP Improvements				
Hydrocyclone (Pretreatment Unit) Modifications	1	Lump Sum	$6,000	6,000
			Base Construction Cost	6,000
			Construction Contingency (40 percent)	2,000
			Construction Cost with Contingency	8,000
			Project Allowances (25 percent)	2,000
			Performance Testing	60,000
			Total Capital Cost	**$70,000**
Capital Cost - Replacement				
General Replacement	1	Lump Sum	$6,000	6,000
			Year of Replacement/Frequency	5
			Future Cost Replacement at Year 30	69,000
			NPV Base Construction Cost	40,000
			Total Net Present Value Base Construction Cost	40,000
			Construction Contingency (40 percent)	16,000
			Construction Cost with Contingency	56,000
			Project Allowances (25pecent)	14,000
			NPV Total Replacement Cost	**$70,000**
Operation and Maintenance Cost				
-	-	-	-	-
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			Net Present Value Total Operating Cost, dollars	**$ -**
			NPV Total Cost, dollars	**$140,000**

It is assumed that the annual water supply available to NMWD each year is 20 AFY. The pretreatment modification can treat up to 70 AFY assuming that there is enough supply available. Table F-11 presents the unit costs for each supply yield over the 30-year operational cycle.

Table F-11. Pretreatment Modification Unit Cost by Year Type

Year Type	Dry Year	Typical Year
NPV Total Cost, dollars	**$140,000**	
Annual Supply, AFY	20	70
Total Supply Yield over 30 Years, AF	600	2,100
NPV of Total Cost per Acre-Foot, dollar/AF	**240**	**70**

6.4.2 Pretreatment Modifications and Ancillary Improvements

A second cost estimate was prepared for the pretreatment modification and the ancillary improvements. The ancillary improvements include the raw water intake modification and wastewater discharge pipeline replacement. Both ancillary improvements would not increase the local water supply but improve the reliability of the STP water supply yield.

Although a site-specific budgetary cost is not available during the preparation of this Study, Ixom, the manufacturer of the raw water intake modification, provided a high-level cost estimate of about $2 million for the equipment and $700,000 for installation cost, not accounting for any contingencies. This estimate is based on a similar-sized Water Selectors that have been recently installed elsewhere. Overall, O&M costs are likely to be similar or slightly lower after implementation of the pretreatment unit modifications, but whether they would be significantly lower and by how much cannot be determined without additional information that is not readily available at this time.

The total capital cost for the wastewater discharge pipeline replacement is estimated to be $442,000. The pipeline was assumed to be 4 inches in diameter, have the same alignment as the current pipeline (estimated length is 4,350 linear feet), and be PVC. The pipeline unit cost was assumed to be $60 per linear foot ($15 per inch diameter per linear foot). The construction contingency was reduced from 40 percent to 35 percent since it is a pipeline replacement. The project allowance used was 25 percent. It is assumed that a pipeline has an approximate life span of 50 years.

Since the Study's operational cycle is less than 50 years, no replacements were assumed to be required. This capital cost would be expected to be offset by reduced NMWD operational and maintenance costs.

NMWD spends an estimated $9,000 per year to perform maintenance on the existing wastewater discharge pipeline. If the existing pipeline were replaced, annual O&M costs are anticipated to be reduced by $9,000 every year. Over a 30-year period, NMWD O&M costs is estimated be reduced by a total NPV of $180,000. Table F-12 summarizes the capital cost for the wastewater discharge pipeline replacements.

Table F-12. Wastewater Discharge Pipeline - Cost Estimate				
Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost				
4-inch wastewater discharge pipeline	4350	LF	$ 60.00	261,000.00
			Base Construction Cost	261,000.00
			Construction Contingency (35 percent)	92,000
			Construction Cost with Contingency	353,000
			Project Allowances (25 percent)	89,000
			NPV Total Capital Cost	**$442,000**
Capital Cost - Replacement				
-	-	-	-	-
Operation and Maintenance Cost				
Annual Maintenance on Existing Wastewater Discharge Pipeline	1	Lump Sum	$9,000	9,000
			Base O&M Cost	9,000
			Contingency (25 percent)	-
			Annual O&M Cost	**$9,000**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total Operating Cost[(a)]	**$(180,000)**
			NPV Total Cost	**$262,000**

Notes:

(a) The pipeline replacement will reduce the level of O&M effort for NMWD and offset the overall cost of the wastewater discharge pipeline replacement.

F-13 summarizes the costs estimate for the pretreatment modification and all ancillary improvements.

Table F-13. Total Estimated Cost for the Pretreatment Modification and Ancillary Improvements	
Cost Item	Estimated Cost, dollars
Total Capital Cost	
Pretreatment Modification[a]	10,000
Performance Testing	60,000
Raw Water Intake Modifications[b]	2,700,000
Wastewater Discharge Pipeline Replacement[c]	442,000
Total Replacement Cost[d]	70,000
Total O&M Cost[e]	(180,000)
NPV Total Cost	**$3,102,000**

Notes:
(a) The construction contingency was estimated to be 40 percent and the project allowance for planning, permitting, engineering, legal, and administrative costs was estimated to be 25 percent.
(b) The capital cost for the raw water intake modification is a high-level cost based on discussions with the manufacturer, Ixom. The capital cost does not account for any contingencies.
(c) The construction contingency was estimated to be 35 percent and the project allowance for planning, permitting, engineering, legal, and administrative costs was estimated to be 25 percent. The construction contingency was reduced from 40 percent to 35 percent due to the wastewater pipeline being a pipeline replacement (no CEQA, no easements, no property rights etc.).
(d) For the pretreatment modification, it is estimated that the valving equipment will need to be replaced every 5 years. An inflation rate of 3.0 percent and discount rate of 3.5 percent was applied to determine the net present value of the replacement costs over the 30-year operational cycle. The construction contingency was estimated to be 40 percent and the project allowance for planning, permitting, engineering, legal, and administrative costs was estimated to be 35 percent. Replacement costs for the ancillary improvements were not included.
(e) For the pretreatment modification, it is anticipated that overall O&M costs would remain the same or be slightly lower but cannot be determine without additional information that is not readily available. For the raw water intake modification, O&M costs are likely to be similar or slightly lower after implementation of the pretreatment unit modifications, but whether they would be significantly lower and by how much cannot be determined without additional information that is not readily available at this time. For the wastewater discharge pipeline replacement, reduction in O&M costs is expected to offset the capital cost by NPV of $180,000 over the 30-year operational cycle.

Table F-14 summarizes the unit cost for the pretreatment modification and all ancillary improvements with the varying supply yields.

Table F-14. Unit Cost By Year Type – Pretreatment Modification and Ancillary Improvements		
Year Type	Dry Year	Typical Year
NPV Total Cost	$3,102,000	
Annual Supply Yield, AFY	20	70
Total Supply Yield over 30 Years, AF	600	2,100
NPV of Total Cost per Acre-Foot, dollar/AF	**$5,200**	**$1,500**

Notes:
Annual supply yield of 20 AFY is assumed to be available during all years equating to 600 AF over 30 years. The pretreatment modification could treat up to an additional 70 AFY, if available. This equates to 2,100 AFY over 30 years. The ancillary improvements would not increase the local water supply but increase the reliability of the STP operations.
Unit Cost = NPV Total Cost divided by the total supply yield over 30 years.

6.5 Divert Captured Stormwater into Stafford Lake

This alternative evaluation considered five options to capture stormwater runoff and diver the runoff to Stafford Lake. The options under this alternative are summarized below as follows:

- **Option 1 - Leveroni Canyon:** Water from Leveroni Canyon would be captured and pumped to Stafford Lake. The required infrastructure would be a pump station and a force main pipeline, all of which are located on NMWD property.
- **Option 2 - Bowman Canyon:** Water from Bowman Canyon would be captured upstream of the confluence with Novato Creek and pumped to Stafford Lake. The required infrastructure would be a pump station and a transmission main pipeline. A basin could also be included to increase the annual water supply volume.
- **Option 3 - Novato Creek (Leveroni and Bowman Canyons):** Water from both Leveroni and Bowman Canyons would be captured downstream of the confluence Bowman Canyon and Novato Creek and pumped to Stafford Lake. The required infrastructure would be a pump station and a transmission main pipeline. A basin could also be included to increase the annual water supply volume.
- **Option 4 – Leveroni Canyon Dam:** Water from Leveroni Canyon would be captured with the use of a dam across Leveroni Canyon, just north of Novato Boulevard. This option would also require a pump station, transmission main pipeline, all located on land this is currently privately property.
- **Option 5 – Bowman Canyon Dam:** Water from Bowman Canyon would be captured with the use of a dam across Bowman Canyon, approximately 300 feet north of Novato Boulevard. This option would also require a pump station, force main pipeline, all located on land this is currently privately property.

The evaluation of Options 1, 2, and 3 identify the total volume of stormwater that could be captured. Further analysis is required to quantify the fraction of the captured water that would generate an increase of the spill over at the Stafford Lake spillway and ultimately not be available as a new usable water supply. The cost estimate for Options 1, 2, and 3 assumes that NMWD can use the total captured stormwater runoff, and none would be lost over the Stafford Lake spillway. Options 4 and 5 involved an enhanced analysis for dam facilities, which included operational rules that considered usable captured stormwater runoff.

All cost estimates for this alternative are only to obtain the raw water supply. The prepared cost estimates do not include treatment of the raw water at the STP nor distribution of treated water.

6.5.1 Option 1, Option 2, and Option 3

Cost estimates were prepared for Options 1 through 3, diverting stormwater from adjacent watersheds without a basin and with a basin, with varying pump station capacities.

Assumptions specific to these options for the capital cost include the following:

- The capital cost of the pump station is dependent in the capacity of the pump station and ranges from about 460,000 for a 2 cfs pump station to $1.2 million for a 10 cfs pump station.

The capital cost of the force main is based on the length and diameter with the following assumptions:

- Pipeline Unit Cost = $15 per inch diameter per linear foot
- For a pump station less than or equal to 6 cfs, a 12-inch diameter pipeline would be required.
- For a pump station greater than 6 cfs, a 15-inch diameter pipeline would be required.
- The proposed force main delivering supply from Leveroni Canyon to Stafford Lake (Option 1) is assumed to be 1,700 linear feet.
- The proposed force main delivering supply from either Bowman Canyon or Novato Creek (Option 2 and Option 3) is assumed to be 4,500 linear feet.
- The proposed transmission main is assumed to follow the Novato Boulevard road alignment. With the construction of the transmission main, an additional $60 per linear foot was included for potential pavement repairs.
- The basin cost estimate is based on $30 per cubic yard (CY) for excavated and hauled soil, $1 million for all associated facilities (e.g., access road, fence, habitat creation / restoration, etc.), and $15,500 per acre for acquisition of 12-acre basin site. The excavation unit cost, $30 per CY, could vary depending on the disposal site location and could be significantly higher.

No replacement costs were identified with these options.

Assumption specific to these options for the O&M cost include the following:

- Power costs to pump water from an average elevation of 110 feet to an average elevation of 188 feet and 30 feet of friction loss. The pumps are assumed to be 70 percent efficient. The expected average cost per kWh of electrical power is $0.18. This results in a cost of just over $28 per acre-foot of water pumped into Stafford Lake. The electrical power cost is based on no pumping occurring during Peak PG&E charge periods (May 1 through October 31), 25 percent of the pumping occurring during Part Peak periods, and 75 percent of the pumping occurring during Off Peak periods. The average electrical power cost also includes the Marin Clean Energy (MCE) credits.
- NMWD staff effort is assumed to include one hour per day, 5 days per week, to operate and monitor the pump station. NMWD staff effort cost is assumed to be $210 per hour.
- Maintenance of the pump station is based on an annual cost of $1,000 per cfs per year (based on previous storm drainage master plan and associated cost estimates prepared by West Yost).
- Maintenance of the detention basin is based on $500 per acre per year (based on previous storm drainage master plan and associated cost estimates prepared by West Yost).

Table F-15 presents the cost estimate for Options 1 through 3 without a basin by pump station capacity. The NPV total cost for these options without the basin ranges from $3.56million to $6.19 million based on pump station capacity and option. The unit cost without the basin ranges from $330 to $1,280 per AF over 30 years based on pump station capacity. For each option, the 10 cfs pump station would provide the lowest unit cost over 30 years.

Table F-15. Without Basin – Cost Estimate			
Pumping Rate	Option 1 Leveroni Canyon	Option 2 Bowman Canyon	Option 3 Novato Creek
Capital Cost, dollars			
2 cfs	1,335,000	1,904,000	1,904,000
4 cfs	1,651,000	2,219,000	2,219,000
6 cfs	1,904,000	2,473,000	2,473,000
8 cfs	2,259,000	2,896,000	2,896,000
10 cfs	2,459,000	3,096,000	3,096,000
Capital Cost – Replacement, dollars			
-	-	-	-
Total NPV O&M Cost over 30 Years, dollars			
2 cfs	2,228,000	2,295,000	2,354,000
4 cfs	2,369,000	2,474,000	2,590,000
6 cfs	2,490,000	2,623,000	2,783,000
8 cfs	2,592,000	2,763,000	2,948,000
10 cfs	2,690,000	2,890,000	3,096,000
Total Cost over 30 Years, dollars			
2 cfs	3,563,000	4,199,000	4,258,000
4 cfs	4,020,000	4,693,000	4,809,000
6 cfs	4,394,000	5,096,000	5,256,000
8 cfs	4,851,000	5,659,000	5,844,000
10 cfs	5,149,000	5,986,000	6,192,000
Total Supply Over 30 Year(a), AF			
2 cfs	2,800	4,700	6,300
4 cfs	4,600	7,600	10,900
6 cfs	6,000	9,700	14,200
8 cfs	6,700	11,500	16,800
10 cfs	7,300	13,000	18,800
NPV of Total Cost per AF over 30 Years(b), dollar/AF			
2 cfs	1,280	900	680
4 cfs	880	620	450
6 cfs	740	530	380
8 cfs	730	500	350
10 cfs	710	470	330

Notes:
(a) Total supply over 30 years is rounded to the nearest 100 AF
(b) Unit Cost = NPV Total Cost divided by the total supply yield over 30 years. Unit costs are rounded to the nearest $10.

Table F-16 presents the cost estimate for Options 1 through 3 with a basin by pump station capacity. The NPV total cost for these options with the basin ranges from $12.45million to $13.64 million based on pump station capacity and option. Option 1, diverting stormwater from Leveroni Canyon, does not have a basin associated with the option and therefore, no cost estimate. The unit cost with the basin ranges from $730 to $1,600 per AF over 30 years based on pump station capacity. For each option, the 10 cfs pump station would provide the lowest unit cost over 30 years.

Table F-16. With Basin – Cost Estimate

Pumping Rate	Option 1 Leveroni Canyon	Option 2 Bowman Canyon	Option 3 Novato Creek
Capital Cost, dollars			
2 cfs	-	12,449,000	12,449,000
4 cfs	-	12,765,000	12,765,000
6 cfs	-	13,018,000	13,018,000
8 cfs	-	13,442,000	13,442,000
10 cfs	-	13,641,000	13,641,000
Capital Cost – Replacement, dollars			
-	-	-	-
Total NPV O&M Cost over 30 Years, dollars			
2 cfs	-	2,690,000	2,749,000
4 cfs	-	2,869,000	2,985,000
6 cfs	-	3,018,000	3,178,000
8 cfs	-	3,158,000	3,343,000
10 cfs	-	3,285,000	3,491,000
Total Cost over 30 Years, dollars			
2 cfs	-	15,139,000	15,198,000
4 cfs	-	15,634,000	15,750,000
6 cfs	-	16,036,000	16,196,000
8 cfs	-	16,600,000	16,785,000
10 cfs	-	16,926,000	17,132,000
Total Supply Over 30 Year[(a)], AF			
2 cfs	-	9,500	11,100
4 cfs	-	12,400	15,700
6 cfs	-	14,500	19,000
8 cfs	-	16,300	21,600
10 cfs	-	17,800	23,600
Total Cost per AF over 30 Years[(b)], dollar/AF			
2 cfs	-	1,600	1,370
4 cfs	-	1,270	1,010

Table F-16. With Basin – Cost Estimate

Pumping Rate	Option 1 Leveroni Canyon	Option 2 Bowman Canyon	Option 3 Novato Creek
6 cfs	-	1,110	860
8 cfs	-	1,020	780
10 cfs	-	960	730

Notes:
(a) Total supply over 30 years is rounded to the nearest 100 AF
(b) Unit Cost = NPV Total Cost divided by the total supply yield over 30 years. Unit costs are rounded to the nearest $10.

6.5.2 Option 4 and Option 5

Table F-17 and Table F-18 summarize the cost estimate for constructing a dam at Leveroni Canyon (Option 4) and Bowman Canyon (Option 5), respectively. Stormwater runoff into the two potential reservoirs would be diverted into Stafford Lake. Both capital costs include a 40 percent construction contingency and a 60 percent project allowance. The operating contingency is assumed to be 40 percent. No replacement costs were identified over the 30-year period.

Assumptions specific to Options 4 and 5 include the following:

- The total capital cost includes a miscellaneous line item of $500,000.
- Reservoir annual maintenance is estimated to be $500 per acre.
- Other cost estimating assumptions such as land acquisition cost, energy cost, labor cost is assumed to be the same as assumptions listed in Section 6.5.1.

The total capital cost for Option 4, Leveroni Canyon Dam, is estimated to be $5.67 million. No replacement costs were identified over the 30-year operational cycle. The annual O&M cost was estimated to be $98,000 per year. Operational cost includes pump station and reservoir maintenance, energy costs for pumping water to Stafford Lake, and labor costs. The 30-year NPV O&M cost is estimated to be $2.81 million using a 3.5 percent discount rate.

The total NPV cost (total capital cost plus 30-year O&M costs) is estimated to be $8.48 million. Assuming an annual supply yield of 175 AF, the additional yield over a 30-year period is estimated to be 5,250 AF. The unit cost is estimated to be $1,700 per AF over a 30-year period.

Table F-17. Leveroni Canyon Dam - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, dollars per Unit	Cost, dollars
Capital Cost - Leveroni Canyon Dam				
Earthwork (on-site cut and fill)	32,000	CY	15	480,000
Concrete Spillway Structures	350	CY	2,000	700,000
Pump Station	3.5	Cps	141,205	494,218
Transmission Main (12 inches)	1,500	LF	180	270,000
Miscellaneous	1	Lump Sum	500,000	500,000
			Base Construction Cost	2,444,000
			Construction Contingency (40 percent)	978,000
			Construction Cost with Contingency	3,422,000
			Project Allowances (60 percent)	2,053,000
Land Acquisition	12.6	Acres	15,500	195,300
			Total Capital Cost	**$5,671,000**
Capital Cost - Replacement				
-	-	-	-	-
Operation and Maintenance Cost				
Pump Station Annual Maintenance	3.5	cps	1,000	3,500
Reservoir Annual Maintenance	12.6	Acres	500	6,300
Chemicals	-	-	-	-
Energy	175	AF	28	4,900
Labor	261	Hours	210	54,810
			Base O&M Cost	69,510
			Contingency (40 percent)	27,800
			Annual O&M Cost	**$98,000**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost, dollars	**$2,808,000**
			NPV Total Cost	**$8,480,000**
			Annual Supply Yield, AFY	175
			Total Supply Yield, AF	5250
			Total Cost per AF over 30 Years[(a)], dollar/AF	**$1,700**

Notes:
(a) Unit Cost = NPV Total Cost divided by the total supply yield over 30 years. Unit cost is rounded up to the nearest $10.
CY = Cubic yard
cps = Cubic feet per second
LF = Linear Feet

The total capital cost for Option 5, Bowman Canyon Dam, is estimated to be $12.31 million. No replacement costs were identified over the 30-year operational cycle. The annual O&M cost was estimated to be $139,000 per year. An operating contingency of 40 percent was used to estimate operational costs over a 30-year period. The 30-year NPV O&M cost is estimated to be $4.00 million using a 3.5 percent discount rate.

The total NPV cost (total capital cost plus 30-year O&M costs) is estimated to be $16.31 million. Assuming an annual supply yield of 753 AF, the additional yield over a 30-year period is estimated to be 22,590 AF. The unit cost is estimated to be $800 per AF over a 30-year period.

Table F-18. Bowman Canyon Dam - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, dollars per Unit	Cost, dollars
Capital Cost - Leveroni Canyon Dam				
Earthwork (on-site cut and fill)	11,200	CY	15	1,680,000
Concrete Spillway Structures	800	CY	2,000	1,600,000
Pump Station	2.5	cps	161,984	404,960
Force Main (12 inches)	5,700	LF	180	1,026,000
Miscellaneous	1	Lump Sum	500,000	500,000
			Base Construction Cost	5,211,000
			Construction Contingency (40 percent)	2,084,000
			Construction Cost with Contingency	7,295,000
			Project Allowances (60 percent)	4,377,000
Land Acquisition	41.16	Acres	15,500.00	637,980
			Total Capital Cost	**$12,310,000**
Capital Cost - Replacement				
-	-	-	-	-
Operation and Maintenance Cost - Sluice Gate				
Pump Station Annual Maintenance	2.5	cps	1,000	2,500
Reservoir Annual Maintenance	41.16	Acres	500	20,580
Chemicals	-	-	-	-
Energy	753	AF	28	21,084
Labor	261	Hours	210.00	54,810
			Base O&M Cost	99,000
			Contingency (40 percent)	40,000
			Annual O&M Cost	**$139,000**
			Operating Lifetime, years	30
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$3,996,000**

Table F-18. Bowman Canyon Dam - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, dollars per Unit	Cost, dollars
			NPV Total Cost	**$16,306,000**
			Annual Supply Yield, AFY	753
			Total Supply Yield, AF	22590
			Total Cost per AF over 30 Years[(a)], dollar/AF	**$800**

Notes:
(a) Unit Cost = NPV Total Cost divided by the total supply yield over 30 years. Unit cost is rounded up to the nearest $10.
CY = Cubic yard
cps = Cubic feet per second
LF = Linear Feet

6.6 Increase Stafford Lake Storage Capacity

This alternative considers increasing the Stafford Lake storage capacity to enhance NMWD's local water supply reliability. Two options were considered under this alternative. The first option is to construct a downward opening slide gate on the secondary spillway to increase the storage capacity by 726 AF. The second option is to excavate sediment from the Stafford Lake bottom to increase the storage capacity.

Stafford Lake spilled over the spillway about two-thirds of the time (sixteen years) during the last twenty-three years. During these events and if either of the options to increase Stafford Lake storage capacity had been completed, the increase storage would have been fully utilized. This same ratio was applied to the 30-year operational cycle. It is assumed that the storage increase would only be available twenty out of the thirty years during this operational cycle.

No replacement costs were associated with either option during the 30-year operational cycle.

Table F-19 summarizes the cost estimate for the spillway modification by adding the spillway notch slide gate to increase the volume of Stafford Lake. The total capital cost is estimated to be $944,000, including the construction contingency and project allowance of 45 percent. The capital cost for each item associated with this option was estimated based on discussions with Waterman Valve, LLC, a manufacturer of spillway notch slide gates. The annual O&M cost was estimated to be $10,160. An operating contingency of 30 percent was used to estimate operational costs over a 30-year period. Operational cost includes materials and labor. The 30-year NPV O&M cost is estimated to be $294,000 using a 3.5 percent discount rate.

The total NPV cost (total capital cost plus 30-year O&M costs) for the spillway notch slide gate is estimated to be $1.24 million. Assuming the storage increase of 726 AFY was twenty years out of the 30-year operational cycle, the additional volume of water supply made available to NMWD would be 14,520 AF over that time period. The unit cost for the spillway notch slide gate is estimated to be approximately $90 per AF over a 30-year period.

Table F-19. Spillway Modification - Cost Estimate				
Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost - Sluice Gate				
Sluice Gate[a]	1	Lump Sum	250,000	250,000
Stainless Steel Stairs - Mounted to Spillway	80	Feet	1,500	120,000
Stainless Steel Walkway - Mounted to Spillway	50	Feet	1,200	60,000
Electrical Power Supply	1	Lump Sum	20,000	20,000
Boom Truck Rental and Operator - 4 week	1	Lump Sum	15,000	15,000
			Base Construction Cost	465,000
			Construction Contingency (40 percent)	186,000
			Construction Cost with Contingency	651,000
			Project Allowances (45 percent)	293,000
			Total Capital Cost	**$944,000**
Capital Cost - Replacement				
-	-	-	-	-
Operation and Maintenance Cost - Sluice Gate				
Materials	1	Lump Sum	200	200
Chemicals	-	-	-	
Energy	-	-	-	
Labor	36	Hours	210	7,560
Other	-	-	-	
			Base O&M Cost	7,760
			Contingency (30 percent)	2,400.00
			Annual O&M Cost	**$10,160**
			Operating Lifetime[b], years	20
			Discount Rate, percent	3.5
			NPV Total O&M Cost	**$294,000**
			Net Present Value Total Cost	**$1,238,000**
			Annual Storage Volume Increase, AFY	726
			Total Storage Increase For 20 Years[b], AF	14,520
			Total Cost per AF over 30 Years[c],dollar/AF	**$90**

Notes:
(a) Based on data from Watermen Valve, LLC
(b) The spillway notch slide gate is estimated to add an additional storage volume of 726 AFY to Stafford Lake. Assuming this storage volume would be utilized 20 years of the 30-year operational cycle, the total storage volume would equate to 14,520 AF. Two-thirds of the 30-year operational cycle was assumed because Stafford Lake has spilled over the spillway two-thirds of the years over the last twenty-three years.
(c) Unit Cost = NPV Total Cost divided by the total supply yield over 30 years. Unit cost is rounded up to the nearest $10.

Table F-20 summarizes the base construction cost for sediment removal at an excavation depth of 1-foot to 15 feet. The base construction cost does not include the construction contingency or project allowance. The following assumptions were made for the sediment removal cost estimate:

- Cost estimate assumes that excavation would take place on the western end of Stafford Lake.
- The excavation unit cost was assumed to be $30 per CY but if the soil was not fully dry, the excavation unit cost could increase significantly. The unit cost could also vary depending on the disposal site location and could be significantly higher.
- Over many years, the sediment would deposit back into the excavated area requiring for the area to be excavated again in the future. The cost estimate does not account for future excavation based on sediment deposits over the 30-year operational horizon.

Table F-20. Lake Stafford Sediment Removal Evaluation

Excavation Depth, ft	Area, acres	Layer Volume, cf	Cumulative Layer Volume, cf	Excavation[(a)], CY	Increase in Storage Volume, AF	Base Construction Cost[(b)], dollars
1	49.0	2,134,440	2,134,440	79,053	49	2,370,000
2	47.3	2,058,210	4,192,650	155,283	96	4,658,500
3	45.5	1,981,980	6,174,630	228,690	142	6,860,700
4	43.8	1,905,750	8,080,380	299,273	186	8,978,200
5	42.0	1,829,520	9,909,900	367,033	228	11,011,000
6	40.3	1,753,290	11,663,190	431,970	268	12,959,100
7	38.5	1,677,060	13,340,250	494,083	306	14,822,500
8	36.8	1,600,830	14,941,080	553,373	343	16,601,200
9	35.0	1,524,600	16,465,680	609,840	378	18,295,200
10	33.3	1,448,370	17,914,050	663,483	411	19,904,500
11	31.5	1,372,140	19,286,190	714,303	443	21,429,100
12	29.8	1,295,910	20,582,100	762,300	473	22,869,000
13	28.0	1,219,680	21,801,780	807,473	501	24,224,200
14	26.3	1,143,450	22,945,230	849,823	527	25,494,700
15	24.5	1,067,220	24,012,450	889,350	551	26,680,500

Notes:

(a) The average dump truck can hold 10 – 15 CY of material.

(b) Base construction cost does not include the construction contingency or project allowance. The base construction cost applies an excavation unit cost of $30 per cubic yard. The excavation unit cost could vary depending on the disposal site location and could be significantly higher.

Table F-21 summarizes the total capital cost for sediment removal at an excavation depth of 15 feet. At a depth of 15 feet, the Stafford Lake volume would have the large increase, 551 AF, compared to the other depths. If the total storage volume increase was utilized twenty years out of the 30-year operational cycle, the total storage increases over the 30-year period is 11,020 AF. The total capital cost of the sediment removal at 15 feet is estimated to be $41.1 million. The unit cost is $3,800.

Table F-21. Sediment Removal at Excavation Depth of 15 feet - Cost Estimate

Cost Component	Quantity	Units	Unit Cost, dollar per Unit	Cost, dollars
Capital Cost - Sediment Removal				
Excavation Depth - 15 feet	890,000	CY	30	26,700,000
			Base Construction Cost	26,700,000
			Construction Contingency (40 percent)	10,680,000
			Construction Cost with Contingency	37,380,000
			Project Allowances (10 percent)	3,738,000
			Net Present Value Total Capital Cost[a]	**$41,120,000**
			Operating Lifetime[b], years	20
			Annual Storage Volume Increase, AFY	551
			Total Storage Increase For 20 Years[b], AF	11,020
			Total Cost per AF over 30 Years[c],dollar$/AF	**$3,800**

Notes:

(a) Cost estimate for sediment removal does not include any cost for future excavation within the 30-year operational cycle or O&M.

(b) The sediment removal at a depth of 15 feet is estimated to add an additional storage volume of 551 AFY to Stafford Lake. Assuming this storage volume would be utilized 20 years of the 30-year operational cycle, the total storage volume would equate to 11,020 AF. Two-thirds of the 30-year operational cycle was assumed because Stafford Lake has spilled over the spillway two-thirds of the years over the last twenty-three years.

(c) Unit Cost = NPV Total Cost divided by the total supply yield over 30 years. Unit cost is rounded up to the nearest $100.

6.7 Desalination

Desalination is not feasible for NMWD at the local level and therefore, no cost estimate was prepared.

Appendix G

2021 Recycled Water Program Strategy Technical Memorandum

WEST YOST
Water. Engineered.

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TECHNICAL MEMORANDUM

DATE: November 19, 2021

Project No.: 861-60-21-03
SENT VIA: EMAIL

TO: Tony Williams, PE

FROM: Don Berger, PE, RCE #47062
Anita Jain, PE, RCE #86097

REVIEWED BY: Rhodora Biagtan, PE, RCE #59371

SUBJECT: Recycled Water Program Strategy

REGISTERED PROFESSIONAL ENGINEER
DONALD EUGENE BERGER
No. C47062
Exp. 12/31/21
CIVIL
STATE OF CALIFORNIA

Donald E Berger

1.0 INTRODUCTION

The North Marin Water District (District) has an established non-potable recycled water program serving the north, central, and south areas of Novato. The District currently has approximately 92 connections and primarily serves landscape irrigation customers along with several carwashes. Previous efforts have focused on construction of the recycled water distribution system and customer retrofit connections.

As the recycled water program has evolved, District staff has identified a number of near-term needs and priorities to optimize and enhance the existing non-potable reuse program. The current drought has advanced the need to implement near-term project options to supplement water supply. The District is seeking to focus on completing cost-effective in-fill connections and other recycled water project options. The District may consider expanding the distribution system should external funding assistance become available. Given that its recycled program is established, the District is also seeking opportunities to reduce resource requirements to administer the program.

The District has identified the following areas of potential recycled water opportunities:

- Additional hydrants or fill stations,
- Privately-owned recycled water storage tanks,
- Livestock watering,
- Residential fill station,
- Delivery of recycled water to residential customers,
- Updates to Regulation 18 (District recycled water regulations), and
- Dual plumbing in new developments for toilet flushing.

The District retained West Yost to assist in developing a strategy for focusing its recycled water efforts. To develop a strategy for the District, West Yost reviewed existing documents that support its current recycled water program. West Yost also met with District staff to discuss the existing program's limitations, and potential opportunities and possible challenges. This Technical Memorandum is prepared to:

- Document the District's needs and near-term priorities,
- Identify feasible, implementable near-term project options, and
- Prioritize project options and provide an action plan to advance them.

2.0 RECYCLED WATER PROGRAM BACKGROUND REVIEW

The District's current recycled water program was established with planning and permit documents, and supported by its local ordinances, regulations, policies, and procedures. District staff have developed institutional knowledge based on the operation of the recycled water system and working directly with its customers. The combined information from recycled water supporting documents and from District staff was used to develop near-term project options for implementation.

2.1 Recycled Water Supporting Documents

The District's existing recycled water planning and permit documents were reviewed to understand the existing program, history, and areas of potential opportunities. These documents include:

- Recycled Water Master Plan, Nute Engineering, February 2004,
- Recycled Water Implementation Plan, Nute Engineering/Winzler & Kelly, May 2006,
- Engineer's Report Supplement No. 1 for Recycled Water Pick-Up Program and Other Uses, RMC, July 2016,
- Engineer's Report for Distribution and Use of Recycled Water, RMC, August 2011,
- State Recycled Water Use General Order (2016-0068-DDW) and Notice of Applicability,
- District Regulation 18 and Ordinance 24 for Recycled Water Service,
- District Regulation 6 for Cross-Connection and Backflow Prevention for Potable Water Service, and
- District Residential Pick-Up and Truck Program Guidelines, 2021.

2.2 Staff Discussion

On September 7, 2021, West Yost met with District staff to discuss the following:

- Findings of West Yost review of existing recycled water program documents,
- District needs and priorities, and
- Potential options to increase recycled water use.

The Power Point presentation from the meeting and list of attendees are attached as Appendix A.

Table 1 provides a summary of opportunities identified, a suggested action plan, and prioritization of near-term recycled water projects identified and discussed. The findings from our review of the program documents and the discussions from the meeting are detailed in Section 3 below.

Table 1. Near-Term Recycled Water Program Priorities and Action Plan

Item	Opportunity	Actions	Priority[1]
1*	Additional Hydrants or Fill Stations	• Install two new hydrants as planned	High
		• Identify additional suitable locations with good vehicle access	Medium
2*	Privately Owned Recycled Water Storage Tanks	• None at this time. Reconsider if drought continues or if public interest increases.	Low
		• Prepare framework for program implementation and user monitoring for next dry season.	Low/ Medium
3*	Livestock Watering	• None at this time. Reconsider when state regulations are in place. (1-2 years)	Low
4*	Optimize Residential Fill Station Operations	• Consider economic analysis of alternative operational scenarios, including automating a fill station.	High
		• Research and evaluate more suitable locations.	Medium
		• Modify Title 22 permit if warranted by changes to operation.	Medium
5*	Deliver Recycled Water to Residential Customers	• None at this time. Reconsider if drought continues or if public interest increases.	Low
6	Update Regulation 18	• Survey other agency recycled water ordinances and policies/procedures for site retrofits	High
		• Identify retrofit funding alternatives (e.g., rebates or customer incentives).	High
		• Develop cost-effectiveness standards for evaluating new retrofits (e.g., minimum payback or $/AF threshold)	High
		• Update Regulation 18.	High
7*	Dual Plumbing for Indoor Uses in New Developments	• Consider requiring dual plumbing for indoor and outdoor non-potable use in large new developments to keep options open for future recycled water use at these sites.	High
		• Survey other agencies with dual plumbing applications to learn from their experiences.	High
		• Consider conducting a year-long demonstration test of recycled water for toilet flushing to identify any potential problems with color or odors that should be addressed.	Medium
8*	Front and backyard irrigation at single family homes	• Evaluate whether to allow front and backyard irrigation at new developments with single family homes	Medium
9*	In-Fill Connections (retrofits)	• Continue with cost-effective in-fill connections	High
10*	Additional Carwashes	• Identify additional suitable locations for retrofit (e.g., Chevron at Vintage Oaks)	High
Other Considerations			
1	Salt and Nutrient Management Plan (SNMP) Compliance	• Participate in the RWQCB's regional SNMP development, and conduct required monitoring of TDS, ammonia, and nitrogen in recycled water in either 2022 or 2023.	Medium
2	Update Regulation 6 - Cross-Connection and Backflow Protection for Potable Water Service	• Update regulation for conformance with pending State Water Board Cross-Connection Control Policy Handbook (Pending)	Medium/Low
3	Recycled Water Hydraulic Model Update	• Consider updating recycled water model and calibrating with actual pressure and flow data	Low

Notes:

*These items will require additional District staffing resources to implement, operate, and administer

Prioritization Timelines

High: 0-12 months

Medium: 12-18 months

Low: 18+ months

3.0 FINDINGS AND RECOMMENDATIONS

The District's original planning documents created a solid foundation for the recycled water program that provided design criteria and other information required for construction of the District's backbone distribution system and customer connections. District staff has diligently maintained the program and list of customers connected to the system. Staff continues to work on in-fill connections.

Based on review of recycled water supporting documents and discussion with staff regarding the recycled water program, conclusions and recommendations were developed to strengthen program management and to potentially expand service. Considerations for expanding services are also discussed below.

3.1 Recycled Water Supporting Documents

The District's permit documents appear to be up to date, and the District has a plan in place to comply with state recycled water Salt and Nutrient Management Plan (SNMP) requirements as described in Section 3.1.3 below.

3.1.1 Planning Documents

The District's original recycled water market assessments were completed at the time of the original master planning work in 2004. These initial customer lists have served as a guide for connecting customers. During the meeting with staff, the potential need for an updated recycled water market survey was discussed to reconfirm potential demands, update connection costs, and identify new and different types of users. The District has been proactively updating these items and is maintaining a list of future customers to target for in-fill connections. Therefore, a new market assessment is not needed at this time.

3.1.2 Permit Documents

The District is now enrolled in the new statewide Recycled Water General Order Permit (2016-0068-DDW) and received a Notice of Applicability (NOA) with updated monitoring and reporting requirements. This new order replaces the prior San Francisco Regional Water Quality Control Board (RWQCB) Order 96-011.

3.1.3 Salt and Nutrient Management Plan Compliance

To maintain compliance with the SNMP requirements in the updated General Order Permit, the District will be participating in the San Francisco RWQCB's regional recycled water SNMP development. This will require monitoring two times in one year (during wet and dry seasons) for total dissolved solids (TDS), ammonia, and two characterizations of nitrogen. The District plans to perform this monitoring in either 2022 or 2023 and submit the results in the annual report to the RWQCB the following year.

3.1.4 NMWD Regulation 6 - Cross-Connection and Backflow Protection for Potable Water Service

Sites served with both potable water and recycled water supplies are subject to the requirements of California Code of Regulations Title 17, Division 1, Chapter 5, Group 4 (Title 17), which sets forth requirements for the protection of the public water supply. Title 17 sets forth cross-connection control and backflow protection of potable water systems, including cases when recycled water is served to the same property. The District's Regulation 6 is based on the requirements of Title 17.

The State Water Quality Control Board (State Water Board) is currently preparing the Cross-Connection Control Policy Handbook (CCCPH).[1] This handbook will replace Title 17 and updates requirements to incorporate 2017 and 2018 updates to the California Safe Drinking Water Act. Updates include the prescriptive requirements for a cross-connection control program, backflow protection, and provisions for the use of a swivel or changeover device (swivel-ell) for supplemental supply to non-potable recycled water systems. The CCCPH is anticipated to be completed in late 2022 or early 2023.

The District should plan on updating its Regulation 6 to maintain conformance with updated State regulatory requirements.

3.2 Potential Project Options

The District's near-term needs and potential options to increase recycled water use, as discussed with District staff, are summarized in this section. Challenges are also identified.

3.2.1 Additional Hydrants or Fill Stations

The District is seeking opportunities to install additional purple hydrants to increase access for commercial recycled water haulers.

DISCUSSION SUMMARY:

- Two new hydrant locations have been identified and the installation of the hydrants should be completed soon.
- Finding additional suitable locations near the recycled water lines has been difficult. The location must be able to handle traffic, have adequate space for vehicles to pull out safely, and the roadway must be able to handle the load.
- The District is in discussions with Caltrans to install a hydrant at a Park & Ride lot, but progress has been slow.
- The Las Gallinas Valley Sanitary District Wastewater Treatment Plant (Las Gallinas WWTP) was considered as a possible location but is too far to the south to be convenient for Novato residents and is outside the District's service area.
- The Novato Sanitary District Wastewater Treatment Plant (Novato San WWTP) is not a good location because the access roads are constrained and in poor condition.

CONCLUSION:

Additional hydrants would be beneficial to improve access for commercial haulers and increase recycled water use.

RECOMMENDED ACTION:

Install additional purple hydrants if suitable locations can be found that meet the traffic load and safety requirements described above.

[1] Water Board November 15, 2021.

3.2.2 Privately Owned Recycled Water Storage Tanks

Some customers have expressed an interest in storing recycled water onsite at personal residences, and possibly sharing water between properties.

DISCUSSION SUMMARY:

- Marin Municipal Water District (MMWD) allows onsite storage at private residences, and some customers in the District's service area have also recently expressed an interest in hauling and storing recycled water.
- Concerns include additional District staff time required to permit, inspect, and monitor these sites.
- There is also a potential increase for cross connections. State Title 17 requires that the potable water service to residences with onsite storage tanks with an alternative water source would need to have a Reduced Pressure (RP) backflow preventer installed. This requirement presents additional costs for installation and annual testing of RP devices for customers. It also presents additional cost for the District to conduct annual monitoring and inspection.
- Allowing onsite storage increases the possibility for cross connections to the potable water system and increases District liability risks.
- Onsite storage, if not properly managed, can lead to water stagnation and odors.
- District staff inquired whether MMWD has a limit on tank size and pointed out that smaller volume tanks would lessen concerns.
- Residents who have a water truck can currently participate in the District's truck fill program and haul water in a tank truck to their property. A few customers do this.
- The District does not permit commercial recycled water haulers to deliver water to residential customers. Although not specifically included in the District's Title 22 Engineer's Report, this could potentially be added by submitting additional supporting documentation to the RWCQB indicating how this service would be administered.

CONCLUSION:

Privately owned storage tanks would increase administrative and permitting costs while providing limited revenue. Costs are expected to exceed revenue. Private onsite storage tanks create additional potential for cross connections and District liability.

RECOMMENDED ACTION:

Privately owned onsite storage tanks at residences should not be allowed until the District establishes a framework for monitoring users cost effectively.

3.2.3 Livestock Watering

The local agriculture industry and agricultural advocacy groups, such as UC Extension, have expressed an interest in using recycled water for livestock watering.

DISCUSSION SUMMARY:

- The State Water Code Section 13521.1 prohibits using recycled water in the water supply for "dairy animals that are currently producing dairy products for human consumption."
- An expert panel commissioned by the State Water Resources Control Board (SWRCB) to evaluate the use of recycled water for non-dairy livestock watering further defined dairy animals in their 2018 report to the SWRCB[2] as "Any lactating or potentially lactating animal, such as dairy cattle and dairy goats, whose milk or milk-derived product may be used for human consumption."
- Because of these limitations, recycled water demand for animal watering would be limited since most livestock watering needs within the District's service area are for dairy use.
- Statewide regulations for livestock watering have not yet been established. Regulations are currently being developed and are expected to be completed in 1-2 years as part of the State's planned update to Title 22 recycled water regulations.
- The Department of Drinking Water (DDW) is willing to consider issuing a conditional use permit for livestock watering (there are no known permitted connections in California), but additional Best Management Practices (BMP's) would need to be implemented that would likely increase the District's costs.
- Required BMPs may include the requirement of additional disinfection at the treatment plant. Coordination would be needed with Las Gallinas and/or Novato San.
- The District's distribution system does not currently extend to rural areas where the water would be used. Recycled water would have to be trucked to these sites, adding to the costs.

CONCLUSION:

Because recycled water cannot be used for dairy animals, demand would be limited. Implementation, permitting and administrative costs would likely exceed revenue from this application. Because there are currently no formal state regulations in place, additional BMP's would be imposed by DDW that would add cost and administrative burden for the District.

RECOMMENDED ACTION:

Reconsider livestock watering when state regulations are in place.

3.2.4 Residential Fill Station

The District currently operates a Residential Fill Station. Community interest and customer use have increased due to the drought. This activity is resource-intensive for the District, and a suitable location has not been found. The ideal location should be able to handle traffic load and provide safe vehicle access. The District would like to explore ways to optimize this program.

DISCUSSION SUMMARY:

- The Residential Fill Station is currently being operated from the purple hydrant on Wood Hollow Drive.

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[2] NWRI Panel Livestock Watering

- About 60 customers are currently signed up (about 0.3% of the approximately 20,000 customers in Novato) to haul recycled water.
- The fill station is open Tuesday, Thursday, and Saturday from 9 am – 1 pm and supplies around 40,000 gallons/week.
- The site is currently staffed by one temporary employee and requires a few additional hours per week of staff time on calls, training, and general program administration.
- The current site has no turnaround area, but the street is wide enough so that vehicles can pull off the road and que up safely next to the curb.
- The previous location at the District Office at 999 Rush Creek Place provided easier access and administration but did not have a recycled water supply line nearby. Recycled water had to be trucked in to fill an onsite storage tank, presenting staff and resource costs for the District.
- The District is seeking a more suitable location near a recycled water line.
- Community pressure has increased for the District to operate a Residential Fill Station during the drought.
- The District reported that the operational costs of the residential fill program are 3 to 4 times the cost of supplying recycled water to the landscape irrigation sites.
- The District's current recycled water permit requires the Residential Fill Station to be staffed.
- West Yost indicated that the City of Brentwood has opted to go with a fully automated facility, but they have an exclusive area dedicated to their residential fill station next to their wastewater treatment plant that allows residents to safely park and fill their tanks.
- Some agencies, such as the Dublin San Ramon Services District, have staffed their fill stations with summer interns.
- Many agencies have their fill stations at a corporation yard or existing facility that is already staffed.
- The District may want to consider an economic analysis of alternatives for the fill station operation.
- Modifications may be needed to the District's Title 22 permit if significant changes were made, such as changing to an automated fill station that was unstaffed.

CONCLUSION:

Operating a residential fill station is desirable during drought periods. Other agencies have implemented alternatives that the District may consider to further optimize this activity.

RECOMMENDED ACTIONS:

- Continue operation of the existing residential fill station
- Consider conducting an economic analysis of alternative operational scenarios
- Continue to research and evaluate alternative siting locations.
- Modify Title 22 permit as necessary with the Regional Board and DDW

3.2.5 Delivery of Recycled Water to Residential Customers

The District has received interest from the community in having the District provide recycled water deliveries, especially during drought periods.

DISCUSSION SUMMARY:

- The City of Healdsburg currently offers recycled water deliveries to residential customers for use on landscaping.
- The City of American Canyon has a similar program.
- Due to the City of Healdsburg's water restrictions and prohibition on using potable water for watering lawns, the City was under pressure to provide an alternative source to customers.
- Implementation of a recycled water delivery program would require additional staff resources and a water truck or contracting with a third party for water deliveries.
- Costs for implementing and operating such a program would likely exceed potential revenue.
- Implementation of such a program would likely require a change to the District's Title 22 permit and preparation of a Supplemental Engineering Report that would need to be reviewed and approved by the Regional Board and DDW.

CONCLUSION:

Delivery of water directly to customers would increase staffing needs, administrative costs and require the District to have a water truck. At this time, the District does not have the resources to pursue this project.

RECOMMENDED ACTION:

None at this time. Continue to monitor and revisit next year if drought persists.

3.2.6 Updates to Regulation 18 (District recycled water regulations)

The existing District recycled water regulations are outdated and need to be updated to be more useful to the District and customers.

DISCUSSION SUMMARY:

- Regulation 18 was originally developed over 10 years ago at the beginning of the program. It was a requirement for permitting and to receive state funding.
- Rather than the District taking the lead role in retrofits as was previously done, the District would like customers to take on more of the responsibilities including design, implementation, and funding.
- Sections (b) and (f) of Regulation 18 are in particular need of updating. These sections are respectively: "Requirements, Conditions, and Procedure for Conversion or Establishment of Recycled Water Service" and "Design and Construction of Retrofit Work."
- Retrofit funding alternatives and customer incentives need to be identified.
- There may be benefits to developing a policy on cost-effectiveness thresholds (e.g., a policy that only retrofits with less than a 15-year payback would be pursued).

- The District expressed an interest in conducting a survey of regulations and policies of other agencies to obtain examples and learn from their experiences.

CONCLUSION:

The District's existing recycled water regulation should be updated to refine District policy and procedures for new recycled water connections and retrofits.

RECOMMENDED ACTIONS:

- Update Regulation 18
- Consider conducting a survey of recycled water regulations and retrofit policies/procedures used by other agencies
- Consider establishing cost effectiveness standards for evaluating potential new connections, such as a minimum payback period.

3.2.7 Requiring Dual Plumbing in New Developments

The District is contemplating requiring certain future developments, such as large multifamily or commercial properties, to be dual plumbed for toilet flushing. Proposed developments in areas along the recycled water transmission pipelines may be potential candidates, particularly the old Fireman's Fund site.

DISCUSSION SUMMARY:

- The old Fireman's Fund site is already served with recycled water for landscape irrigation and will be redeveloped into residential units, including multifamily and single-family homes.
- A large, proposed development beyond Wood Hollow Drive could potentially be dual-plumbed for both indoor and outdoor recycled water use.
- The Fireman's fund site would continue to use recycled water for irrigation and possibly for the existing water feature. Shortly, the District will need to decide if it should require the developer to install dual plumbing at this site for indoor use in toilet flushing.
- The District may opt to require the developer to install indoor dual plumbing with new construction but condition that it may not initially connect the indoor plumbing to recycled water.
- Dual plumbing is generally not practical to add later as a retrofit. Having dual plumbing included during construction for indoor and/or outdoor use gives the District time to evaluate it further and develop appropriate administrative procedures.

CONCLUSION:

Requiring dual plumbing for toilet flushing in new developments could provide future benefits to the District.

RECOMMENDED ACTIONS:

Consider requiring dual plumbing for indoor and outdoor non-potable use in large new developments to keep options open for future recycled water use at these sites.

3.2.7.1 Considerations for Dual Plumbing in Indoor Applications

Dual plumbing for indoor use such as for toilet flushing or cooling applications is more costly to administer than recycled water use for landscape irrigation sites. Additional monitoring and cross connection testing are required by State regulations. Water service concerns associated with reliability and water quality will need to be considered. Table 2 provides a summary of the benefits and challenges associated with dual plumbing for toilet flushing as discussed with District staff. These issues are discussed in more detail below.

DISCUSSION SUMMARY:

- Other agencies have had issues with the color of recycled water in toilets, which can create the appearance of the toilet not being flushed. These agencies (such as East Bay Municipal Utility District) have had to explore installing additional treatment to remove color.
- Many of the onsite reuse systems installed in commercial buildings recently in the Bay Area have included a reverse osmosis treatment step to remove color.
- Every recycled water supply is different. Ideally, a demonstration test should be conducted to determine if color would be objectionable without reverse osmosis or additional treatment before approving such an application. The opportunity to conduct a demonstration may be available at the NSD recycled water treatment plant.
- Indoor applications such as toilet flushing require a higher level of reliability than is typically needed for landscape irrigation. Unlike the potable water system, the recycled water distribution is not a looped system. Service interruption due to any line break or maintenance activity could interrupt service. Dual plumbed sites often have a potable water air gap tank so that potable water can be introduced should the recycled water supply need to be shut down.
- The potential for interior odors during the low flow winter months was also discussed. Without the high flow irrigation demands on the distribution system to keep the water fresh, the water will have a longer residence time in the system before reaching the customer site. As a result, water may potentially stagnate in the system and cause odors without additional line flushing. Additional flushing would require more maintenance activities and staff resources.
- Increased cross connection testing is required for indoor applications. Standard cross connection testing methods using a full shutdown test would be disruptive to residents. The District may need to consider allowing alternative testing methods, such as the differential pressure testing method to avoid having to enter each residential unit to check flows.
- The District expressed an interest in potentially surveying other Bay Area agencies regarding their experiences and lessons learned with dual plumbing.

RECOMMENDED ACTIONS:

- This application will need further evaluation. Survey other agencies with dual plumbing applications.
- MMWD has successfully implemented multiple dual plumbed recycled water use sites, and District staff should also consider contacting them to assess the viability of similar dual plumbed connections at District sites.
- Consider conducting a demonstration test of recycled water for toilet flushing to identify any potential problems with color or odors that should be addressed.

Table 2. Considerations for Using Recycled Water in Dual Plumbing for Indoor Applications

Item	Description
1	District gains more recognition in community for promoting recycled water.
2	Reduction in potable water demands.
3	Can be beneficial to the developer in sales and marketing of property (e.g., many home buyers are now seeking “Green Buildings.” Recycled also water adds points for LEED certification and can help achieve a higher level of certification.)
4	Higher District administrative costs (e.g., requires development of additional administrative, engineering and training procedures and documents; additional monitoring and oversight; annual visual check of the system for potential cross connections; and cross connection testing every four years).
5	Additional regulatory approvals required. A Supplemental Engineering Report must be prepared and submitted to the Regional Board and DDW for review and approval.
6	Higher potential for water quality complaints due to color and odors.
7	Increased potential for cross connections, therefore more oversight and inspections are required.
8	Higher level of reliability needed compared to landscape users. Onsite connection to potable water system with an air gap tank is desirable since District does not currently have a loop system for recycled water.
9	Increased potential for odors in winter months when recycled water demands are low due to longer residence time in distribution system. May require periodic distribution system flushing by District O&M staff in winter months to maintain freshness.
10	District will need to monitor property ownership and/or management changes to maintain contact with site supervisor.

3.2.7.2 Front and Backyard Irrigation at Single Family Homes

There may also be an interest in front and backyard irrigation for new single-family homes at the Fireman’s Fund site.

DISCUSSION SUMMARY:

- Recycled water for front and backyard irrigation is being done elsewhere in California.
- Concerns with this application is substantially similar to those listed in Section 3.2.7.1 because the same regulatory requirements apply. Compliance will require additional District resources.
- The potential for cross connections at sites using recycled water for front and backyard irrigation are high.
- Allowing recycled water for irrigation at single family homes also requires more administrative time including homeowner training and annual inspections, especially for backyard irrigation.

CONCLUSION:

Use of recycled water for front and backyard irrigation at single family homes present similar challenges as use of recycled water for toilet flushing.

RECOMMENDED ACTIONS:

Evaluate allowing front and backyard irrigation in new developments with single family homes.

3.3 Other Recommendations

Review of the District's recycled water supporting documents and recommended actions are provided in Section 3.1. Those recommendations are in the medium to low priority as the development of documents leading those efforts are under development.

A recommendation to update the District's recycled water system hydraulic model is discussed below.

3.3.1 Recycled Water Distribution System Hydraulic Model

West Yost did not specifically review the District's recycled water system hydraulic model. However, it was noted during the meeting with staff that now may be an appropriate time to update the model given that many of the planned connections have been made. An updated model would assist the District in identifying operational issues that may impact existing customers and future connections. The hydraulic model can be a valuable predictive tool to evaluate the feasibility of new connections and identify potential problems with pressure or water quality, which may be a concern for future use, such as toilet flushing applications when there are no irrigation demands and water can stagnate in the system during winter months.

The hydraulic model will need to be calibrated with field data collected from diurnal pressure recorders installed at key locations in the distribution system, and actual demands from water meter readings.

4.0 Project Prioritization

Based on discussions and considerations of the proposed projects, a prioritization table with associated action items was developed (Table 1). The table is intended to serve as a road map for the District as it moves forward with evaluation and implementation of the identified near-term recycled water expansion projects. A prioritization of High, Medium, or Low was assigned to each project based on District needs and current resource availability. Prioritization assignment is associated with a timeline for implementation:

- High: 0 – 12 months
- Medium: 12 – 18 months
- Low: + 18 months

The table should be considered a "living document" and periodically reviewed and updated as more information becomes available, and as District needs and resources change.

Attachment A

Power Point Presentation – Project Kick-off Meeting September 7, 2021 and Attendee List

North Marin Water District
Recycled Water Program Strategy
Project Kick-off Meeting
September 7, 2021

Agenda:

1. Introductions
2. Review Project Objectives
3. Findings of West Yost review of existing RW program documents
4. Discussion of District needs and interests
5. Options suggested by staff or community to increase RW use
6. Next Steps

Project Objectives

- Develop a strategy to determine where to best focus the District's recycled water efforts and optimize its existing non-potable recycled water program
- Reduce staff and District resource requirements where possible (e.g., residential fill station monitoring and in customer retrofit process)
- Prepare a RW Strategy Memo that:
  - Documents District needs and potential near-term opportunities;
  - Includes a plan to address and move forward with near-term needs that have been identified by staff; and
  - Identifies a prioritization of future work

Program Documents Reviewed

Planning Documents

- 2004 Recycled Water Master Plan
- 2006 Recycled Water Implementation Plan

Permit Documents

- Title 22 Engineer's Report (2011 and Revision 4, 2016)
- State Recycled Water Use General Order (2016-0068-DDW) and Notice of Applicability

Local Ordinances and Regulations

- Regulation 18 and Ordinance 24

Policies and Procedures

- Residential Pick-up and Truck Program Guidelines, 2021

Take-aways and Initial Considerations

- Initial planning documents created a solid foundation for program.
- Permit has been updated for coverage under new statewide 2016 Recycled Water General Order
- Consider updated market survey to reconfirm potential demands, update connection costs, and identify new and different types of users
- Suggest hydraulic modeling of existing as-built system to identify expansion constraints (e.g., pressure) and potential operational issues (e.g., water stagnation, chlorine residual, or odor issues)

Discussion of District Needs and Interests

- Options suggested by staff or community to increase RW use
  - Additional hydrants or fill stations (e.g., new hydrant at Park-n-Ride)
  - Privately owned RW storage tanks
  - Livestock watering
  - Additional carwashes or other types of businesses to retrofit (e.g., building cooling towers)
- Other options
  - Can permit be modified to reduce Residential Fill Station monitoring requirements
  - Identify modifications to Reg 18
  - Dual plumbing requirements for future developments (e.g., multifamily near Civic Center)

Additional Hydrants or Fill Stations

- **Are there opportunities to add additional hydrants or fill stations to the system?**
- Considerations:
  - Park and Ride
  - Additional CalTrans hydrants

Privately Owned RW Storage Tanks

Should the District allow residents to store recycled water on site?

- Neighboring water agency, MMWD, allows RW residential storage tanks
- MMWD permit requires:
  - Tanks set back at least 50 feet from water source and surface water body
  - Proper screening and sealing of tanks to prevent insects/mosquitos
  - Avoiding conditions to allow for water to become stagnant
  - Discharge of unused recycled water to landscape area or sewer system only
- Concerns:
  - Monitoring of appropriate use/potential misuse of water
  - Degradation of water quality when stored for long periods of time
  - District liability
  - Possible cross connections to potable systems

Livestock Watering

Should the District modify its program to allow for livestock watering?

- Considerations:
  - No known permitted connections for this use in CA
  - Expert Panel report identified data gaps; consequently, additional BMPs would be required
  - Currently no regulations in place for this use; new regulations specifying the requirements for this use are expected in the next 1-2 years
  - Water Code Section 13521.1 specifically prohibits the use of RW for dairy applications
  - Dairy is the predominant livestock water demand in the NMWD service area
  - Additional costs and staff time required to implement and permit such a program is expected to exceed minimal revenue that would be obtained from this application

Residential Fill Station Monitoring

Can the District's permit for operating a residential fill station be modified to reduce the staffing requirements?

- Current recycled water permit requires residential fill station to be staffed while the fill station is in use.
- Changing the permit could also allow for the fill station to be open additional hours and increase use.
- Considerations:
  - How do other agencies manage staffing at residential fill stations?
  - Mitigation measures for run-off

Reg 18 Update

How can District Regulation 18 be modified to encourage customers to design and implement site retrofits?

- Considerations:
  - Under Reg 18, District pays for site retrofit on the customer side of the meter
  - Suggest a survey of other agencies to see what incentives & cost share models are used
  - Identify additional retrofit funding alternatives
  - Develop policy on cost-effectiveness thresholds (e.g., only those with 15 year or less payback)

Dual Plumbing in Future Development

Should the District require future development to be dual plumbed (e.g. recent multifamily housing facility near the Civic Center)?

- Considerations:
  - Would this apply to all development or development over a specific size?
  - Would this apply to development located within the District' recycled water service area and located near a recycled water main?
  - Explore benefits of developing policies and procedures for requiring dual plumbed systems in new construction

Next Steps

1. West Yost to prepare Draft RW Program Strategy Memo:	2 weeks
2. Schedule meeting to discuss draft Memo:	Sep/Oct
3. Finalize and submit Memo:	October

Appendix H

Recycled Water Demands

Table H-1. Future Recycled Water Demands			
ID No.	APN	Location	Recycled Water Demand, AFY
North			
N-1	125-180-38	Campus Properties - (Valley Oaks at Pinkston) (Part of 7711 Redwood Boulevard)	1.02
N-2	125-180-49	PG&E (Habitat for Humanity Redwood)	3.39
N-3	125-180-61	Buck Institute (worker housing)	1.02
N-4	125-480-45	Birkenstock (Chg to business ofc/biotech)	3.39
N-5	125-202-03 125-202-04 125-202-05	777 San Marin LLC	50.92
N-6	125-202-12	Oakview Office	1.02
N-7	125-202-13 125-202-14	Campus Properties - Wood Hollow (Hyatt Hotel)	2.04
N-8	125-580-16	Landsea Homes, 7711 Redwood Boulevard	2.72
N-9	125-580-17	Campus Properties - (Valley Oaks at Pinkston) (Part of 7711 Redwood Boulevard)	3.39
N-10	125-600-51 125-600-52	Atherton Place Townhomes 7533 and 7537 Redwood Boulevard	2.72
N-11	141-234-10	1110 Olive Avenue (vacant lot)	0.34
N-12	141-234-15 141-234-16	Corner of Olive & Redwood (Auto sales + service)	0.68
N-13	141-244-03 141-244-12 141-244-17	Olive and First (vacant- behind the Loop)	0.34
N-14	141-253-09	1017 Fourth Street	0.34
N-15	141-261-30	1053 Third Street	0.34
N-16	141-262-12 141-262-13	1212/1215 Grant Avenue	0.34
N-17	141-263-30	Vallejo and First (vacant)	0.34
N-18	141-264-22	7409 Redwood Boulevard (Enterprise Car Rental)	0.34
N-19	143-011-05	7506 Redwood Boulevard, AHO Site #4 (east of Trader Joe's)	1.02
N-20	143-011-06	Residence Inn by Marriott (Hotel - 103 rooms)	1.36
N-21	143-011-08	7506 Redwood Boulevard, AHO Site #4 (east of Trader Joe's)	0.51

Table H-1. Future Recycled Water Demands			
ID No.	APN	Location	Recycled Water Demand, AFY
N-22	143-061-01 143-061-02	7552 Redwood - Shamrock	0.34
N-23	143-061-06	7576 Redwood - Recycling Center	0.34
N-24	143-061-08	7596 Redwood - Landscape Materials	0.34
N-25	143-061-10 143-061-11	7586 Redwood - Solar/Fence	0.34
N-26	153-041-01	7416 Redwood Boulevard (Chianti Restaurant)	0.34
N-27	141-212-17	NUSD office 1015 7th Street	0.81
N-28	141-212-21	130501 Marion Park, 1700 Grant	5.91
N-29	141-061-01	Pioneer Park, 1015 Simmons Lane	9.95
N-30	141-201-19	Marin Library, 1720 Novato Boulevard	2.14
N-31	141-201-43	1770 Novato Boulevard Mixed Use	0.16
N-32	141-212-13	1025 7th Street	0.18
N-33	Various	Miscellaneous single-family units throughout N Zone 1 (excluded from figures)	1.7
		North Service Area Subtotal	**100.13**
Central			
C-1	153-340-06	Hanna Ranch Mixed Use (125 room hotel)	3.39
C-2	160-591-71	Victoria Commons 999 South Novato Boulevard	0.68
C-3	150-480-12	College of Marin IVC Meter 1800 Ignacio Boulevard	14.9
C-4	150-480-12	College of Marin IVC Garden 1800 Ignacio Boulevard	3.23
C-5	150-030-13	San Jose Middle School NUSD	6.66
C-6	160-290-16	Hoog Park, 571 Marin Oaks Dr. - City of Novato	9.66
C-7	150-030-14	San Jose Middle School, 1000 Sunset Pkwy - NUSD	2.8
C-8	150-180-12	City of Novato Athletic Field - 1800 Ignacio Boulevard	14
C-9	150-561-62	Ignacio Creek HOA, 298 Indian Way	3.18
C-10	160-950-01	City Median 1501 Ignacio Boulevard	1.45
C-11	160-950-01	City Median 1503 Ignacio Boulevard	1.26
C-12	150-030-14	City Median 1718 Ignacio Boulevard	0.62
C-13	140-291-27	Babe Silva field and Arroyo Avichi Park (City of Novato)	6
C-14	151-061-06	Novato Unified School District - 625 Arthur (Novato High)	1
C-15	140-281-09	City of Novato - 1560 Hill Road	12
		Central Service Area Subtotal	**80.83**

Table H-1. Future Recycled Water Demands

ID No.	APN	Location	Recycled Water Demand, AFY
South			
S-1	157-690-09	700 Hangar Avenue Infill (8 Hamilton Landing) "Park"	2.04
S-2	157-690-47	Hamilton Town Center/Theater Parcel	0.68
S-3	157-690-52	516 Hospital Drive (Avesta)	0.68
S-4	157-690-53	Hamilton Visiting Officer's Quarters	1.7
S-5	157-860-03 157-860-04	Hamilton Cottages (Senior Housing Triangle)	0.68
S-6	157-970-03	Hamilton Village (802 State Access)	4.41
S-7	157-970-04	Novato Village (801 State Access) Built	4.41
S-8	157-970-07	Hamilton Commissary Triangle -- HUD Parcel (826 State Access)	1.36
S-9	157-980-03	933 C Street (Northbay Children's Center)	1.7
S-10	157-980-05	C Street Village, 970 C Street	3.39
		South Service Area Subtotal	**21.05**
		Grand Total	**202.01**

Source: AFY = acre-feet per year

Appendix I

Future Recycled Water Retrofit Opportunities

Table I-1. Recycled Water Retrofit Opportunities

Site	Notes
1. Meadow Park HOA	This HOA has 4 remaining meters that have not been retrofitted. One has a retrofit design but it could be a costly retrofit. It is downstream of NMWD's booster pump and would have adequate pressure. The other three will require some consolidation into pre-existing retrofitted services that have pumps. There are some pressure limitations of the RW system in that area and a pumps is likely required for the three retrofits.
2. Lanham Village HOA	NMWD currently has a design to retrofit 3 of the 5 meters in the HOA. The irrigation system is quite old and a pump would be required for the system to operate properly. We have attempted many different creative ways to get this site retrofitted in the past but it is going to be a costly endeavor. At this point likely way more than the $100,000 budget.
3. Hillside Park #1 HOA (Redwood/S. Novato Boulevard)	Not enough system pressure to retrofit the entire site. They could maybe irrigate the hill along South Novato Boulevard
4. Hillside Park East HOA (Redwood/S. Novato Boulevard)	Not enough system pressure to retrofit the entire site. They could maybe irrigate the hill along South Novato Boulevard
5. Marin Glen HOA (Ignacio Valley Circle)	Individual customers have in-ground irrigation and this site is considered a dual plumbed irrigation site.
6. Hamilton Park HOA (Gann/Holiday)	Individual customers have in-ground irrigation and this site is considered a dual plumbed irrigation site.
7. Partridge Knolls HOA (Common area at the corner of Redwood and Wood Hollow)	Avram just mentioned putting in a service for this one along with another project he is doing.
8. Smart Train Station (Hamilton)	Would maybe require connection fees.
9. Smart Train Station (San Marin)	Would maybe require connection fees.
10. Western Oaks Village (many small meter conversions in Phase 3 of their HOA)	Costly retrofits for small landscape areas. Advise that customer perform their own retrofits.
11. Medians on Rowland Way at intersection of Rowland Boulevard	Would require cutting across the Road at Moylans to connect into the new irrigation system they installed for the common area.
12. Medians on Vintage Way	Would require cutting across the road somewhere along the way to connect into the irrigation system watering around Costco.
13. Ignacio Valley Apartments	Recommend customer retrofit. Not a lot of water use compared to the cost of the retrofit.
14. Small City park at Laurelwood	Recommend City do the retrofit. Not a lot of water use to justify the retrofit.
15. Matt and Jeff's Car Wash Site	Would be an extensive retrofit design and customer is not currently interested.

Table I-1. Recycled Water Retrofit Opportunities

Site	Notes
16. Chevron Car Wash at Rowland Way and Rowland Boulevard	Would require a retrofit design recon inspection to determine feasibility. Best done by Eric Kur first and David Ladd.

Source: Email Correspondence with NMWD on January 27, 2022.

Appendix J

Leveroni Canyon and Bowman Canyon Watersheds Stormwater Runoff Capture Calculations

Leveroni Canyon and Bowman Canyon Watersheds Stormwater Runoff Calculations

The purpose of this analysis is to estimate stormwater runoff that could be diverted from Leveroni Canyon Watershed and Bowman Canyon Watershed and pumped to Stafford Lake for use by North Marin Water District (NMWD).

Both the Bowman Canyon Watershed and Leveroni Canyon Watershed have not been previously studied. For the purposes of the NMWD Local Water Supply Enhancement Study, runoff estimates for each of these watersheds were developed using the County of Marin Department of Public Works' *Hydraulic Assessment of Existing Conditions, Novato Creek Watershed Project* (June 2014).[1] Runoff from the Stafford Lake Watershed was scaled to the Leveroni Canyon Watershed and Bowman Canyon Watershed sizes.

This appendix describes the method and assumptions that were used to estimate water supply that could be captured from these canyons and pumped to Stafford Lake.

Runoff from Stafford Lake Watershed

The estimated daily runoff that flows into Stafford Lake from the Stafford Lake Watershed (see Chapter 9, Figure 9-2) was calculated based on the following equation:

Change in Storage Volume = Runoff – Uses – Fish Flows – Evaporation – Spills – Percolation

Table J-1 provides a description of each variable used in the calculation of daily runoff. The graph in Figure J-1 presents the calculated daily runoff into the Stafford Lake Watershed.

[1] https://www.marinwatersheds.org/resources/publications-reports/novato-watershed-hydraulic-study-2014-2016

Table J-1 Daily Runoff Variables

Known Variable[(a)]	Description
Known Parameters	
Change in Storage Volume	NMWD provided the data for change in Stafford Lake storage volume based on the Stafford Lake water level
Uses	NMWD provided the raw water volume for the following uses – STP, golf course, and Marin County Parks
Fish Flow	Volume required for fish flows
Evaporation	Evaporation measured by NMWD and the California Irrigation Management System (CIMIS) for Stafford Lake.
Spills	Calculated based on water surface elevation (WSE) and the depth over the spillway crest.
Unknown Variable	
Runoff	Runoff = Change in Storage Volume + Uses + Fish Flows + Evaporation + Spills + Percolation However, in the summer months, there is no runoff, so in the summer it is known to be zero. Runoff was calculated for storm periods
Percolation	Calculated for the summer months (when runoff is zero, then percolation is the only unknown). The summer percolation rate was assumed to be the same in the winter months. Through this evaluation, percolation was found to range from positive values (water transferred from the lake to the ground) to negative values (water transferred from the ground to the lake). Overall percolation averaged to be small fraction of the water volumes in this evaluation.

(a) Units for each variable are in acre-feet (AF).

Relationship Between Rainfall and Runoff

Cumulative rainfall and cumulative runoff from 2016 through 2020 were plotted to determine the relationship between rainfall and runoff (see Figure J-2 through J-5) in the Stafford Lake Watershed. The results from these figures show that no significant runoff occurs until approximately 8 to 11 inches of rainfall occurs. These figures are confirmed by NMWD staff's observations. Results are as follows:

- In normal rainfall years, one inch of rain produces approximately 310 AF of runoff from the Stafford Lake Watershed into Stafford Lake.
- In drought years, one inch of rain produces approximately 160 AF of runoff from the Stafford Lake Watershed into Stafford Lake.

Runoff from Leveroni Canyon Watershed and Bowman Canyon Watershed

The Leveroni Canyon Watershed and Bowman Canyon Watershed runoff were compared with the runoff from the Stafford Lake Watershed. Both Leveroni Canyon and Bowman Canyon Watersheds are smaller than the Stafford Lake Watershed (see Chapter 9, Figure 9-2). The estimated runoff for Leveroni Canyon and Bowman Canyon Watersheds were calculated based on the ratios of their sizes with the Stafford Lake Watershed size. The results are as follows:

- Leveroni Canyon - In normal rainfall years, one inch of rain should produce approximately 70 AF of runoff. In drought years, one inch of rain is estimated to produce approximately 36 AF of runoff.
- Bowman Canyon - In normal rainfall years, one inch of rain should produce approximately 123 AF of runoff. In drought years, one inch of rain is estimated to produce approximately 64 AF of runoff.

The Leveroni Canyon Watershed and Bowman Canyon Watershed runoff were scaled in proportion to the calculated runoff from the Stafford Lake Watershed. The graph in Figure J-1 provides the estimated daily runoff from Stafford Lake Watershed, Leveroni Canyon Watershed, Bowman Canyon Watershed, and the combined runoff from Leveroni and Bowman Canyon Watersheds.

Volume of Stormwater Captured and Pumped to Stafford Lake

The volume of water that is captured and pumped into Stafford Lake from the Leveroni Canyon Watershed, Bowman Canyon Watershed, and Novato Creek just downstream of Bowman Canyon was calculated. This evaluation was conducted with the following assumptions:

- The fish flow requirements in the summer can range up to 404 gpm (approximately 0.6 cfs)
- At least 1 cfs of fish flow would be required for each of Leveroni and Bowman Canyon Watershed
- At least 3 cfs of fish flow would be required for Novato Creek downstream of Bowman Canyon
- Water would not be pumped into Stafford Lake if water was flowing over the Stafford Lake spillway.

Table J-2 summarizes the number of days in which the flow exceeded creek flow rates of 3, 5, 7, 9, and 11 cfs (allowing pumped diversions of 2, 4, 6, 8, or 10 cfs) from the Leveroni Canyon Watershed, Bowman Canyon Watershed, and Novato Creek. Table J-3 provides the volumes of water that could be captured for each option for the various sized pump stations, with or without the water supply basin. Because of space limitations at the NMWD property at Leveroni Canyon, use of a water supply basin for Leveroni Creek (Option 1), is not feasible.

Table J-2. Summary of Days of Pumping from 2016 through 2020

Creek Flow Rate, cfs	Option 1 Leveroni Canyon, cfs	Option 2 Bowman Canyon, cfs	Option 3 Novato Creek, cfs
3	94	157	213
5	62	99	153
7	44	70	112
9	26	62	85
11	21	49	70

cfs = cubic feet per second

The time required for the pump station to vacate the water supply volume of the basin depends on the pump station capacity. Table J-3 summarizes the time required for the pump station to vacate the water supply volume of the basin.

Table J-3. Estimated Time to Empty Proposed Basin

Pump Station Capacity, cfs	Estimated Time, days
2	20
4	10
6	7
8	5
10	4

cfs = cubic feet per second

Calculations show that the water stored in in the basin (80 AF) could be pumped into Stafford Lake approximately 6 to 8 times during a 4-year evaluation period, or about twice per year. Thus, installation of an 80 AF basin would increase the water supply volume by approximately 160 AFY.

In Table J-4, the stormwater runoff estimates are provided that could be diverted from Leveroni Canyon Watershed and Bowman Canyon Watershed and pumped to Stafford Lake for use by NMWD.

Table J-4. Summary of Captured Water Volumes

Pumping Rate, cfs	Option 1 Leveroni Canyon, AFY	Option 2 Bowman Canyon, AFY	Option 3 Novato Creek, AFY
For 2016 – 2020 (water years) with No Water Supply Basin			
2	373	623	845
4	619	1,016	1,452
6	793	1,293	1,896
8	897	1,539	2,233
10	980	1,734	2,511
Per Year, On Average, With No Water Supply Basin			
2	93	156	211
4	155	254	363
6	198	323	474
8	224	385	558
10	245	433	628
Per Year, On Average, with 80 AF Water Supply Basin Used Twice Per Year			
2	-	316	371
4	-	414	523
6	-	483	634
8	-	545	718
10	-	593	788

cfs = cubic feet per second
AFY = acre-feet per year

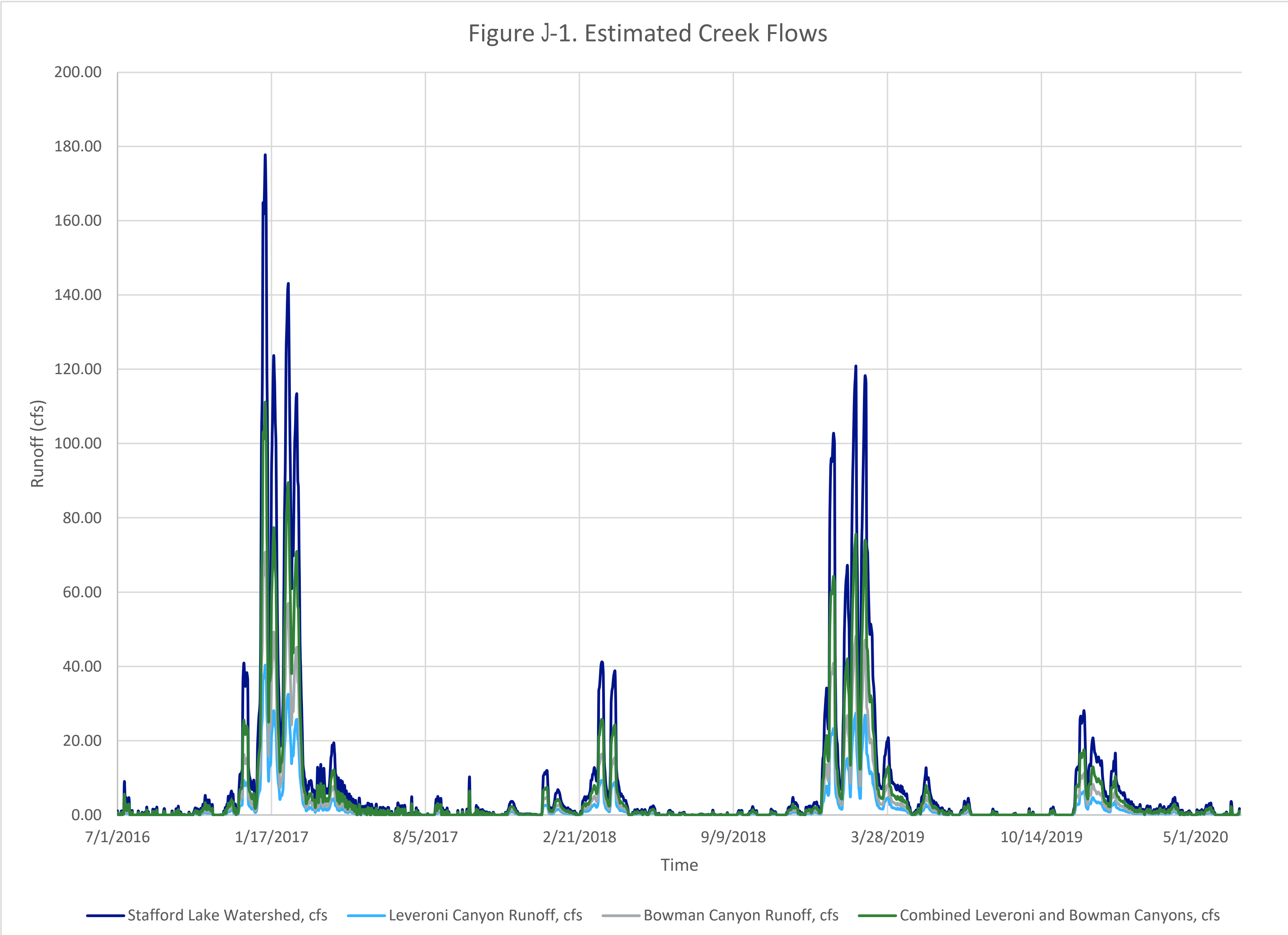
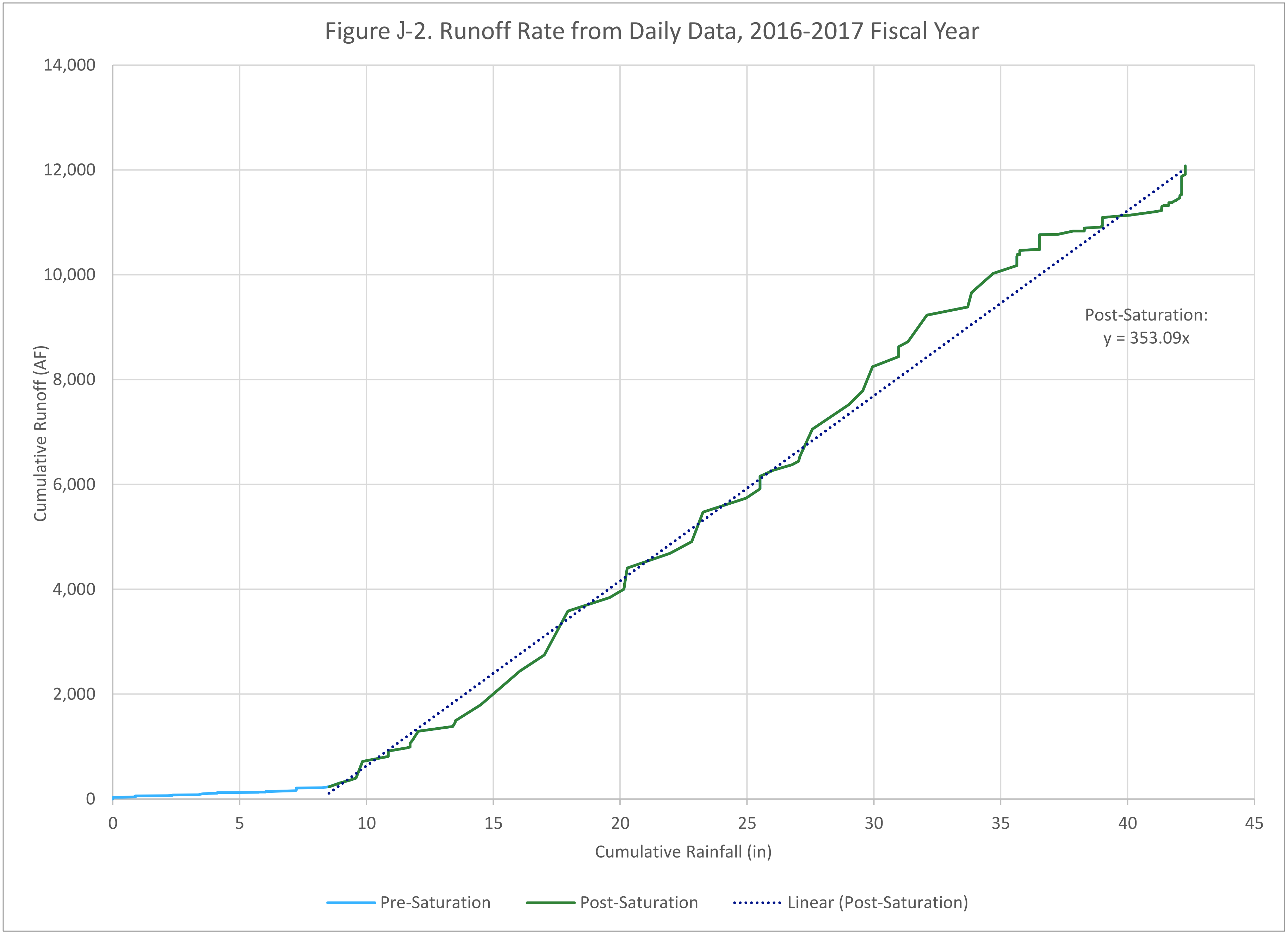


Figure J-1. Estimated Creek Flows
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Runoff (cfs)
7/1/2016
1/17/2017
8/5/2017
2/21/2018
9/9/2018
3/28/2019
10/14/2019
5/1/2020
Time
Stafford Lake Watershed, cfs
Leveroni Canyon Runoff, cfs
Bowman Canyon Runoff, cfs
Combined Leveroni and Bowman Canyons, cfs

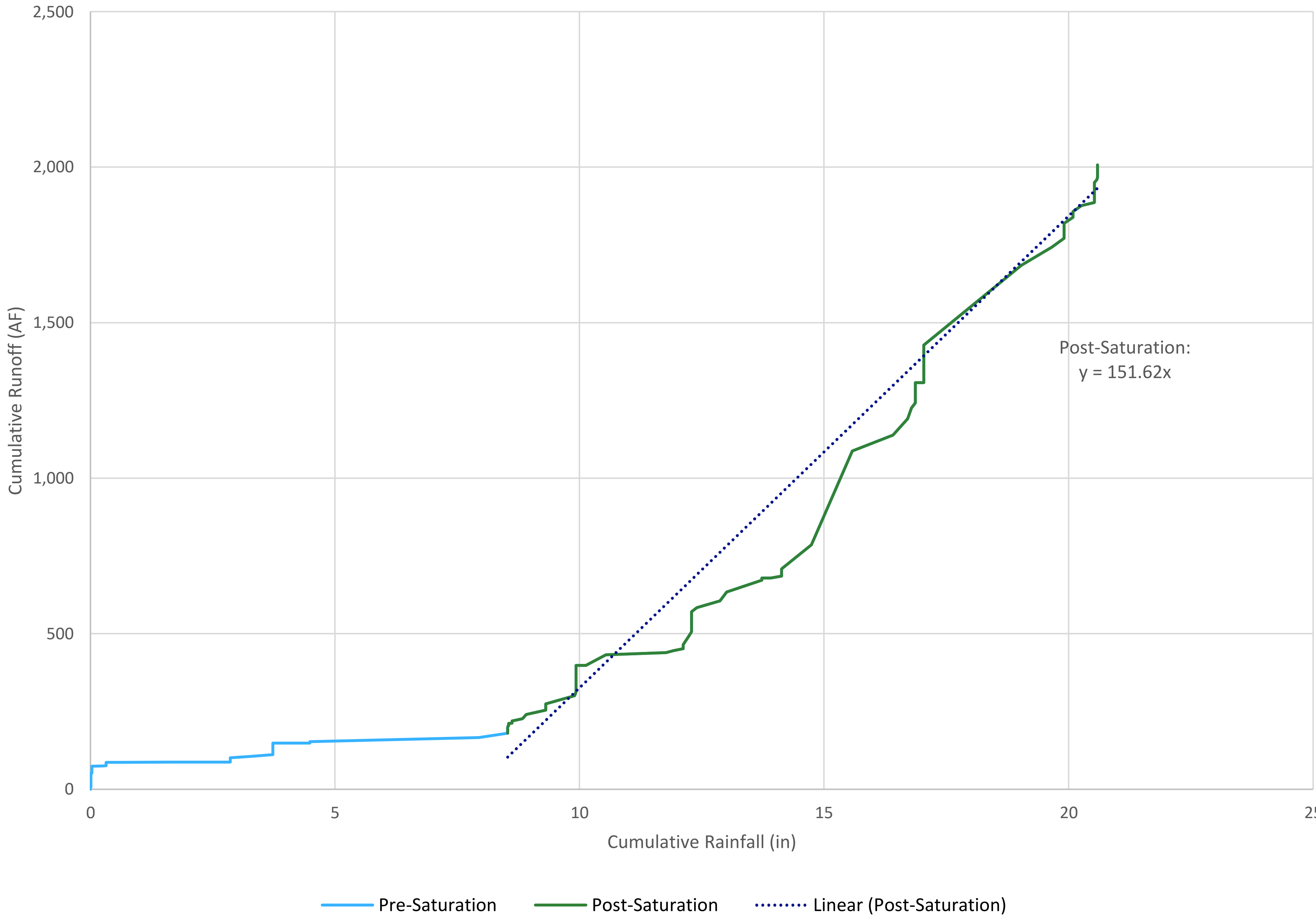


WEST YOST

K-C-861-60-21-04-WP

North Marin Water District
Local Water Supply Enhancement Study
Last Revised: 03-29-22

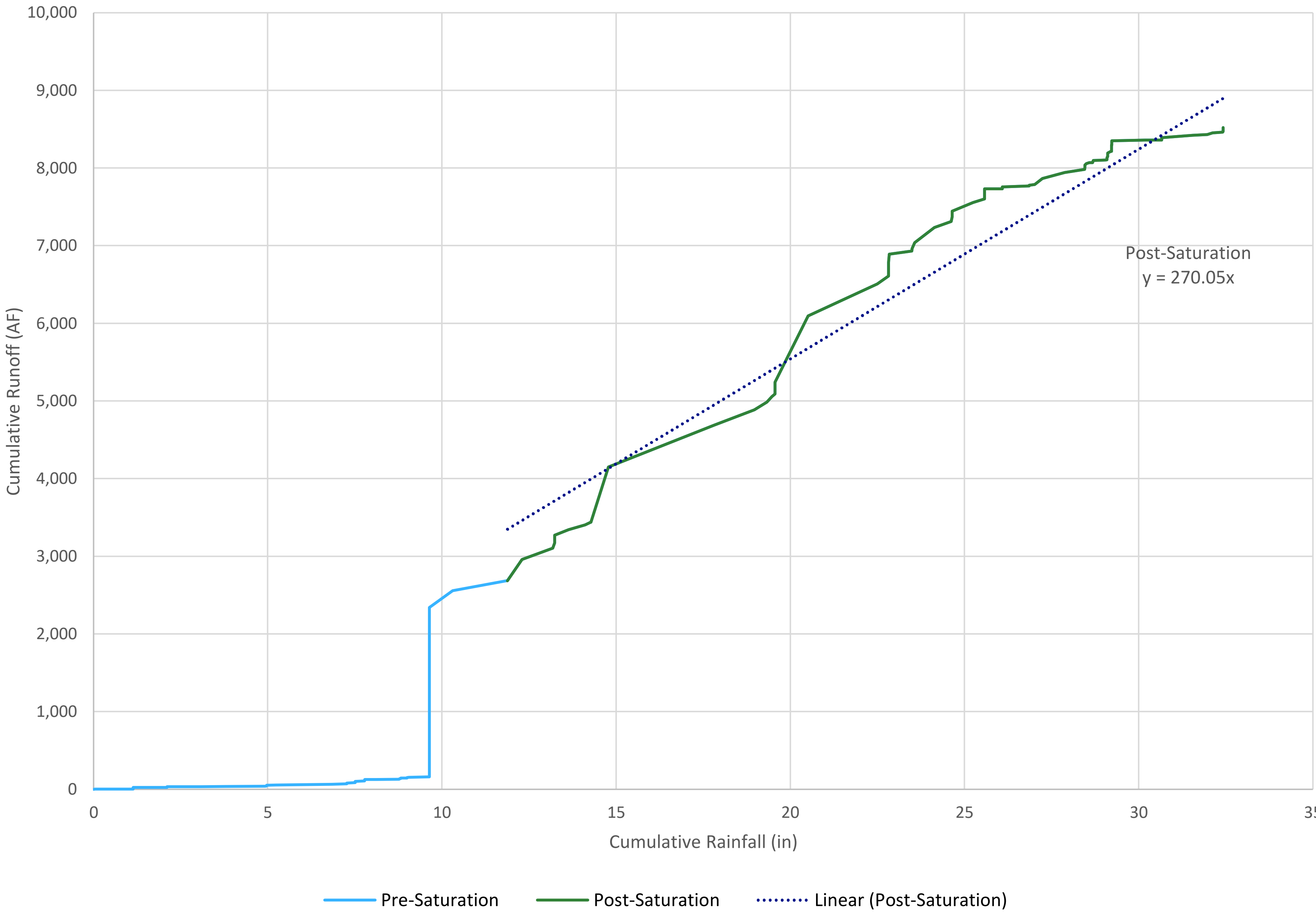
Figure J-3. Runoff Rate from Daily Data, 2017-2018 Fiscal Year



WEST YOST

K-C-861-60-21-04-WP

Figure J-4. Runoff Rate from Daily Data, 2018-2019 Fiscal Year



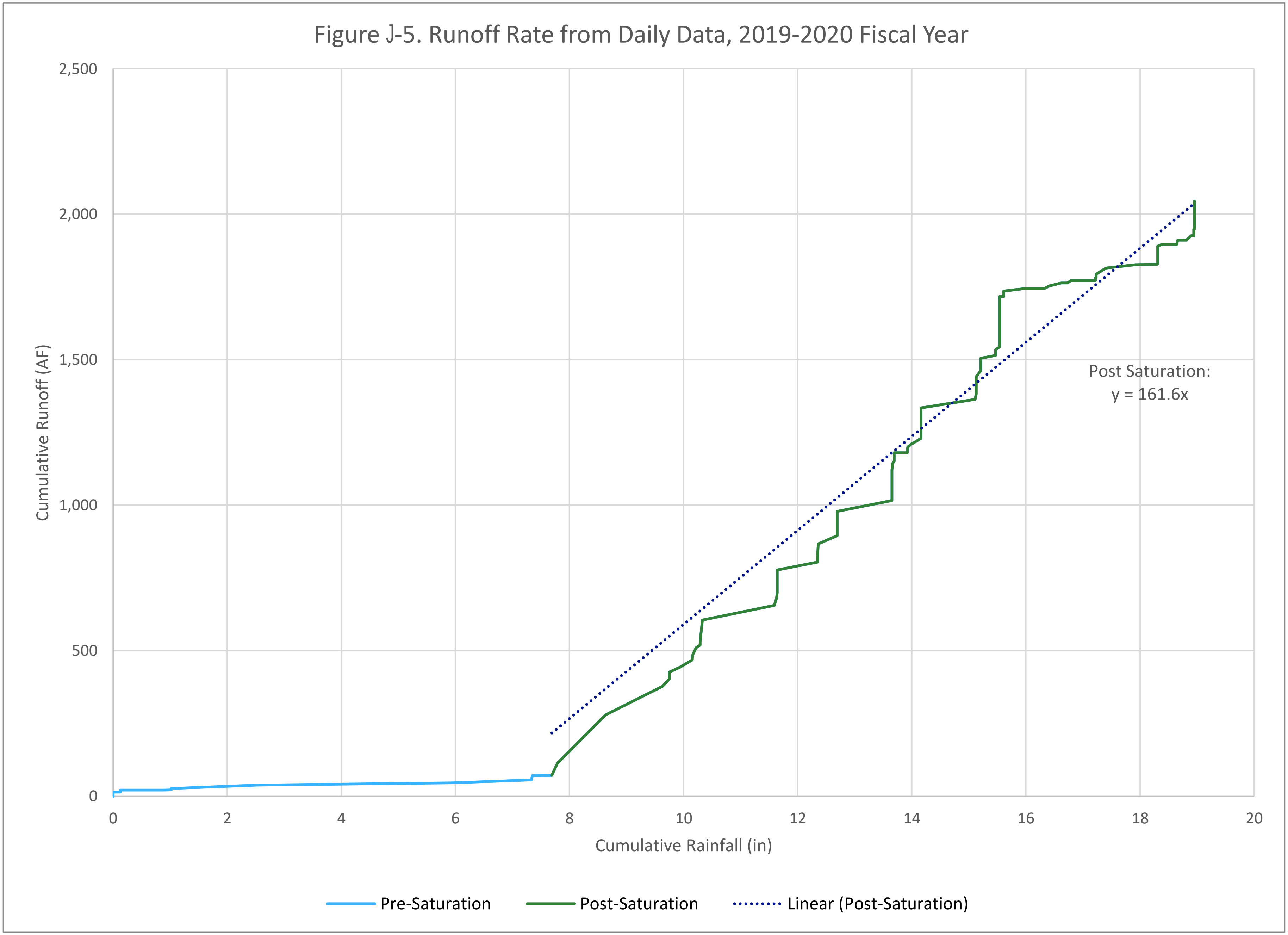
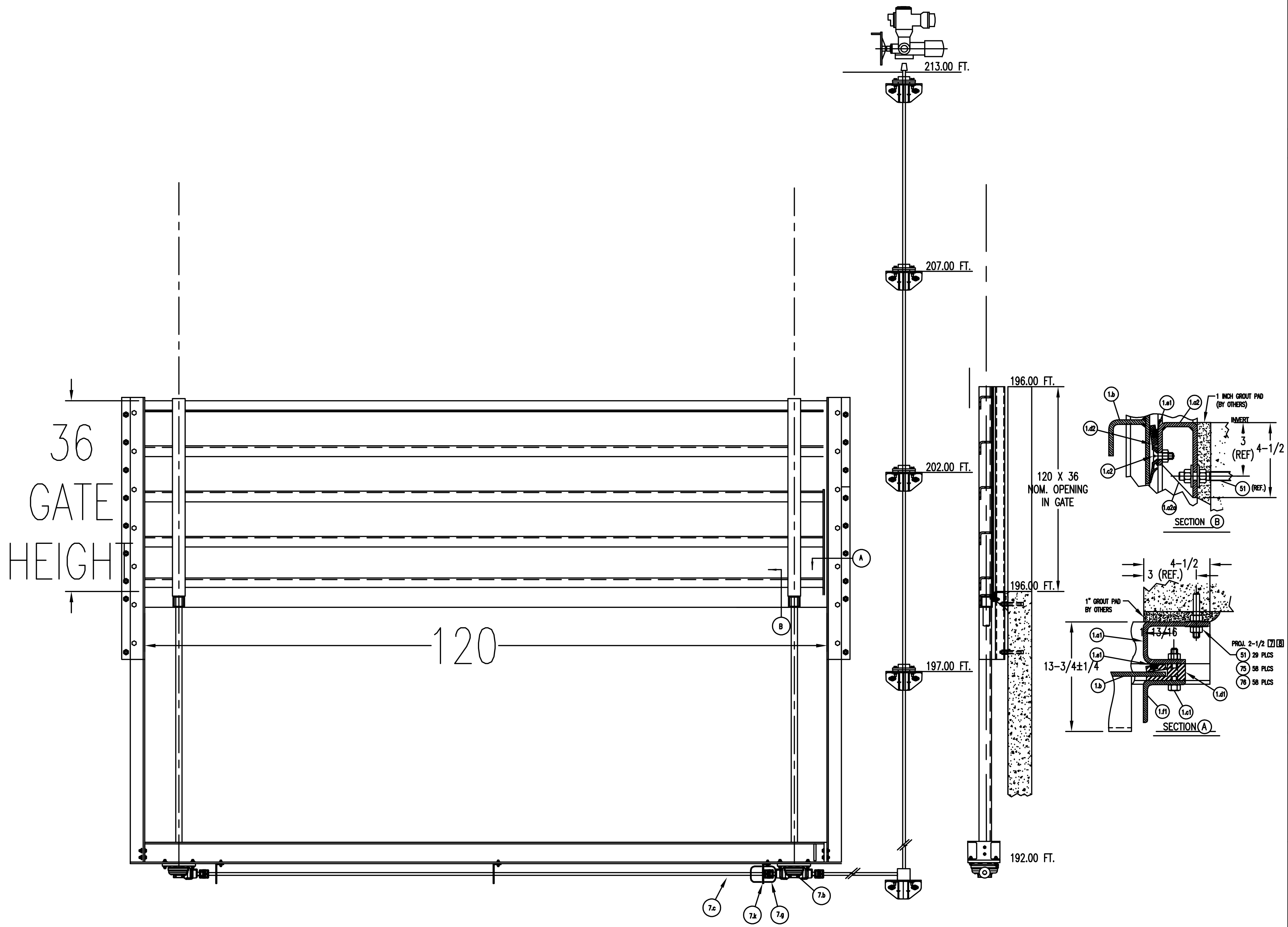


Figure J-5. Runoff Rate from Daily Data, 2019-2020 Fiscal Year
2,500
2,000
1,500
1,000
500
0
Cumulative Runoff (AF)
0
2
4
6
8
10
12
14
16
18
20
Cumulative Rainfall (in)
Post Saturation:
y = 161.6x
Pre-Saturation
Post-Saturation
Linear (Post-Saturation)

Appendix K

Slide Gate Schematic



MATERIAL KEY	FINISH KEY	PAINT KEY
1. CAST IRON:ASTM A-126 CL. B 6. STRUCTURAL STEEL: ASTM A-36 9A. STN STL SHAPES:ASTM A-276 TY.304/304L D/C 9B. STN STL SHAPES:ASTM A-276 TY.316/316L D/C 9C. STN STL PLATE:ASTM A-240 TY.304/304L D/C 9D. STN STL PLATE:ASTM A-240 TY.316/316L D/C 13. NEOPRENE RUBBER:ASTM D-2000 14. CLEAR PLASTIC BUTYRATE PIPE:ASTM D-707 15A. STN STL HDW:ASTM F-593C/D & 594 GRP 1 (TY 304) 15B. STN STL HDW:ASTM F-593G/H & 594 GRP 2 (TY 316) 15C. STN. STL. HDW: ASTM F-879 GRP 1 (TYP 304) 21. UHMW POLYETHYLENE:ASTM D-6712	1. AS CAST 2. MILL 3. MACHINED 4. GALVANIZE-ASTM A-123 5. GALVANIZE-ASTM A-153 6. SEE PAINT KEY 35A. PVC PLASTIC PIPE:ASTM D-1785 99. ALUMINUM BRZ: ASTM B505 AL. C95800	6H BLAST CLEAN PER SSPC-SP6 (2) CTS POLYAMIDE EPOXY PAINT & (1) CT POLYURETHANE ENAMEL (TDFT-7 MILS) COLOR: GRAY 6 6H-L VENDER STANDARD PRIME COAT (2) CTS POLYAMIDE EPOXY PAINT & (1) CT POLYURETHANE ENAMEL (TDFT-7 MILS) COLOR: GRAY 6 6T AUMA STANDARD SHOP COAT

ITEM DESCRIPTION	MATERIAL KEY	FINISH KEY	PART NO. OR SIZE (FOR WATERMAN USE ONLY)	QTY/ GATE	TOTAL QTY
1. GATE ASSEMBLY	-	-	REF. 108496	1	2
a) FRAME WELDMENT	9C	2	REF. 108499	1	
1) GUIDE RAIL	9C	2	REF. 108312 (MODIFIED; NO KICK)	2	
2) CROSS RAIL	9C	2	REF. 110616	1	
a) GUSSET	9C	2	REF. 110748	6	
4) HEAD RAIL	9C,15A	2	REF. 110802-2 (8 X 3 X 1/4 CHANNEL)	2	
b) COVER WELDMENT	9A,9C	2	1/4 THK (SEE BUILD PLANS)	1	
c) ASSEMBLY HARDWARE	15A,15C	2	3/8 NC	A/R	
1) GUIDE RAIL HARDWARE	15A	2	3/8 NC X 2-1/4 LG.	A/R	
2) CROSS RAIL HARDWARE	15A,15C	2	3/8 NC X 1-1/4 LG.	A/R	
d) SEATS & SPACER	21	-	-	-	
1) SIDE SEAT	21	2	REF. 107595/108391	2	
2) CROSS SEAT	21	2	REF. 109999	1	
e) SEALS	-	-	-	-	
1) SEAL	13	2	REF. 109352-21 (7/16)	A/R	
f) RETAINER ASSEMBLY	-	-	-	-	
1) RETAINER WELDMENT	9A,9C	2	REF. 108501 (3 X 3 X 1/4 LG. ANGLE)	2	
2) STEM BRACE	9C	2	REF. 110806-22	1	
3) ANCHOR TAB	9C	2	REF. 111072-1	2	
g) STEM BOLT & NUT	15A	2	5/8 NC X 3-1/2 LG.	4/4	
3. STEM (RISING)	9A	2,3	1-1/2 DIA., 4 TPI, 5 9 (REF. 106219-9)	2	4
7. LIFT ASSEMBLY (CAN BE ROTATED 180°)	-	-	-	1	2
a) ELECTRIC MOTOR OPERATOR	-	6T	TYPE AUMA SA10.2/AM02.1	1	
b) LIFT (DRIVE) 'AK'	1,99	6H-L	3R4-2:1 TRIPLE BOSS @ 90° (SYTELINE # 48895396)	1	
1) INPUT FLANGE	1	6H	FA10 ADPATER FLANGE	1	
c) LIFT (SLAVE) 'AT'	1,99	6H-L	TYPE 3R4-2:1 (REF. 110191)	1	
d) BASEPLATE	6	6H	REF. 110628-1	2	
e) FLAT HEAD BOLT	15C	2	3/8 NC X 1-1/4 LG.	8	
f) HEX HEAD BOLT, NUT & WASHER	15A	2	1/2 NC X 2-1/2 LG.	8/8/16	
g) TANDEM SHAFT CONFIGURATION	-	-	REF. 110860	2	
h) KEY (NOT SHOWN)	-	-	1/4 X 1/4 X 1 LG.	1	
k) SHAFT SUPPORT	9C,21	2	REF. 111034	1	
8. STEM COVER (W/ MYLAR STRIP INDICATER)	14,35A	2	REF: 110257 (3 X 2-1/2 IN) 36 LG	2	4
15. IDENTIFICATION TAG	9D	2	REF. 110493	1	2
51. ALL THREADED STUD 8	9B	2,3	1/2 NC X 7 LG.	29	58
75. HEX NUT	15B	2	1/2 NC	58	116
76. WASHER	316 SS	2	1/2 DIA.	58	116

NOTES: UNLESS OTHERWISE SPECIFIED.
1. (GATE CAPACITY) MAXIMUM SEATING HEAD = 2 FT.; MAXIMUM UNSEATING HEAD = 1 FT. (S.P.= 85 LB/IN)
2. OPERATING HEAD FROM GATE CENTER LINE: SEATING HEAD = 2.0 FT.; UNSEATING HEAD = 1.0 FT. 6
3. TORQUE SWITCH SETTING CAPACITY = 5,598 LBS @ 13.5 IN/MIN (81 FT-LBS @ 54 RPM) / PER LIFT.
4. TURN HANDCRANK CCW TO OPEN (LOWER) GATE.
5 29° STUB ACME THREADS. (1/4 PITCH, 1/4 LEAD, SL)
6 CONTRACTOR TO VERIFY OR SUPPLY.
7 DIMENSION INCLUDES GROUT PAD THICKNESS.
8 CONTRACTOR TO PROVIDE HILTI HIT-RE 500 V3 (WET OR DRY CONDITIONS), HILTI HY-200 (DRY CONDITIONS ONLY); OR EQUAL EPOXY FOR ANCHORS.
9 SHOP NOTE: PROVIDE RIGHT HAND THREADS FOR AK LIFT; LEFT HAND THREADS FOR AT LIFT.

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120 X 36 WATERMAN MODEL SS-254-1-Y-X SLIDE GATE

FOR:

PO:

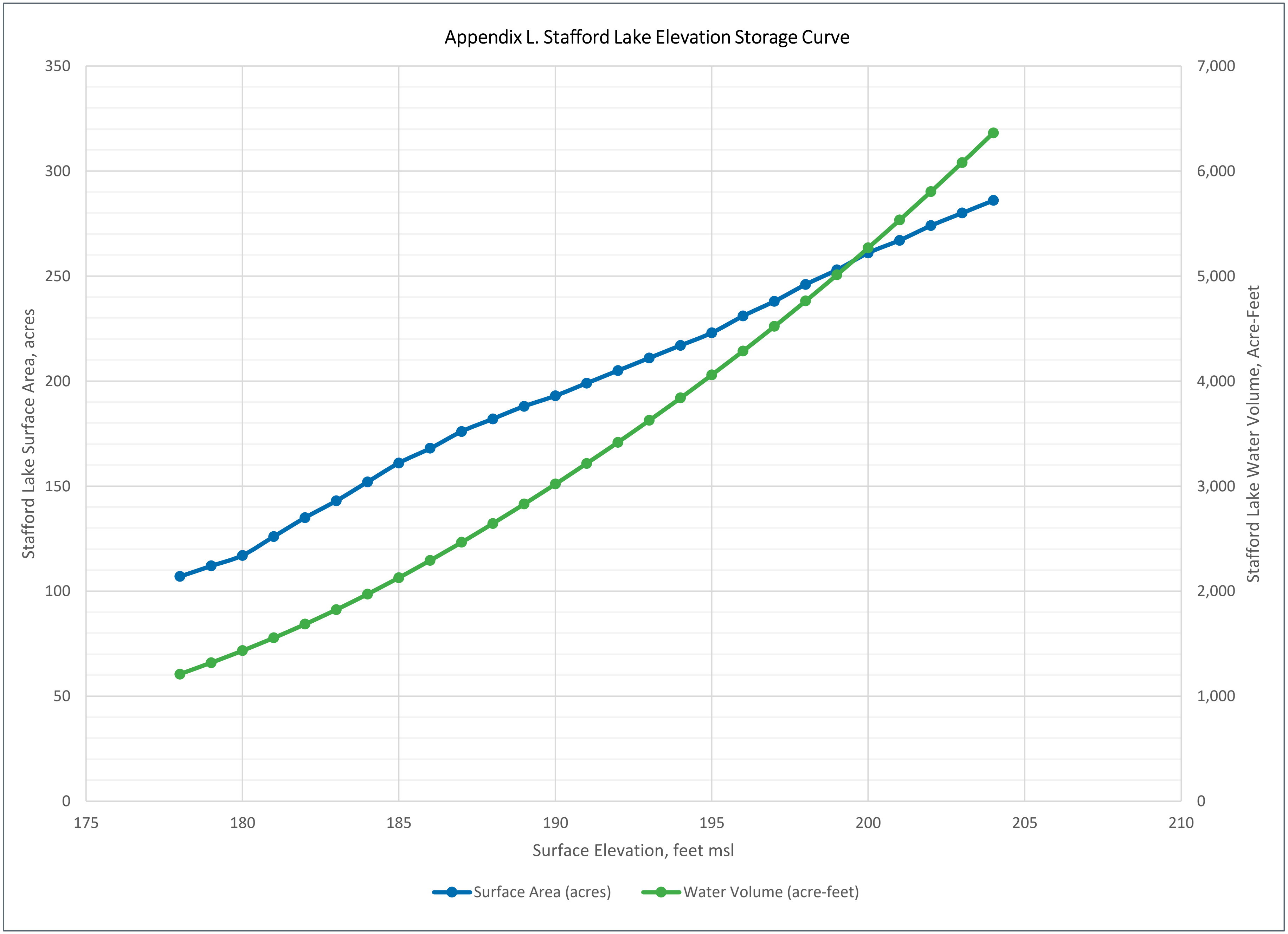
REF:

ENG: MITCHEEL E. FREEMAN

REV.NO.	DATE	BY	JOB NO.	PROJECT MANAGER
REV.NO.	DATE	BY	QUOTE NO.	DRAWN BY / CHK'D BY / ENGINEER
REV.NO.	DATE	BY	QUOTE ITEM NO.	SHEET 1 OF 1
REV.NO.	DATE	BY	SCALE	DATE NOV. 4, 2021
REV.NO.	DATE	BY JG	DRAWING NO.	

Appendix L

Stafford Lake Elevation Storage Curve



Appendix L. Stafford Lake Elevation Storage Curve
350
300
250
200
150
100
50
0
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Stafford Lake Surface Area, acres
Stafford Lake Water Volume, Acre-Feet
175
180
185
190
195
200
205
210
Surface Elevation, feet msl
Surface Area (acres)
Water Volume (acre-feet)

Appendix M

July 8, 2022 Draft Technical Memorandum #3
Stafford Lake Hydraulic Modeling Evaluation

8 July 2022

DRAFT Technical Memorandum #3 – Stafford Lake Hydraulic Modeling Evaluation

To: Tony Williams, North Marin Water District

From: Connor Rutten, P.E., Kennedy Jenks

Reviewed By: Rod Houser, P.E., Kennedy Jenks

Subject: Stafford Lake Hydraulic Modeling Evaluation
KJ 2168014*00, Task 3

1.0 Purpose and Background

As California's wet season becomes increasingly shorter with higher intensity storms, North Marin Water District (District) is looking to increase their ability to store surplus water during the wet season in the Stafford Lake Reservoir (Stafford Lake) by increasing the dam height from 196 ft to 199 ft. The main purpose of this technical memorandum (TM) is to identify any potential system improvements that would allow for the District to convey additional flow to Stafford Lake from the North Marin Aqueduct (NMA) via the San Marin Pump Station (PS).

The District owns and operates Stafford Lake and Stafford Lake Water Treatment Plant (WTP), which provide another water supply for the District. The treatment plant is capable of serving the District's Zone 1. Stafford Lake can store up to 4,450 acre-feet (AF) of storage, and the WTP can produce up to 6 MGD of finished water. Stafford Lake normally fills via rainfall runoff from the 8.3 square miles of surrounding watershed. However, during periods of extended drought, the District has also filled the lake by pumping water from the NMA (via their agreement with Sonoma Water) up to the lake via the San Marin PS. The District currently has capacity to convey up to 7.2 MGD to the Stafford Lake, which is fed via San Marin PS and Zone 2 (see **Appendix A** for the Distribution System Profile).

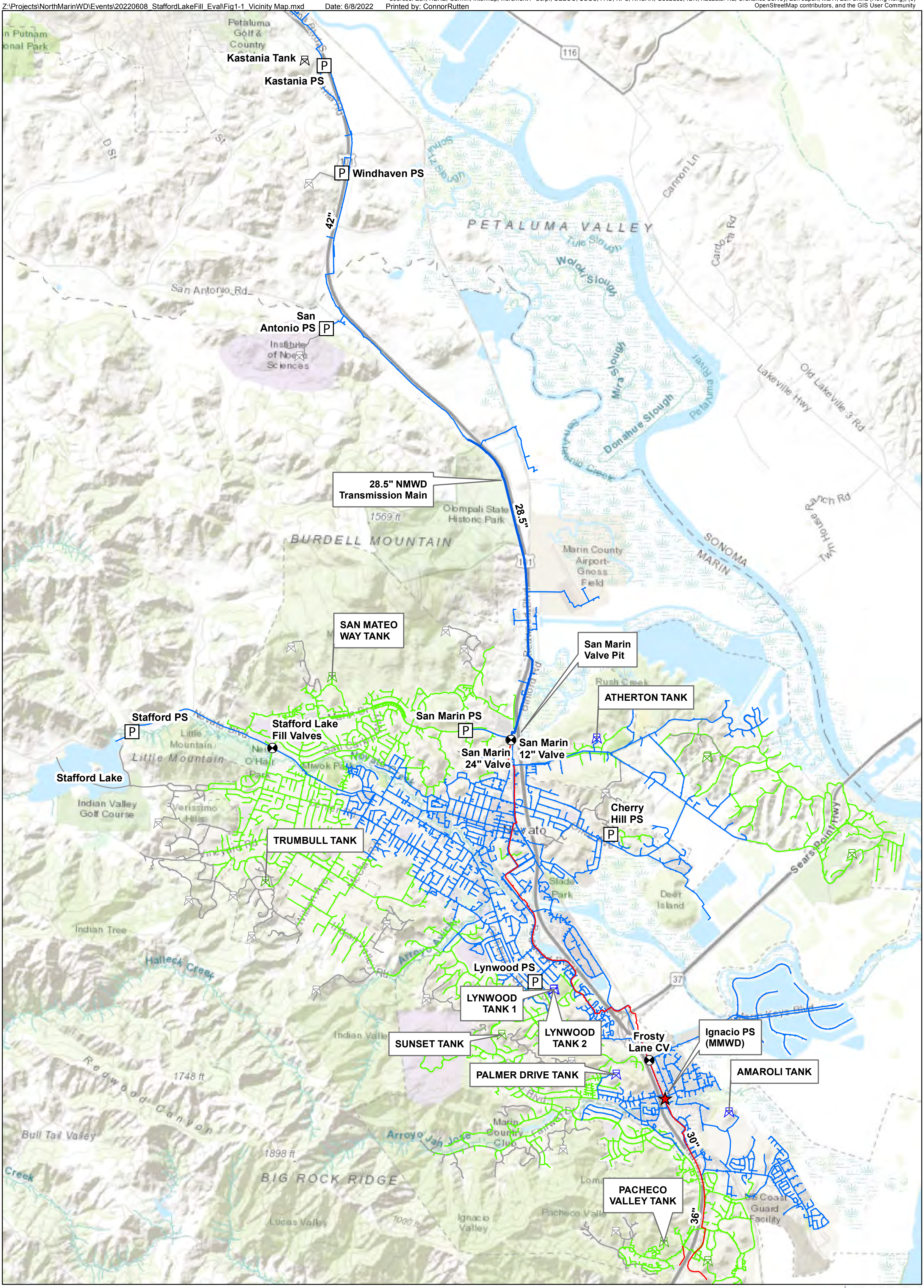
Kennedy Jenks previously provided the District with two (2) TMs under Task Order 2. The first TM (TM 1) evaluated the firm pumping capacity of San Marin PS. San Marin PS produced up to 7 MGD while filling the lake based on 2021 pumping data. However, the firm pumping capacity of San Marin PS with the largest pump out of service is only 5.2 MGD, indicating that San Marin PS operates beyond its firm capacity at times when filling Stafford Lake. The second TM (TM 2) evaluated the impacts of the reimplementation of Kastania Pump Station (KPS) on the District's system. It quantified how much flow the District could provide to Marin Municipal Water District's (MMWD) Ignacio Pump Station (IPS) under various operational scenarios without violating the District's performance criteria (system pressures and velocities). The analysis varied the following parameters:

- Status of Kastania Pump Station (on/off)

- Valve configurations at the San Marin Valve Pit and Frosty Lane
- Total System Demand
- Status of Zone 1 Pumps (on/off)
- Status of Zone 1 Tanks (open/closed)

This provided the District with information on how Kastania Pump Station (KPS) and Ignacio Pump Station (IPS) operations could affect the District's system.

The analysis included in this TM (TM 3) combines the results from the previous two analyses to evaluate what system improvements could be made to increase the flow to Stafford Lake under various operational scenarios. **Figure 1-1** provides a high-level overview of the District's system and highlights the facilities relevant to this Stafford Lake hydraulic evaluation.



Legend

P Pump	**Pipe by Zone**		**Tank by Zone**
Valve	Zone 1		Zone 1
Ignacio PS	Zone 2		Zone 2
	MMWD		Other
	Supply		
	Other		

Kennedy Jenks

North Marin Water District
Marin County, CA

Stafford Lake Hydraulic Modeling Evaluation Pressure Zones 1 and 2 Vicinity Map

2168014*00

Figure 1-1

2.0 Project Scope

The scope of this analysis consists of the following:

1. Identify potential system improvements that could increase the flow conveyed to Stafford Lake
2. Evaluate the impacts of the reinstated KPS on the District's ability to fill Stafford Lake
3. Analyze a new potential bypass interconnection around San Marin Valve Pit that would allow Stafford Treatment Plant to feed the District's Zone 1 with San Marin Valve Pit and/or NMA offline.

This analysis utilized the updated InfoWater hydraulic model developed as part of TM 2 that involved adding KPS to the model and including the proper controls for the scenarios where KPS is online. This model focuses primarily on the District's distribution system, and includes a portion of the NMA that runs through the District's service area (from Kastania tank to Marin Valley Drive). The existing model is limited in scope, however, as it does not presently include any aqueduct data or other potential boundary conditions (e.g., tanks or pump stations) north of Kastania tank, or south of Marin Valley Drive.

For Items 1 and 2 listed above, the following information was required for each Stafford Lake fill scenario modeled:

- KPS Status
- Kastania Tank water level
- Stafford Lake water level
- Zone 1 tank initial water levels
- Zone 1 Pump Station Statuses (including San Marin PS)
- MMWD Demand at Ignacio PS
- Aqueduct control valve positions (open/closed)
    - San Marin Valve Pit
    - Frosty Lane

The settings and assumptions made for the information needed above are discussed in the following sections. For Item 3, the District provided information for the proposed bypass interconnection piping alignments, pipeline sizes, and valve locations to be analyzed. These bypass configurations are discussed in the following sections.

3.0 System Information and Model Setup

3.1 Stafford Lake Fill Operations

While Stafford Lake is being filled, there are specific valves that are opened and closed in order to direct flow from Zone 2 into Stafford Lake, as shown on **Figure 3-2**. There are two isolation valves near the intersection of Novato Blvd and Sutro Ave that normally closed to separate Zone 1 and Zone 2. These valves are opened in order to direct flow from Zone 2 into the 18-inch fill line along Novato Blvd and up to Stafford Lake. Another valve further east along Novato Blvd near Eucalyptus Ave is then closed to maintain separation between Zone 2 and the rest of Zone 1.

San Marin PS is the primary PS responsible for supplying water to Zone 2 while Stafford Lake is filling. The system HGL in this region of Zone 2 is regulated by the San Mateo Way tank, which is approximately 100 ft higher than Stafford Lake. Based on correspondence with District Operations staff, two (2) of the three (3) pumps at the San Marin PS are normally operated while filling Stafford Lake. When the San Mateo Way tank level drops to its minimum operating level, the third pump is called on to refill San Mateo Way tank. This third pump is called back off once San Mateo Way tank is full.

Flow into Stafford Lake is controlled via a flow control valve located at the Stafford Lake valve vault, with a current maximum flow of 5,000 gpm or 7.2 MGD. According to historical flow tests performed by District Operations Staff, this is the current maximum flow that can be conveyed into Stafford Lake without draining Zone 2 and exceeding the capacity of San Marin PS. See **Section 4.4** for further information on the rationale for this maximum flow rate.

Figure 3-1 shows a simplified hydraulic profile between San Marin PS and Stafford Lake during filling operations with San Mateo Way Tank 30% full, 3 pumps active at San Marin PS, 7.2 MGD flowing into Stafford Lake, for a range of system winter demands and Stafford Lake HGLs. See **Table 3-3** for additional information on the system demands and Stafford Lake HGLs evaluated. See **Appendix A** for more detail on the system hydraulic profile.

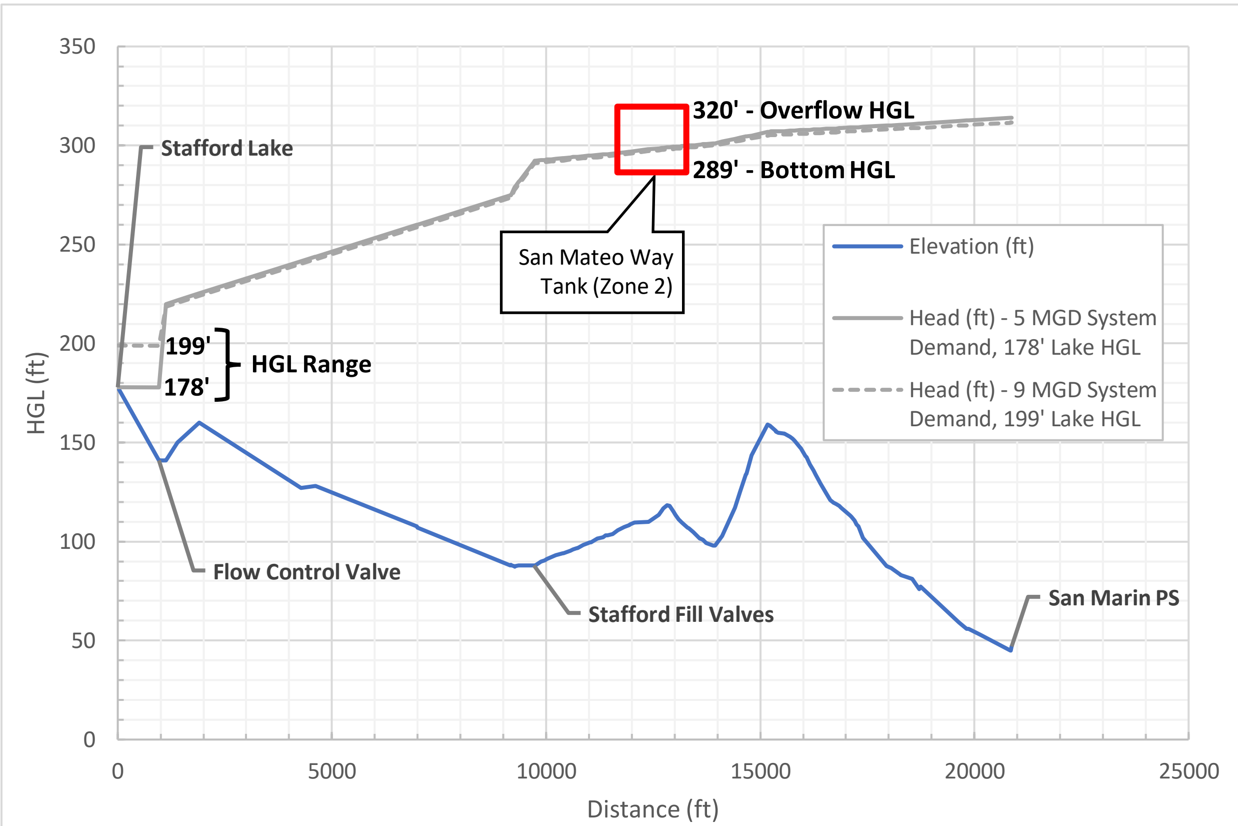


Figure 3-1: San Marin PS to Stafford Lake System HGL Plot – 7.2 MGD to Stafford Lake

3.2 San Marin Valve Pit Bypass Operations

The purpose of bypassing the San Marin Valve Pit is to allow for Stafford Lake to feed the San Marin PS while the NMA is offline due to required repairs/rehabilitation or due to a pipeline failure. The District has identified two possible bypass configurations that were evaluated using the hydraulic model. The system pressures and velocities for two proposed configurations were compared and are presented in Section 5. Both configurations are shown in **Figure 3-3** and are described below.

Configuration 1 consists of installing 240 LF of 24-inch pipeline from the downstream side of the SM Valve Pit to the 24-inch east/west pipeline that connects the NMA to the San Marin PS suction line. A 24-inch isolation valve would also be required to fully isolate the NMA while flow is conveyed around the San Marin Valve Pit to San Marin PS.

Configuration 2 consists of installing 1,680 LF of 24-inch pipeline from Escallonia Dr/Redwood Blvd north to the intersection of San Marin Dr and E Campus Dr. This configuration also requires installing new isolation valves to fully isolate the NMA and direct flow around the San Marin Valve Pit and towards the San Marin PS.

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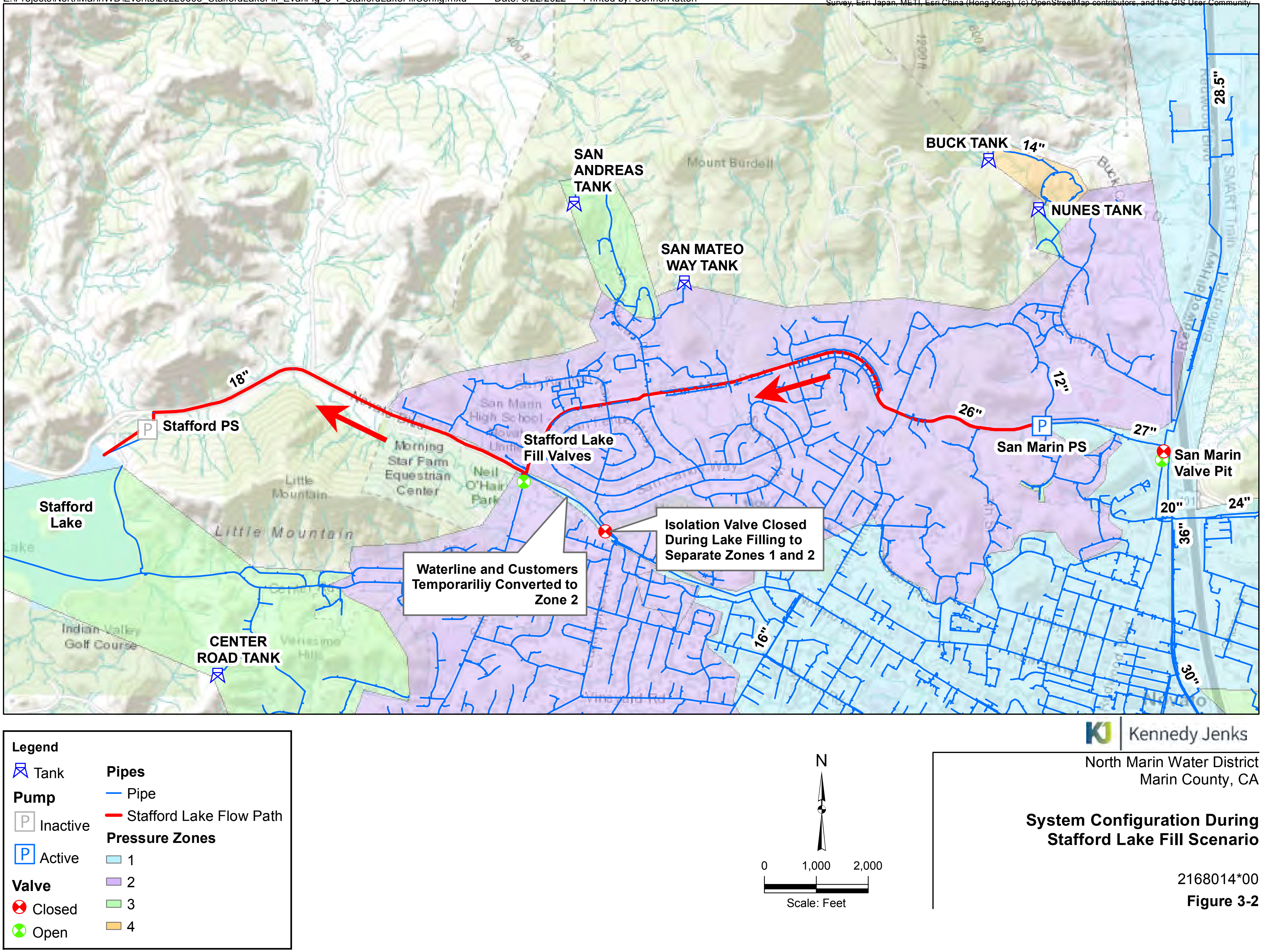

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Marin County, CA

System Configuration During Stafford Lake Fill Scenario

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Figure 3-2

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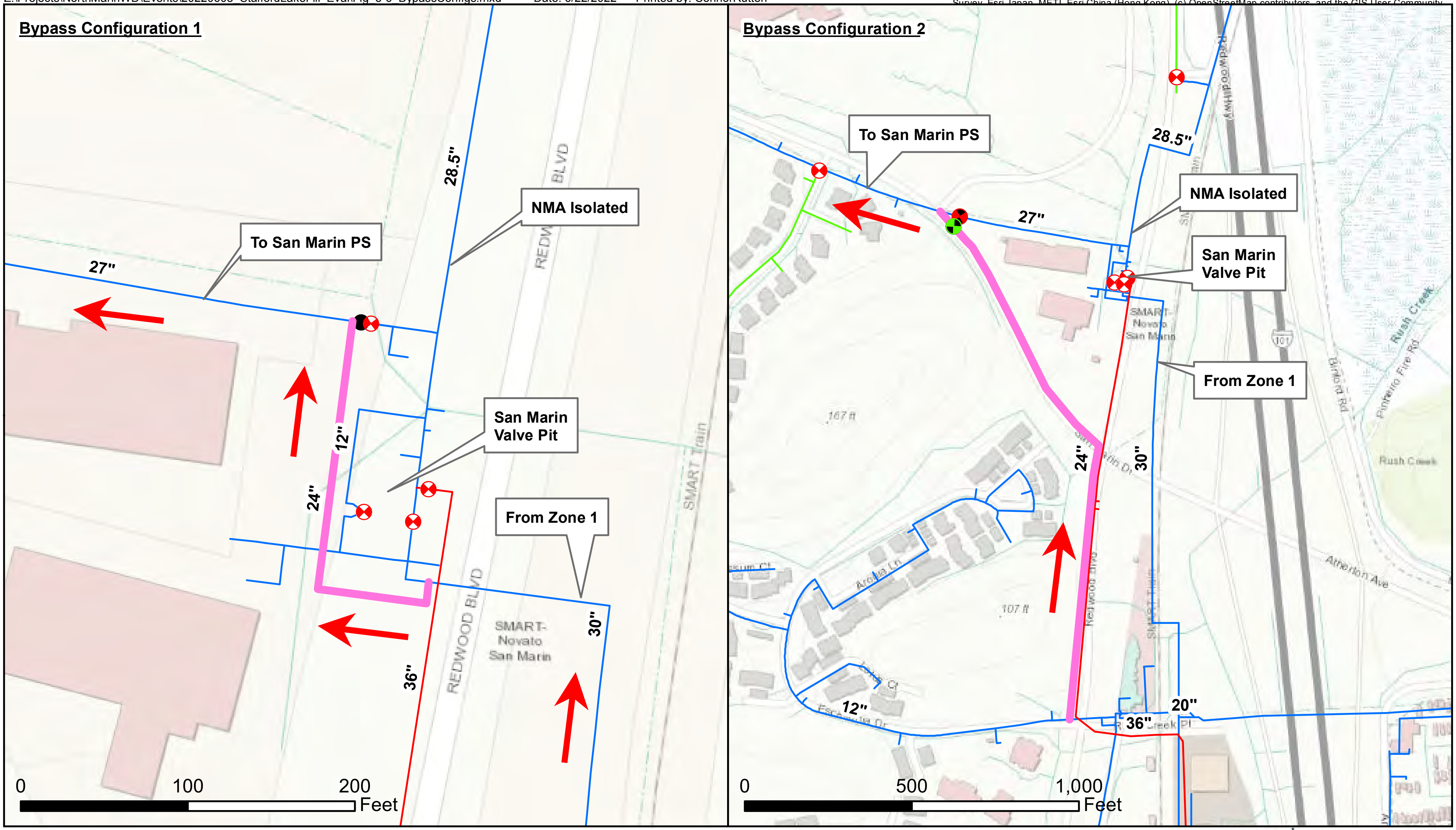
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

New Valve	Existing Valve	Pipes
STATUS	**STATUS**	**Pipe Zone**
Closed	Closed	Zone 1
Open	Open	Zone 2
New Bypass Piping		MMWD
		Supply
		Other

Notes:
1. North Marin Aqueduct Closed
2. System Demand: 5 MGD
3. Stafford WTP Flow Rate: 6 MGD
4. San Marin PS # Pumps Active: 2

N

Kennedy Jenks

North Marin Water District
Marin County, CA

San Marin Valve Pit
Bypass Configurations

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Figure 3-3

3.3 System Facilities and Model Initial Conditions

Zone 1 is fed by five (5) tanks, listed below along with their nominal storage in million gallons (MG):

- Atherton Tank (5 MG)
- Lynwood Tank 1 (0.5 MG) and Lynwood Tank 2 (0.85 MG)
- Palmer Tank (3.0 MG)
- Amaroli Tank (4.5 MG)

The initial levels/statuses in these tanks do not have a significant impact on the Stafford Lake fill operations since they are hydraulically separated from Zone 2; therefore, all of the tanks were open to the system during the modeled scenarios, and had initial levels set to 30% full as shown by **Table 3-1** to simulate the minimum operating level of the tanks (the remainder of the tank volume is preserved for fire storage). In reality, these tanks will cycle numerous times while Stafford Lake is filling; however, the model evaluations are only steady-state, and examining Zone 1 pressures/tank cycling is not the focus of this analysis. Stafford Lake is also connected to Zone 1; see **Section 3.3.1** for a description of the range of the HGLs modeled.

Table 3-1: Zone 1 Modeled Initial Tank Levels

Tank	Maximum Level (ft)	Initial Tank Level (ft)	% Full	HGL (ft)
Atherton Tank	31.5	9.5	30%	142.5
Lynwood Tank 1	30.4	9.1	30%	141.8
Lynwood Tank 2	33.4	10.0	30%	141.0
Palmer Tank	30	9.0	30%	139.0
Amaroli Tank	30	9.0	30%	139.0

Zone 2 is fed by six (tanks), listed below along with their nominal storage in MG:

- San Mateo Way Tank (5.0 MG)
- Crest Tanks 1 and 2 (total 1.0 MG)
- Trumbull Tank (1.5 MG)
- Sunset Tank (5.0 MG)
- Pacheco Tank (5.0 MG)
- Air Base Tank (1.03 MG)

The initial levels of the Zone 2 tanks were also set to 30% full, reflecting the minimum operating level of the tanks. The measured flow in or out of the tank will illustrate the direction of flow, and more specifically, the ability of San Marin PS to fill San Mateo Way Tank. If San Mateo Way Tank is still draining at 30% full, the operational scenario is not valid, as the fire storage volume is being depleted. The initial levels shown in **Table 3-2** are used for all modeling scenarios.

Table 3-2: Zone 2 Modeled Initial Tank Levels

Tank	Maximum Level (ft)	Initial Tank Level (ft)	% Full	HGL (ft)
San Mateo Way Tank	31.5	9.5	30%	298.2
Crest Tank	47.5	14.3	30%	308.1
Trumbull Tank	23.5	7.1	30%	292.1
Sunset Tank	35.5	10.7	30%	298.7
Pacheco Tank	24.6	7.4	30%	305.8
Airbase Tank	27.5	8.3	30%	258.7

Kastania Tank (12.0 MG), which under the majority of conditions maintains the suction head for KPS and the NMA, is set to an initial tank level of 30 ft (75% full). This tank level corresponds to a hydraulic grade line (HGL) at elevation 225 ft for all scenarios, and is active for all scenarios.

Lastly, there are four (4) major pump stations (PS) that take suction from Zone 1. Pump station output varied depending on the scenario definitions. Firm capacities of each pump station are listed below:

- San Marin PS (3,600 GPM, 5,400 GPM when operated beyond firm pumping capacity when filling Stafford Lake and San Mateo Way tank)
- School Rd PS (400 GPM)
- Cherry Hill PS (140 GPM)
- Lynwood PS (3,600 GPM)

All four (4) of these pump stations are active for all modeled scenarios, simulating the end of a tank fill cycle with the Zone 2 tanks nearing full capacity. Other minor PS's including Windhaven PS (25 GPM) and San Antonio PS (100 GPM) were assumed to be "off" for all model scenarios. Lastly, the Hayden and Diablo Hills PS, which both pull from Zone 1 and sustain system pressures via hydropneumatic tank systems, were active for all model scenarios. Both draw miniscule flow from Zone 1 (< 5 GPM).

3.3.1 Initial Conditions Specific to Stafford Lake Fill Scenarios

As the District's hydraulic profile shows (**Appendix A)**, there are three (3) valve pits/interties that control hydraulic connectivity between NMWD's Zone 1 and the NMA. These valve pits are San Marin (SM), Hanna Ranch (HR), and Frosty Lane (FL). Based on correspondence with District staff, the HR control valve is not typically operated, and was closed for all model scenarios. SM Valve Pit contains two control valves, a 12-inch isolation valve (either fully open or closed) and a 24-inch modulating control valve (can be set to a % open or closed). The position of these valves changes based on the status of KPS as well as the amount of system demand.

Each modeled scenario was run under both low system demand (5.0 MGD) and high system demand (9.0 MGD) to simulate the beginning and end of the Stafford Lake fill season, which is assumed to begin in the month of January and end in the month of May. Two different initial water levels were evaluated for the beginning of the fill season (177.9 ft / 185.1 ft), while the max fill level at the end of the fill season was fixed at the new proposed crest elevation of 199 ft. Secondly, some scenarios had KPS active while some did not. **Table 3-3** shows the typical NMA valve positions and Stafford Lake HGLs for the combination of system demands and KPS activity.

Table 3-3: Modeled Valve Status & Scenario Description

Demand Scenario	KPS Off	KPS On	Stafford Lake HGL (ft)
Low (5.0 MGD)	SM 12-inch: Open SM 24-inch: Closed FL Valve: Closed	SM 12-inch: Open SM 24-inch: Closed FL Valve: Open	177.9 / 185.1
High (9.0 MGD)	SM 12-inch: Closed SM 24-inch: Open FL Valve: Closed	SM 12-inch: Closed SM 24-inch: Open FL Valve: Open	199

For scenarios implementing system improvements to convey additional flow to Stafford Lake, the flow control valve setting at Stafford Lake was increased to 10.0 MGD. Beyond 10 MGD, flows through the NMA (while KPS is active and IPS is taking 7.0 MGD) nearly exceed the maximum allowable flow of 22.9 MGD, which corresponds to 8.0 fps.

3.3.2 Initial Conditions Specific to San Marin Valve Pit Bypass Scenarios

For both modeled scenarios, NMA was isolated from the District's system (all San Marin valves closed), relying on Stafford WTP to supply the system. The Stafford WTP production rate was set to 6.0 MGD, which is the current maximum production. A system demand of 5.0 MGD was assumed while evaluating the difference in system performance of the two bypass configurations. San Marin PS was active with 2 pumps running to serve to Zone 2.

3.4 Scenario Definitions

The Stafford Lake fill scenarios evaluated are defined and described below in **Table 3-4**.

Table 3-4: Stafford Lake Fill Scenario Definitions

Scenario	Stafford Lake HGL (ft)	KPS Status	San Marin PS No. of Pumps Active	System Improvements?	Stafford Lake Flow Control Valve Setting (MGD)	Scenario Description/Purpose
1A	177.9/199	Off	2	No	7.2	New San Mateo Tank 24" Fill Line Inactive – simulate existing conditions
1B	177.9/199	Off	2	No	7.2	New San Mateo Tank 24" Fill Line Active – simulate effect of new fill line
1C	177.9/199	Off	3	No	7.2	Scenario 1B but with third pump at San Marin PS active – shows that San Mateo Way tank fills. Baseline for 177.9 ft lake HGL.
2	185.1	Off	3	No	7.2	Scenario 1C, but baseline for 185.1 ft lake HGL
3	177.9/199	**On**	3	No	7.2	Scenario 1C, but KPS On
4	185.1	**On**	3	No	7.2	Scenario 2, but KPS On
5	177.9/199	Off	4	**Yes**	10.0	Scenario 1C with system improvements
6	177.9/199	**On**	4	**Yes**	10.0	Scenario 5 but KPS On
7	177.9/199	**On**	4	**Yes**	10.0	Scenario 6 but no linear improvements (only pump station improvements)
8	177.9/199	**On**	4	**Yes**	10.0	Scenario 6 but limited linear improvements

Both San Marin Valve Pit Bypass scenarios use the same initial conditions, as shown below in **Table 3-5**.

Table 3-5: San Marin Valve Pit Bypass Scenario Definitions

Bypass Configuration	System Demand (MGD)	Stafford Lake HGL (ft)	Stafford WTP Production (MGD)	San Marin PS No. of Pumps Active
1	5.0	177.9	6.0	2
2	5.0	177.9	6.0	2

4.0 Stafford Lake Hydraulic Analysis and Results

4.1 Model Assumptions

All of the model scenarios were run under steady-state conditions, looking at a snapshot of the District's system in terms of pump flow rates, tanks levels, and system pressures. Pump and tank cycling patterns were not evaluated.

The District's hydraulic model terminates at the suction node of the IPS, which is modeled at an elevation of 19.3 ft (see **Figure 1-1**). For each model scenario with KPS active/online, 7.0 MGD of flow is demanded by the IPS since delivering flow to the IPS is the main objective of bringing KPS back online. The flow demanded by the IPS is modeled as a single node which terminates at the end of the 30-inch transmission main. Hydraulic grade elevations on the suction side of Ignacio pump station range between elevations 135 to 170 ft.

4.2 Supply and Demand Summary

While Zone 2 is filling Stafford Lake, the two pump stations hydraulically connected that feed the western portion of Zone 2 and all subsequent higher zones are San Marin PS and Lynwood PS (see **Figure 1-1** and **Appendix A** for the hydraulic connectivity of Zone 2). **Table 4-1** describes the nominal and modeled combined capacity of the two pump stations.

Table 4-1: Western Zone 2 Pump Station Capacities

Zone 2 Pump Station	No. of Pumps Active	Discharge Pressure Zone	Nominal Capacity (gpm)	Modeled Capacity with Zone 1 and 2 Tank Levels at 30%[1]
San Marin[2]	3 of 3	2	5,400	5,678
Lynwood	2 of 3	2	3,600	3,853
Total (gpm)			**9,000**	**9,531**
Total (MGD)			**13.0**	**13.7**

1. Scenario 1C with high system demand (9.0 MGD)
2. 3 of 3 pumps running (based on correspondence with operations, beyond firm pumping capacity)

Comparing the combined supply from these two pump stations with the total demand downstream of the pump stations and the flow demanded by Stafford Lake will provide the maximum amount of system demand that can be supported based on the desired fill rate of Stafford Lake, without draining any of the Zone 2 tanks hydraulically connected to Stafford Lake when the lake is filling. For a total District system demand of 9.0 MGD, the San Marin PS and Lynwood PS meet a total demand of 4.35 MGD (48% of total District system demand). **Table 4-2** shows the available system demand that can be met under the existing and proposed Stafford Lake fill rates.

Table 4-2: Supply vs Demand under Stafford Lake Fill Scenarios

Stafford Lake Fill Rate (MGD)	San Marin + Lynwood PS Capacity (MGD)	System Demand That Can be Met by San Marin + Lynwood PS (MGD)	Corresponding Total District System Demand (MGD)[1]
7.2	13.7	6.5	13.5
10.0	13.7	3.7	7.7

1. Based on 48% ratio of demand met by San Marin and Lynwood PS versus total District system demand

Table 4-2 supports the fact that Stafford Lake can be filled at 7.2 MGD while supporting high system demand (9.0 MGD), previously illustrated by **Figure 3-1**. However, the system will struggle to provide 10.0 MGD to Stafford Lake under high system demand (can only support 7.7 MGD of District system demand). This theory was tested within the model in order to account for any hydraulic restrictions that the simplified supply vs demand analysis done in **Table 4-2** cannot account for. Scenario 1C was run under low and high demand conditions while setting the Stafford Lake flow control valve to 10.0 MGD. **Figure 4-1** below shows that the existing system can only fill Stafford Lake at a rate of 9.0 MGD under low system demand and 8.1 MGD under high system demand based on the available head and existing headloss gradient.

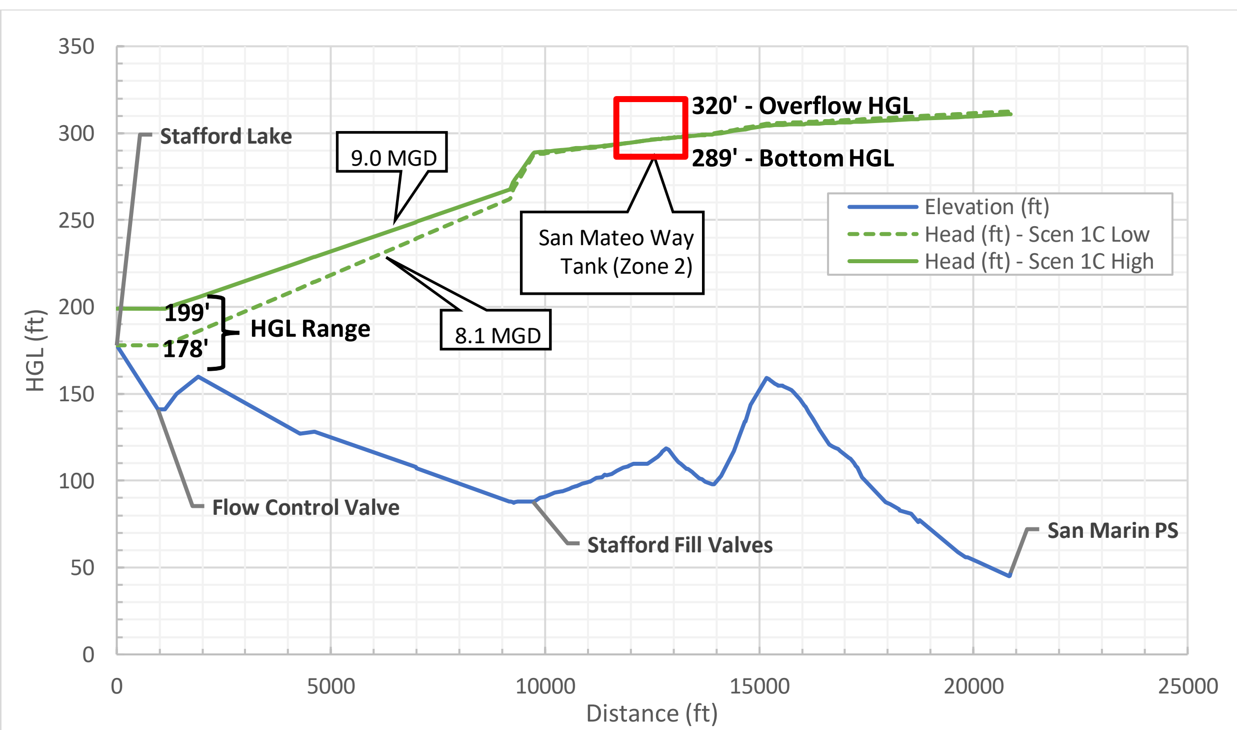

Figure 4-1: Maximum Available Flow to Stafford Lake Under Existing System Conditions for both Low and High System Demand

4.3 System Criteria

As stated under Section 1, the goal of each modeled scenario was to examine the system hydraulics and capacity of the system to fill Stafford Lake under a variety of initial conditions, both with and without system improvements. In addition to the main operational rules listed above in Section 2, the other main system criterion is limiting the maximum velocity through the NMA and through all conveyance piping to Stafford Lake to 8.0 feet per second (fps)[1]. The District also provided correspondence with Sonoma Water indicating that Sonoma Water also utilizes a maximum allowable velocity of 8 fps for major transmission mains. The goal of this criterion is to prevent excessive energy consumption via increased frictional headloss and to protect the interior pipeline coatings from the abrasive effects of high velocities.

Scenarios 1A through 4 simulate the existing distribution system under Stafford Lake fill scenarios. Scenarios 5 through 7 implement combinations of linear improvements and improvements at the San Marin PS in order to increase the flow conveyed to Stafford Lake.

4.4 Existing System Analysis and Results

The complete and detailed model output results for all scenarios can be found in **Appendix B**. The following analysis highlights the main takeaways from the hydraulic analysis.

As stated in Section 2.1, the main indicator used by Operations to manage flow entering Stafford Lake and the San Marin PS is the San Mateo Way tank level. **Table 4-3** provides a summary of Scenarios 1A through 4 to examine how the system currently performs with no system improvements implemented.

[1] Carollo Engineers, Inc. (2021). Kastania Pump Station Rehabilitation Project – Basis of Design Report. Section 5.3: Hydraulic Analysis. Pages 13-14.

Table 4-3: Existing System Scenario Results

Scenario	Scenario Description	San Marin PS No. of Pumps Active	Stafford Lake Fill Rate (MGD)	San Marin PS Flow Rate (MGD)		San Mateo Way Tank Fill/Drain Rate (gpm)[2]	
				Low[1]	High[1]	Low[1]	High[1]
1A	New San Mateo Tank 24-inch Fill Line **Inactive**	2	7.2	6.0	5.8	-418	-824
1B	New San Mateo Tank 24-inch Fill Line **Active**	2	7.2	6.0	5.8	-358	-930
1C	Scenario 1B but with third pump at San Marin PS active. Baseline for 177.9 ft lake HGL.	3	7.2	8.4	8.2	1,187	634
2	Scenario 1C, but baseline for 185.1 ft lake HGL	3	7.2	8.4	8.2	1,187	634
3	Scenario 1C, but KPS On	3	7.2	8.3	8.2	1,095	632
4	Scenario 2, but KPS On	3	7.2	8.3	8.2	1,095	632

1. "Low" indicates low (5.0 MGD) system demand and low Stafford Lake HGL (177.9 ft / 185.1 ft) vs "High" which indicates high (9.0 MGD) system demand and high Stafford Lake HGL (199 ft)
2. Negative value indicates tank is draining, positive value indicates tank is filling

Based on the results for Scenarios 1A and 1B, the addition of the San Mateo Way 24-inch fill line has a minimal effect on whether the tank is filling or draining while filling Stafford Lake. When comparing Scenarios 1B and 1C, activating the third pump at San Marin PS causes the San Mateo tank to fill rather than drain, both under low and high system demand/lake HGL conditions. The model mimics the real-world operations described in **Section 3.1**, indicating that the model is valid and is performing as expected.

Comparing Scenario 1C to Scenarios 2, 3, and 4 shows that changing the lake HGL from 177.9 ft to 185.1 ft as well as activating KPS has very little impact on the capacity of San Marin PS capacity and the fill rate of the San Mateo Way tank.

Figure 4-2 and **Figure 4-3** show the resulting headloss within the system when filling Stafford Lake for Scenarios 1A and 1C. Under both conditions, the 18-inch pipeline along Novato Blvd has a velocity of 6.3 fps and a headloss gradient of 6.8 ft per 1,000 ft. The section of 12-inch pipeline along San Marin Dr has a velocity of 10.7 fps and a headloss gradient of nearly 29 ft per 1,000 ft.

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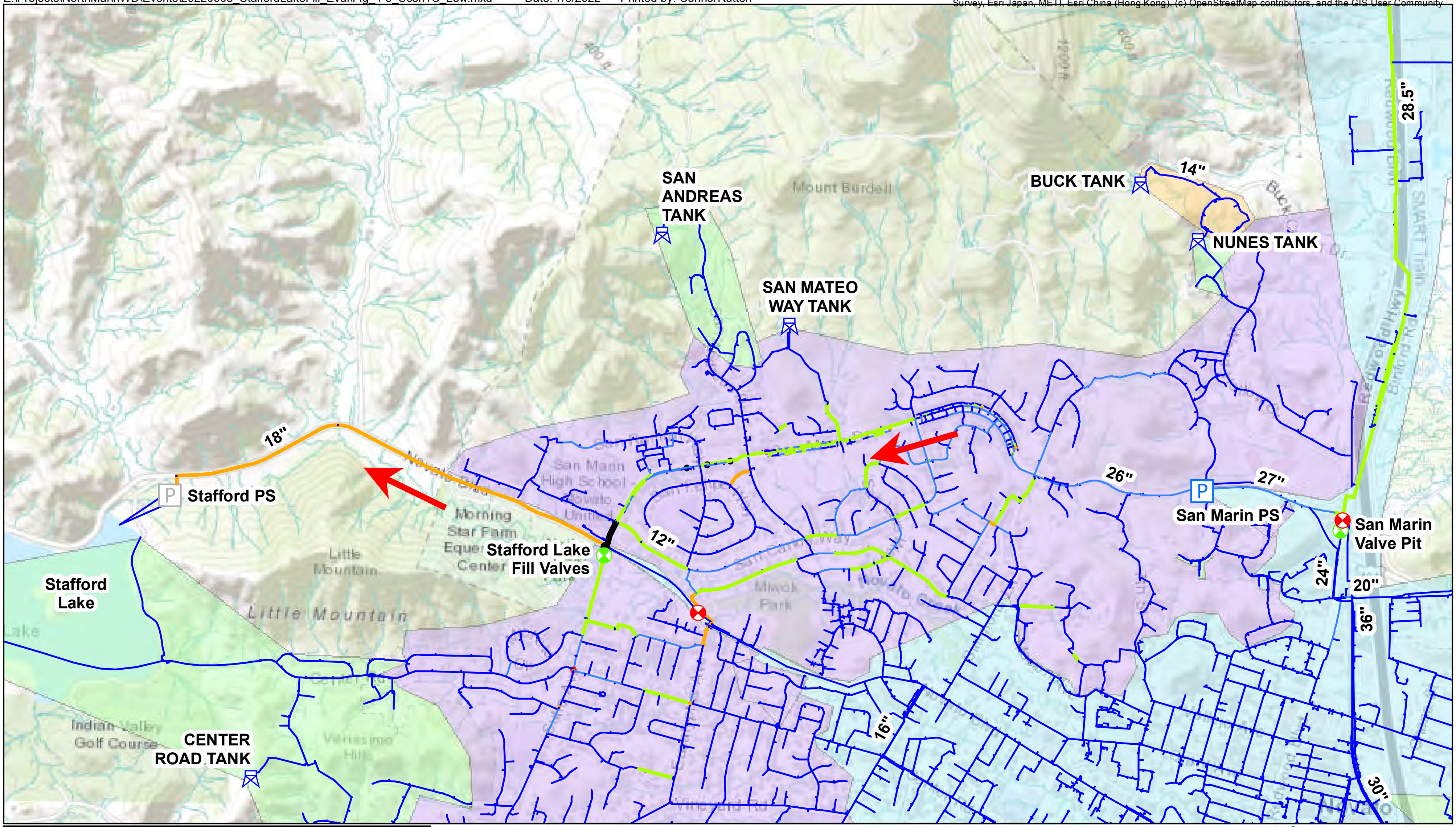


Legend

Tank

Pump
- Inactive
- Active

Valve
- Closed
- Open

Pressure Zones
- 1
- 2
- 3
- 4

Pipes

Headloss Per 1000 ft
- < 1
- 1-2
- 2-5
- 5-10
- 10-15
- 15-20
- > 20

Notes:

1. System Demand: 5 MGD
2. Stafford Lake Level: 177.9 ft
3. San Mateo Tank 24" Fill Line Active
4. # Pumps Operating at San Marin PS: 3

N

0 1,000 2,000
Scale: Feet

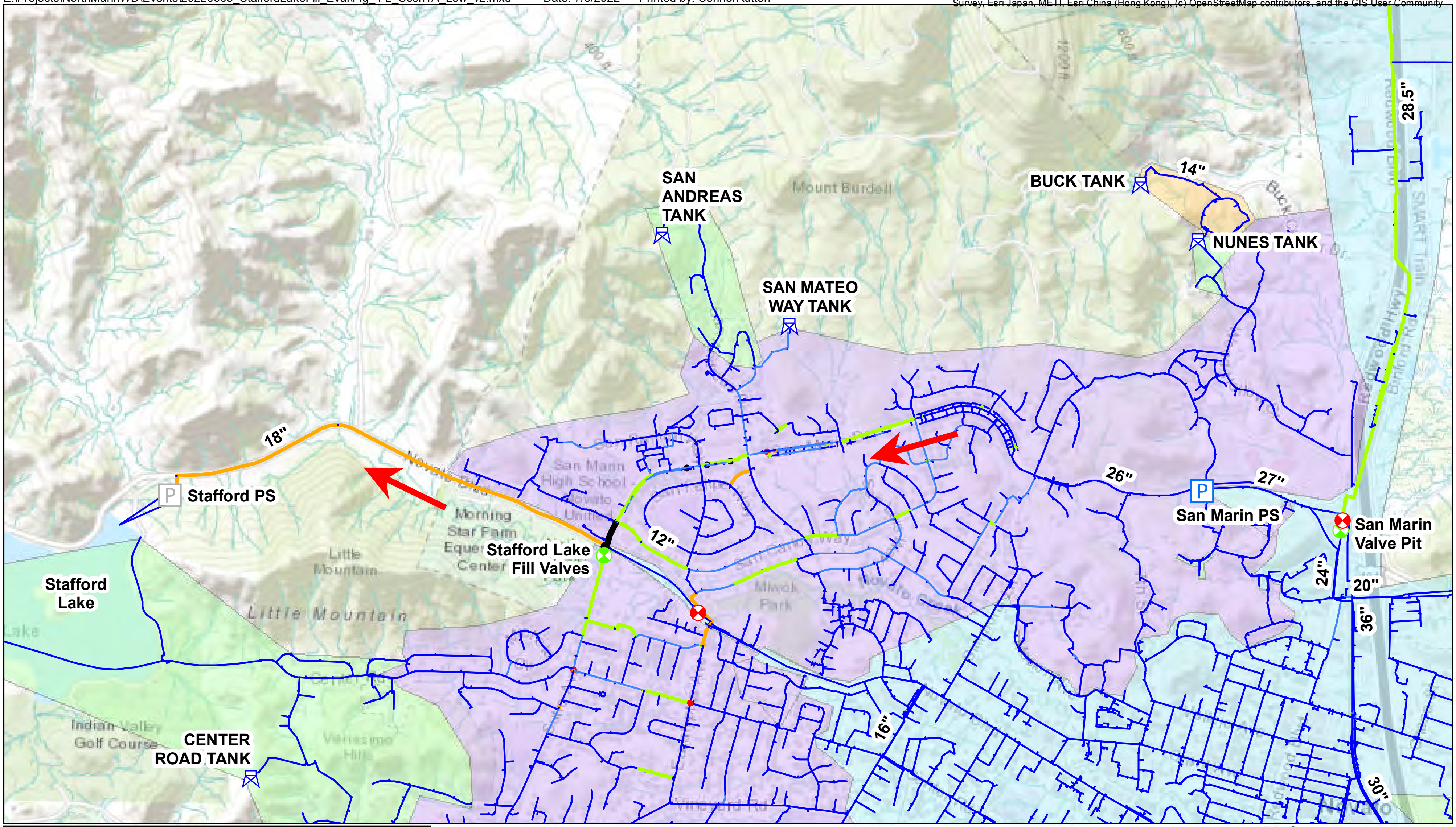
Kennedy Jenks

North Marin Water District
Marin County, CA

Stafford Lake Fill Evaluation
Scenario 1C-Low
System Headloss

2168014*00

Figure 4-3



Legend

Tank

Pump
- Inactive
- Active

Valve
- Closed
- Open

Pressure Zones
- 1
- 2
- 3
- 4

Pipes

Headloss Per 1000 ft
- < 1
- 1-2
- 2-5
- 5-10
- 10-15
- 15-20
- > 20

Notes:

1. System Demand: 5 MGD
2. Stafford Lake Level: 177.9 ft
3. San Mateo Tank 24" Fill Line Inactive
4. # Pumps Operating at San Marin PS: 2

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

North Marin Water District
Marin County, CA

Stafford Lake Fill Evaluation
Scenario 1A-Low
System Headloss

2168014*00

Figure 4-2

4.5 Proposed System Improvements and Results

4.5.1 Increasing San Marin PS Capacity

According to historical flow tests performed by District Operations Staff, the current maximum flow that can be conveyed into Stafford Lake without draining Zone 2 and exceeding the capacity of San Marin PS is 7.2 MGD. This is due to hydraulic restrictions within the system, with the primary constraint being the maximum capacity of San Marin PS. As **Figure 4-1** showed, the model predicted that only 8.1 MGD of flow could be send to Stafford Lake under high system demand. Given that the model conditions most likely varied from the conditions of the District's flow test, including pump operations, system demand, and tank levels, the model only deviates by 12% of the measured maximum flow into Stafford Lake, corroborating the District's flow test data.

Kennedy Jenks evaluated the firm pumping capacity of San Marin PS in TM 1 under Task Order 2. This TM identified that the current firm pumping capacity for San Marin PS was 5.2 MGD, and considered replacing the existing three pumps with larger capacity pumps so that the firm pumping capacity with two (2) pumps running was 7.0 MGD. However, when San Marin PS has all three (3) pumps operating, the total PS capacity increases to approximately 8.2 MGD based on the model results. During March of 2021, District operators reported 7.0 MGD output when operating all three (3) pumps simultaneously to fill the Zone 2 tanks while also filling Stafford Lake.

Since identifying new pump selections at San Marin PS was not the focus of this analysis, a fourth pump was simply added to San Marin PS with an identical pump curve and specifications to the existing pumps to bring the total San Marin PS Capacity up to 10.2 MGD. For Scenarios 5 through 7, all four (4) pumps at San Marin PS were active in order to convey additional flow to Stafford Lake. Along with increasing the flow capacity from San Marin PS, the flow control valve setting at Stafford Lake was increased to 10.0 MGD; beyond 10 MGD, flows through the NMA (while KPS is active and IPS is taking 7.0 MGD) nearly exceed the maximum allowable flow of 22.9 MGD, which corresponds to 8.0 fps.

A future evaluation should be completed by the District to determine the associated risk with running the San Marin PS beyond its firm pumping capacity and the impacts to the District upon failure of one of the pumps.

4.5.2 Linear Improvements

As **Figure 4-2** and **Figure 4-3** show, the 18-inch pipeline along Novato Blvd, as well as a section of 12-inch pipeline along San Marin Dr, both experience increased headloss ranging between 6.8 to 29 ft of headloss per 1,000 ft of piping. This headloss only worsens as additional flow is conveyed to Stafford Lake. Scenarios 5 and 6 evaluate the impact of replacing the 550 LF of 12-inch pipeline and 8,100 LF of 18-inch pipeline with 8,650 LF of 24-inch pipeline to reduce system headloss. Scenario 8 includes replacing only the 550 LF of 12-inch pipeline. Scenario 7 incorporates the pump station improvements without the linear improvements to see what the system impacts are of increasing flow without upsizing and pipelines.

Table 4-4 provides a summary of Scenarios 5 through 7, examining the effects of increasing the capacity of San Marin PS and implementing the linear improvements discussed above.

Table 4-4: System Improvements Scenario Results

Scenario	Scenario Description	San Marin PS No. of Pumps Active	Stafford Lake Fill Rate (MGD)		San Marin PS Flow Rate (MGD)		San Mateo Way Tank Fill/Drain Rate (gpm)[2]	
			Low[1]	High[1]	Low[1]	High[1]	Low[1]	High[1]
5	Scenario 1C with system improvements (no KPS)	4	10.0	10.0	10.5	10.3	700	227
6	Scenario 5 but KPS On	4	10.0	10.0	10.4	10.3	636	218
7	Scenario 6 but no linear improvements (only pump station improvements)	4	9.1	8.2	10.3	10.3	1,525	1,586
8	Scenario 6 but limited linear improvements	4	10.0	9.1	10.4	10.4	636	699

1. “Low” indicates low (5.0 MGD) system demand and low Stafford Lake HGL (177.9 ft / 185.1 ft) vs “High” which indicates high (9.0 MGD) system demand and high Stafford Lake HGL (199 ft)
2. Negative value indicates tank is draining, positive value indicates tank is filling

The main takeaway from **Table 4-4** is that with low system demand (5.0 MGD) and low lake HGL (177.9 ft), all scenarios that include linear improvements are capable of sending 10 MGD of flow to Stafford Lake while also filling San Mateo Way tank, indicating that San Marin PS can maintain Zone 2 pressures. With no linear improvements (Scenario 7), only 9.1 MGD can be conveyed to Stafford Lake.

When comparing Scenarios 5 and 6, the effect of operating KPS remains negligible with the Zone 1 and 2 tanks set at 30% full. **Figure 4-4** and **Figure 4-5** show system headloss for Scenarios 5 and Scenario 6 as additional flow is demanded downstream by IPS.

Scenarios 5 and 6 are also able to deliver 10 MGD to Stafford Lake under high system demand (9.0 MGD) and with the high lake HGL (199 ft). Scenarios 7 and 8 can only convey 8.2 and 9.1 MGD to Stafford Lake under high demand conditions, respectively.

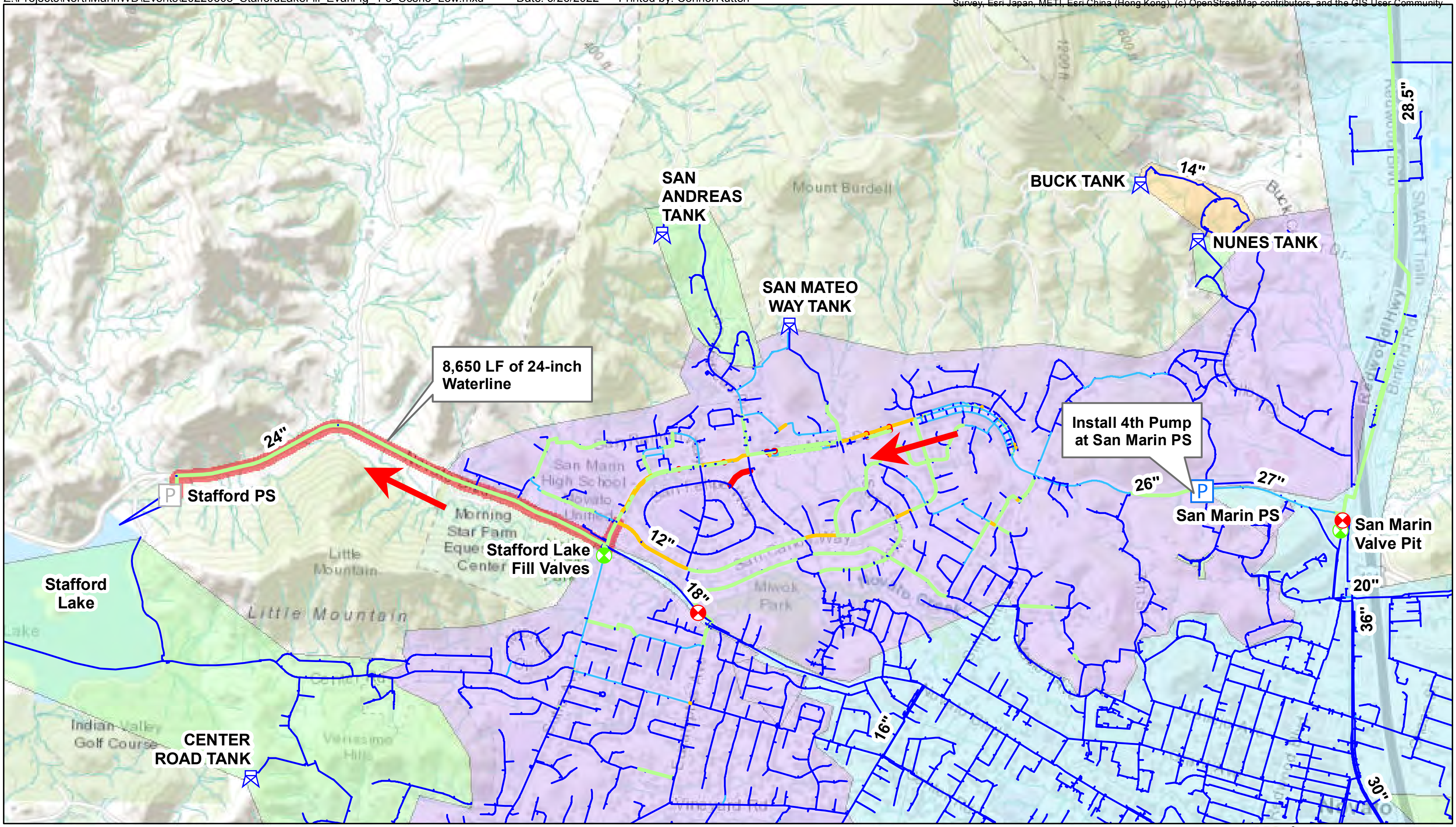
Scenario 7 illustrates the importance of the linear improvements. Under high demand/lake HGL conditions, Stafford Lake can only receive 8.2 MGD due to the additional headloss incurred through the 12 and 18-inch pipelines along San Marin Dr and Novato Blvd. Velocities though the 12-inch and 18-inch pipelines are 14.5 and 8.6 fps, respectively, exceeding the District’s goal of keeping distribution system pipeline velocities below 8 fps. It is more hydraulically favorable for flow from San Marin PS to fill San Mateo Way tank, resulting in a significant increase in the San Mateo Way tank fill rate.

Figure 4-6 shows the excessive headloss incurred through the pipelines (ft per 1,000 ft).

Scenario 8 is a much cheaper alternative to Scenario 5/6 by only replacing the 550 LF of 12-inch piping just upstream of the Stafford Fill Valves. By removing this hydraulic bottleneck, the system can convey 10 MGD to Stafford under low demand conditions and 9.1 MGD under high demand conditions for roughly 10% of the project cost of replacing 8,650 LF of pipe with 24-inch pipe.

Z:\Projects\NorthMarinWD\Events\20220608_StaffordLakeFill_Eval\Fig_4-3_Scen5_Low.mxd Date: 6/26/2022 Printed by: ConnorRutten

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

Tank

Pump

Inactive

Active

Valve

Closed

Open

Pipes

Headloss Per 1000 ft

< 1

1-2

2-5

5-10

>10

Linear Improvements

Pressure Zones

1

2

3

4

Notes:

1. System Demand: 5 MGD
2. Stafford Lake Level: 177.9 ft
3. San Mateo Tank 24" Fill Line Active
4. Kastania Pump Station Off
5. # Pumps Operating at San Marin PS: 4
6. Linear Improvements Included

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

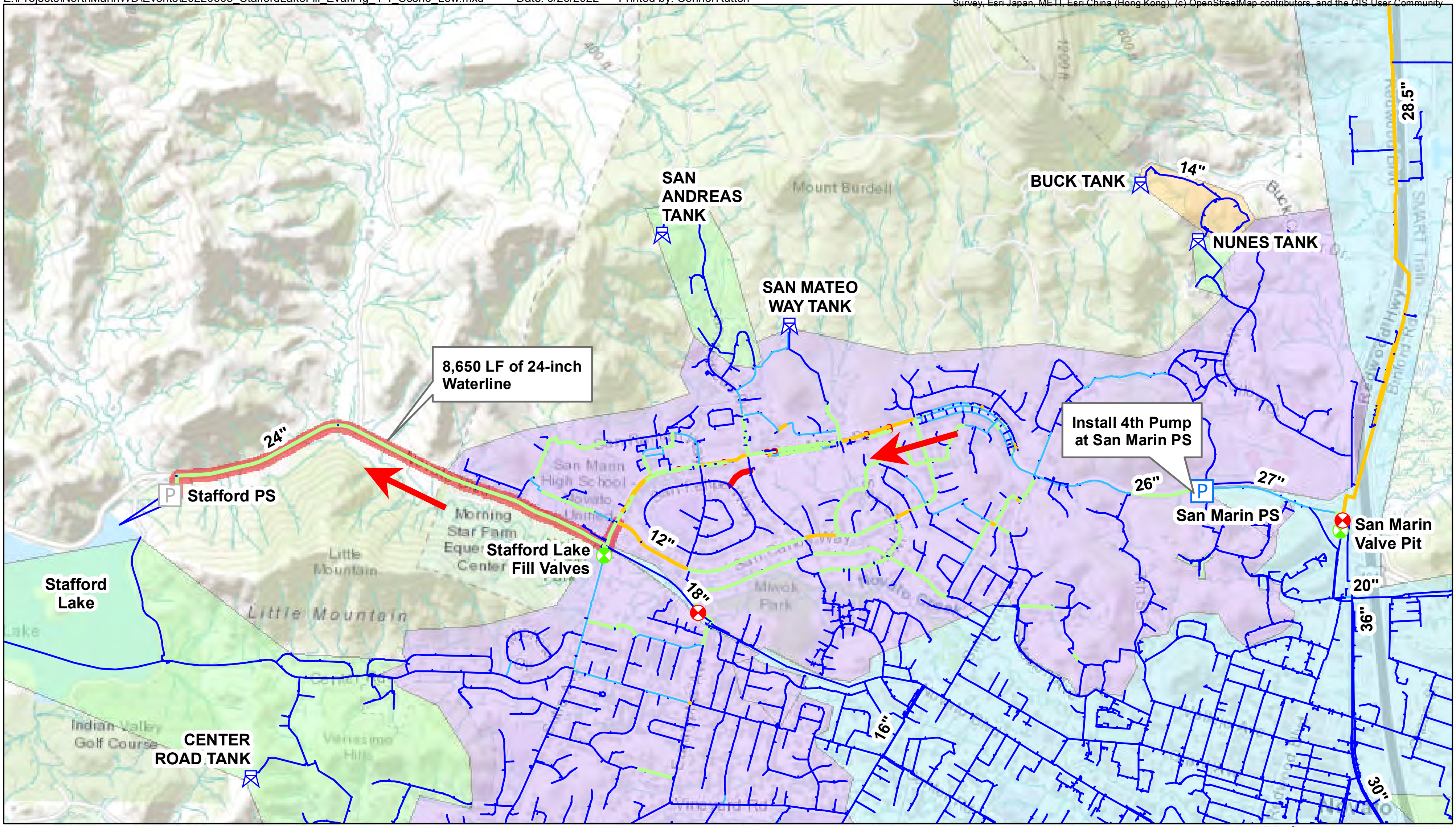
North Marin Water District
Marin County, CA

Stafford Lake Fill Evaluation
Scenario 5-Low
System Headloss

2168014*00

Figure 4-4

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

- Tank
- **Pump**
  - Inactive
  - Active
- **Valve**
  - Closed
  - Open

Pipes

Headloss Per 1000 ft

- < 1
- 1-2
- 2-5
- 5-10
- >10
- Linear Improvements

Pressure Zones

- 1
- 2
- 3
- 4

Notes:

1. System Demand: 5 MGD
2. Stafford Lake Level: 177.9 ft
3. San Mateo Tank 24" Fill Line Active
4. Kastania Pump Station On
5. # Pumps Operating at San Marin PS: 4
6. Linear Improvements Included

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

North Marin Water District
Marin County, CA

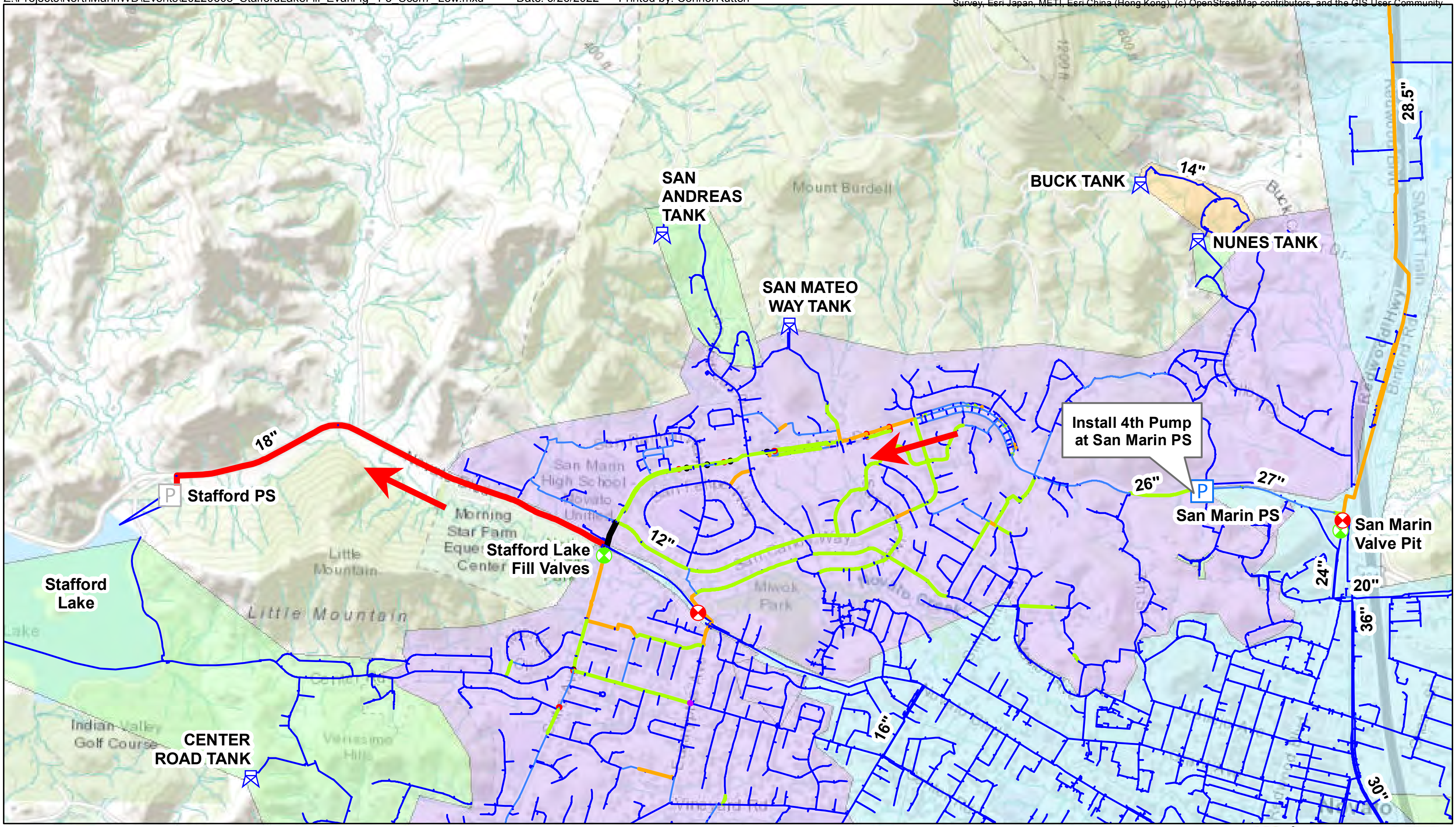
Stafford Lake Fill Evaluation
Scenario 6-Low
System Headloss

2168014*00

Figure 4-5

Z:\Projects\NorthMarinWD\Events\20220608_StaffordLakeFill_Eval\Fig_4-5_Scen7_Low.mxd Date: 6/26/2022 Printed by: ConnorRutten

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

Tank

Pump
- Inactive
- Active

Valve
- Closed
- Open

Pipes

Headloss Per 1000 ft
- < 1
- 1-2
- 2-5
- 5-10
- 10-15
- 15-20
- > 20

Pressure Zones
- 1
- 2
- 3
- 4

Notes:

1. System Demand: 5 MGD
2. Stafford Lake Level: 177.9 ft
3. San Mateo Tank 24" Fill Line Active
4. Kastania Pump Station On
5. # Pumps Operating at San Marin PS: 4
6. Linear Improvements NOT Included

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

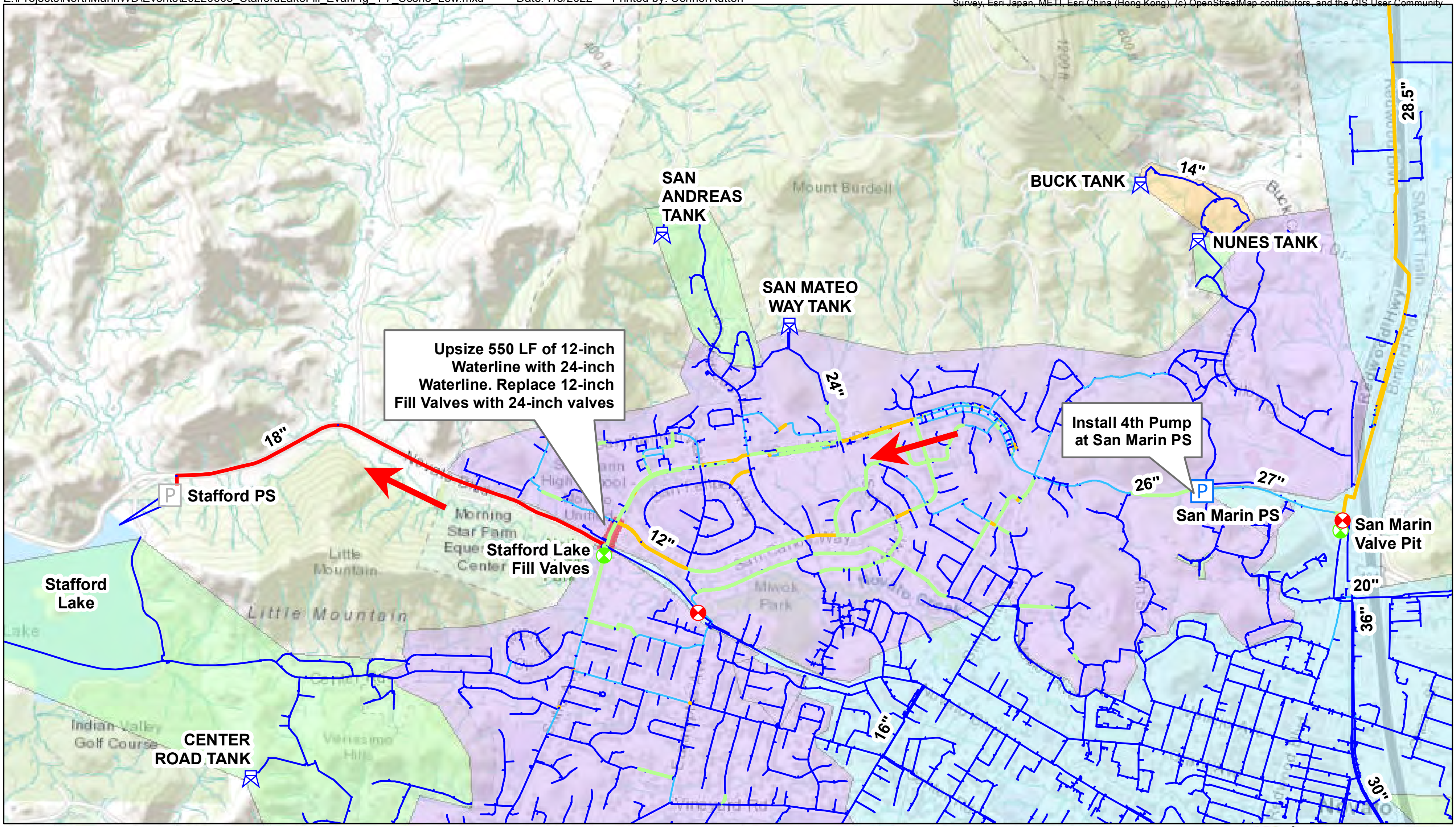
North Marin Water District
Marin County, CA

Stafford Lake Fill Evaluation
Scenario 7-Low
System Headloss

2168014*00

Figure 4-6

Z:\Projects\NorthMarinWD\Events\20220608_StaffordLakeFill_Eval\Fig_4-7_Scen8_Low.mxd Date: 7/8/2022 Printed by: ConnorRutten



Legend

Tank

Pump

Inactive

Active

Valve

Closed

Open

Pipes

Headloss Per 1000 ft

- < 1
- 1-2
- 2-5
- 5-10
- >10
- Linear Improvements

Pressure Zones

- 1
- 2
- 3
- 4

Notes:

1. System Demand: 5 MGD
2. Stafford Lake Level: 177.9 ft
3. San Mateo Tank 24" Fill Line Active
4. Kastania Pump Station On
5. # Pumps Operating at San Marin PS: 4
6. Limited Linear Improvements Included

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

North Marin Water District
Marin County, CA

Stafford Lake Fill Evaluation
Scenario 8-Low
System Headloss

2168014*00

Figure 4-7

Figure 4-8 shows the HGL profiles for the baseline Scenario 1C as well as the system improvement Scenarios 5 through 8 for both low and high demand/lake HGL conditions. The benefits of the linear system improvements can be seen between Scenarios 5/6 versus Scenario 7, which has a significantly steeper hydraulic grade due to significantly higher friction losses. Scenario 8 shows the benefit of removing the largest hydraulic restriction by replacing the 550 LF of 12-inch waterline with 24-inch waterline. While the flow control valve at Stafford Lake typically throttles and induces headloss across the valve to regulate flow (seen in Scenarios 1C, 5, and 6), the valve remains wide open for Scenario 7, indicating that there is no available head in the Novato Blvd pipeline by the time it reaches the flow control valve.

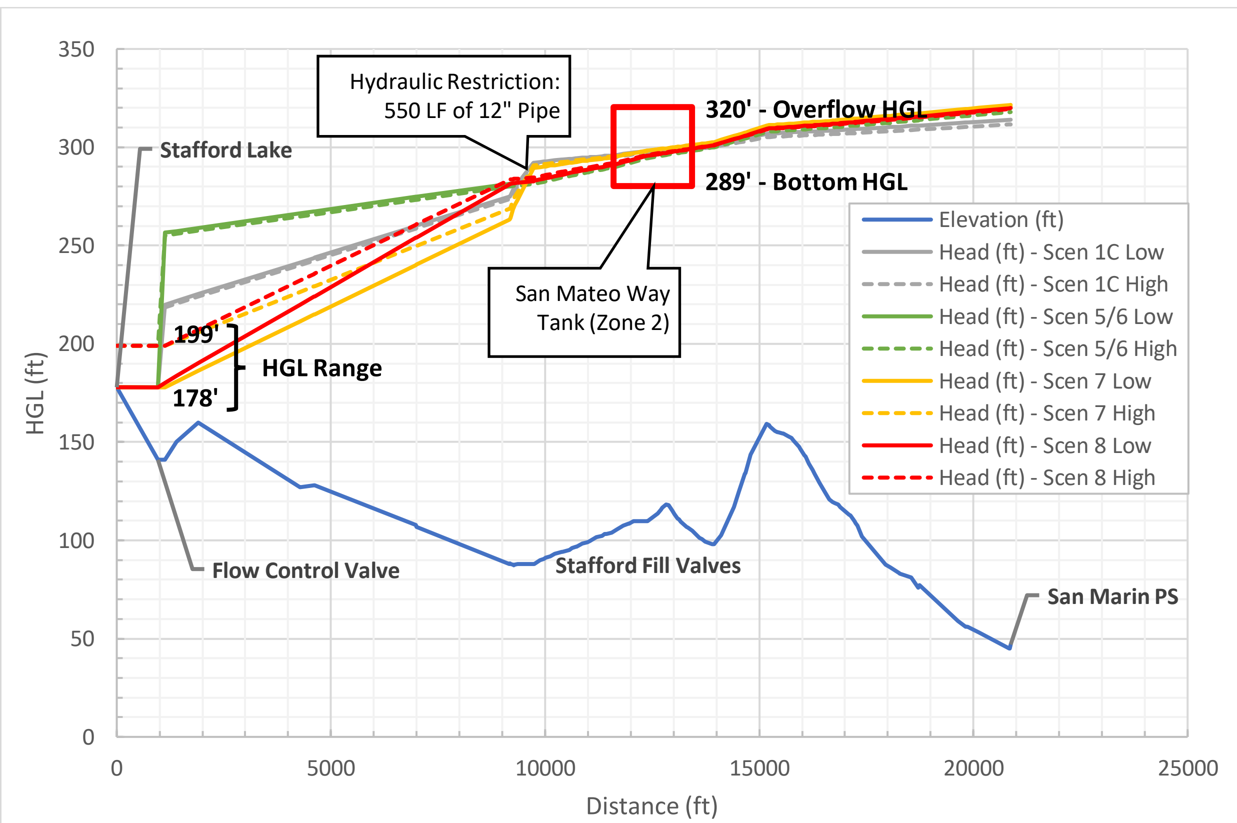


Figure 4-8: HGL Profiles from San Marin PS to Stafford Lake

Finally, the time it takes to fill Stafford Lake from both 177.9 ft and 185.1 ft was calculated using the identified fill capacities from each scenario. District staff provided Kennedy Jenks with a depth vs volume curve for Stafford Lake from elevations 150 ft up to elevation 199 ft. For Scenario 7, which dropped in terms of flow entering Stafford Lake between the low and high demand periods, it was assumed that the flow rate into the lake decreased linearly between

Month 1 (January, low demand, 5.0 MGD) to Month 5 (May, high demand, 9.0 MGD). The fill times are summarized below in **Table 4-5**.

Table 4-5: Stafford Lake Fill Times By Scenario and Initial Lake HGL

Scenario	No. Days to Fill (from 177.9 ft)	No. Days to Fill (from 185.1 ft)	No. Months to Fill (from 177.9 ft)	No. Months to Fill (from 185.1 ft)
1A – 4	173	130	5.8	4.3
5	124	93	4.1	3.1
6	124	93	4.1	3.1
7	145	108	4.8	3.6
8	131	97	4.4	3.2

Depending on the initial lake HGL, it typically takes between 4 to 6 months to fill Stafford Lake with the current system. With the proposed system improvements, Stafford Lake could be filled in 3 to 4 months, assuming continuous filling for the entire period.

5.0 San Marin Valve Pit Bypass Hydraulic Analysis and Results

5.1 Model Assumptions

All of the model scenarios were run under steady-state conditions, looking at a snapshot of the District's system in terms of pump flow rates, tanks levels, and system pressures. Pump and tank cycling patterns were not evaluated.

For both modeled scenarios, NMA was isolated from the District's system, relying on Stafford WTP to supply the system. As Section 3.3 described, a system demand of 5.0 MGD was assumed while evaluating the difference in system performance of the two bypass configurations.

5.2 System Criteria

The main system criteria evaluated for the two bypass configurations is limiting the maximum velocity through all conveyance piping to 8.0 fps[2] and maintaining a minimum system pressure of 40 psi.

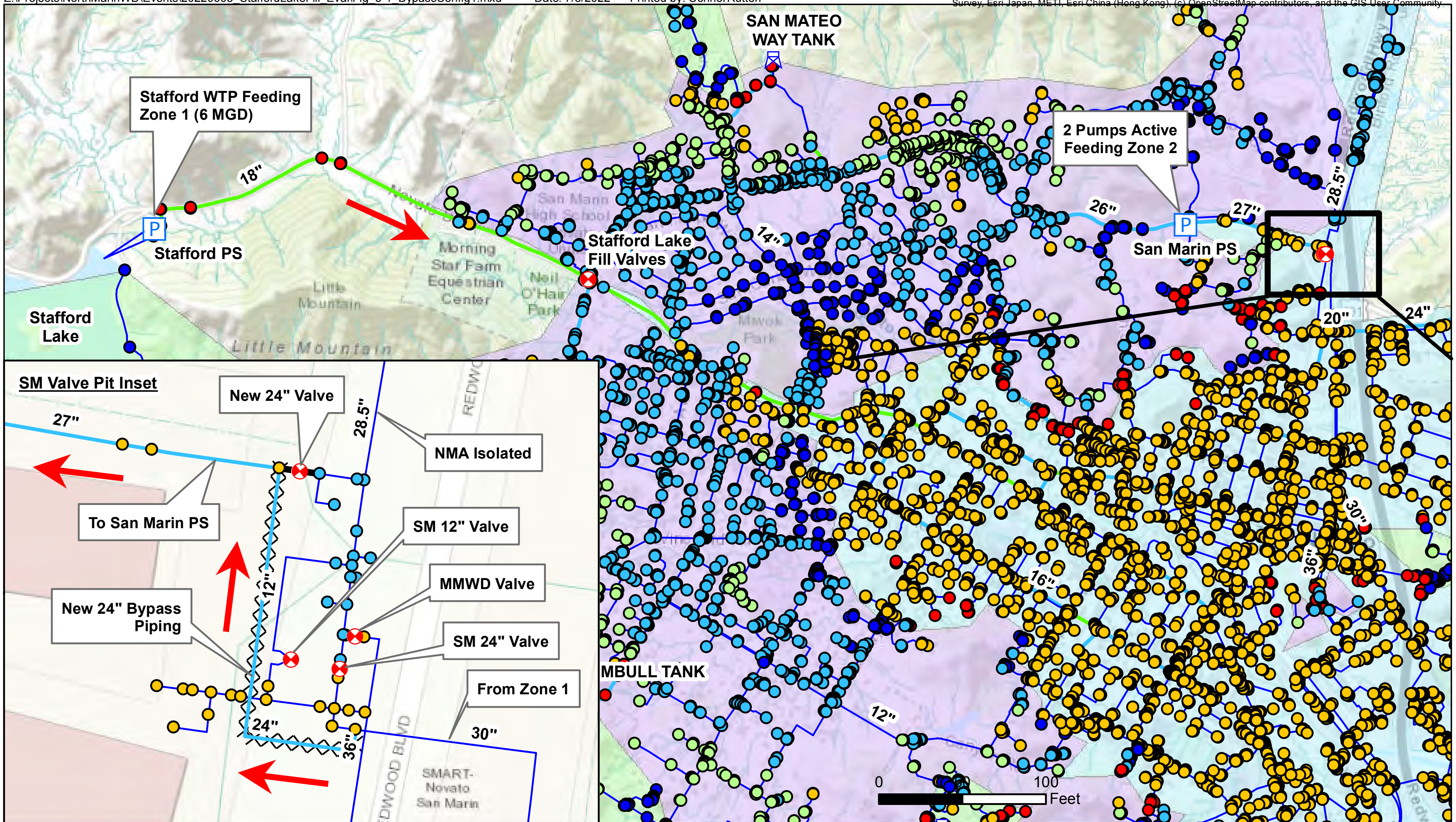
5.3 Analysis and Results

Figure 5-1 and **Figure 5-2** show the system pressures and pipeline velocities as the system is supplied by Stafford WTP.

[2] Carollo Engineers, Inc. (2021). Kastania Pump Station Rehabilitation Project – Basis of Design Report. Section 5.3: Hydraulic Analysis. Pages 13-14.

Z:\Projects\NorthMarinWD\Events\20220608_StaffordLakeFill_Eval\Fig_5-1_BypassConfig1.mxd Date: 7/8/2022 Printed by: ConnorRutten

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

Tank	**Pressure Zones**	**Pipes**	**Junctions**
Pump		**Velocity (fps)**	**Pressure (psi)**
Inactive	1	< 2	< 40
Active	2	2 - 4	40 - 60
	3	4 - 6	60 - 80
Valve	4	6 - 8	80 - 100
Closed	New Bypass Piping	> 8	> 100
Open			

Notes:
1. North Marin Aqueduct Closed
2. System Demand: 5 MGD
3. Stafford WTP Flow Rate: 6 MGD
4. San Marin PS # Pumps Active: 2

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

North Marin Water District
Marin County, CA

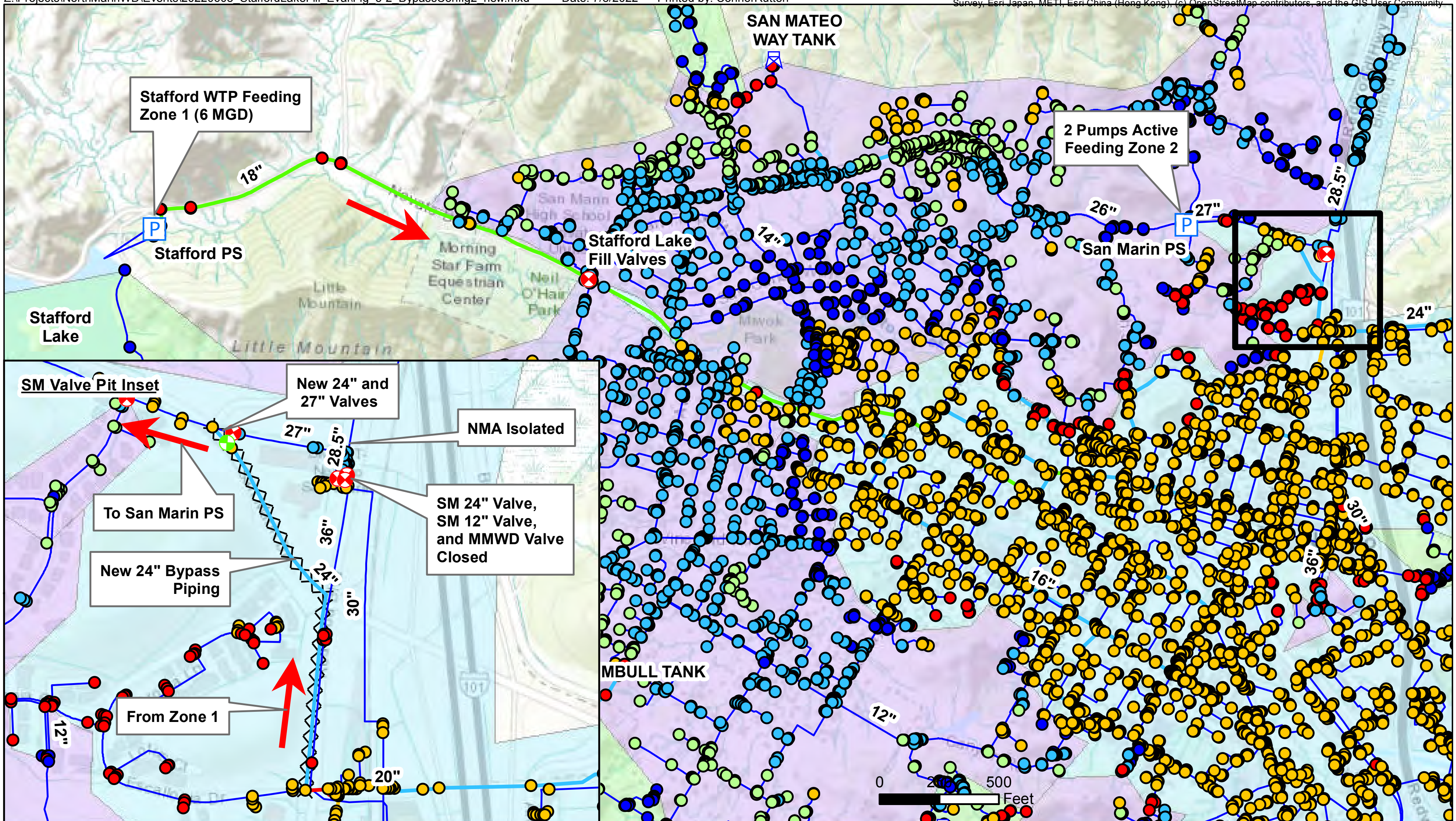
San Marin Valve Pit Bypass Configuration 1

2168014*00

Figure 5-1

Z:\Projects\NorthMarinWD\Events\20220608_StaffordLakeFill_Eval\Fig_5-2_BypassConfig2_new.mxd Date: 7/8/2022 Printed by: ConnorRutten

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend

Tank

Pump

Inactive

Active

Valve

Closed

Open

Pressure Zones

1
2
3
4

New Bypass Piping

Pipes

Velocity (fps)

< 2
2 - 4
4 - 6
6 - 8
> 8

Junctions

Pressure (psi)

< 40
40 - 60
60 - 80
80 - 100
> 100

Notes:
1. North Marin Aqueduct Closed
2. System Demand: 5 MGD
3. Stafford WTP Flow Rate: 6 MGD
4. San Marin PS # Pumps Active: 2

N

0 1,000 2,000

Scale: Feet

Kennedy Jenks

North Marin Water District
Marin County, CA

San Marin Valve Pit Bypass Configuration 2

2168014*00

Figure 5-2

When comparing the resulting pressures and velocities for the two bypass configurations Bypass Configuration 1 results in fewer portions of the system falling below 40 psi. Bypass Configuration 2 also results in some high velocities through the 8 and 12-inch piping along Rush Creek Pl and N Redwood Dr, as flow must pass through these pipelines to reach San Marin PS. Bypass Configuration 1 makes better use of the existing 30-inch pipeline which follows the SMART Train alignment and does not require pushing flow through the small-diameter piping. **Table 5-1** highlights the most significant model result findings for the two modeled scenarios. The full model results for the two modeled bypass configurations can be found in **Appendix B**.

Table 5-1: Stafford Lake Fill Times By Scenario and Initial Lake HGL

Bypass Configuration	Stafford WTP Production Rate (MGD)	Stafford WTP Discharge HGL (ft)	San Marin PS No. of Pumps Active	San Marin PS Suction Pressure (psi)	San Marin PS Flow Rate (MGD)
1	6.0	235	2	38	5.4
2	6.0	235	2	27	4.7

The one potential benefit of Bypass Configuration 2 is the additional system redundancy created by adding a parallel North/South 24-inch transmission main next to the existing 30-inch transmission main that follows the SMART Train alignment. If this configuration is considered, additional pipe upsizing for the Rush Creek Pl and N Redwood Dr. should be considered to reduce the excessive velocities and resulting pressure drops within Zone 1.

6.0 Conclusions and Recommendations

Based on the results of this analysis, the following items should be considered if the District desires to convey additional flow to Stafford Lake:

- Depending on the amount of flow demanded by MMWD's IPS, conveying more than 10.0 MGD to Stafford Lake may result in velocities > 8 fps through the NMA.

- With the Zone 1 and 2 Tanks set at 30% full and 7.0 MGD of demand at Ignacio PS, the operation of the KPS does not have a significant impact on the Stafford Lake fill operations.

- The District should implement the following system improvements if they desire to convey additional flow to Stafford Lake:

    - Install a 4th pump at San Marin PS or consider upsizing the existing three (3) pumps to achieve a total capacity of 10.2 MGD. A future evaluation should be completed by the District to determine whether the pump station will continue to be operated beyond its firm pumping capacity. The District should identify the risk associated with running the San Marin PS beyond its firm pumping capacity and the impacts to the District upon failure of one of the pumps.

- Replace the 550 LF of 12-inch pipeline and the 12-inch Stafford fill valves with 24-inch piping and valves. This project will cost roughly 10% of what it would cost to install the full 8,650 LF of 24-inch piping, and still removes the most significant hydraulic bottleneck in the District's system. The 8,100 LF of 18-inch pipeline along Novato Blvd could eventually be replaced with 24-inch pipe at the end of the useful lifespan of the existing piping (see **Figure 4-4** and **Figure 4-7**).

San Marin Valve Pit Bypass Configuration 1 (see **Figure 5-1**) is the preferred configuration based on the resulting system pressures observed near San Marin valve pit and at the suction of San Marin PS. Configuration 1 results in less junctions violating the minimum pressure criteria of 40 psi and results in a suction pressure at San Marin PS of 38 psi (as opposed to 27 psi with Configuration 2). Bypass Configuration 1 makes better use of the existing 30-inch pipeline which follows the SMART Train alignment and does not require pushing flow through the small-diameter piping that Configuration 2 is forced to use. Configuration 1 is likely the least expensive of the two configurations, but does not offer additional system redundancy.

Appendix A: NMWD Distribution System Profile

NOVATO WATER SYSTEM
DISTRIBUTION PROFILE

REGULATING STATIONS NOT SHOWN ON DRAWING:

CAMBRIDGE & SUNSET PARKWAY
HAMILTON PALM DRIVE
SAN MARIN EAST
PLUM STREET

REGULATED
HYDROPNEUMATIC
ZONE 4
ZONE 3
ZONE 2
ZONE 1
SUPPLY

● PIPE CHANGE
GRAVITY STORAGE
HYDROPNEUMATIC STORAGE
N.O.T. "NOT ON TELEMETRY"
ONE WAY FLOW CHECK VALVE

AV ALTITUDE VALVE
CB CHLORINE BOOST STATION
FS FLOW SENSOR
P PUMP
CV CONTROL VALVE
M METER

MG-### MAXIMUM HYDRAULIC GRADIENT
OF-### OVERFLOW
BM-### BOTTOM

NOTES:

1. PUMP STATIONS SHOW FLOW WITH ONE PUMP RUNNING.
2. ALL PUMP STATIONS ARE EQUIPPED WITH FLOW METERS AND ARE ON TELEMETRY UNLESS OTHERWISE NOTED (N.O.T.).

NO.	DATE	REVISION	BY	APP
8	07/06/18	REMOVED NORMAN TANK, REVISED AND REFORMATTED INFORMATION IN FIGURE	SD	DJ
7	12/05/12	UPDATED TANK INFORMATION	AC	DJ
6	01/03/08	REMOVED HANCOCK TANK	LJ	MM
5	12/14/07	REVISED W.H.V., CENTER RD & CABRO PIPE CONFIGURATION	LJ	MM
4	01/19/07	ADDED BLACK POINT TANK, UPDATED INFO	LJ	MM
3	10/02/02	ADDED TANK DATA, AMMO HILL AND AIR BASE	MM	MM
2	10/19/98	ADDED WINDHAVEN AND BUCK PUMP STATIONS AND TANKS	PS	PS
1	05/07/98	ADDED TITLE BLOCK TO EXISTING DISTRIBUTION MAP	TM	PS

NORTH MARIN WATER DISTRICT
NOVATO, CALIFORNIA

NOVATO WATER SYSTEM
DISTRIBUTION PROFILE

DES	DR	CH	SCALE : NONE
TM, PS	TM	PS	DATE : 05/28/97
APPROVED: CHIEF ENGINEER			SHEET NO. : 1 OF 1 SHEETS
R.E. C75950			SERVICE AREA 1 · ACCT.NO. 52401 · NO. OP13

Jul 12, 2018 – 2:41pm W:\JOB\MISC\OPERATIONS\NMWD Distribution System Profile.dwg User: SDOVE

Appendix B: Complete Tabulated Model Results

Stafford Lake Fill Model Scenarios		Model Notes								
		5 MGD system demand, 177.9 lake level, San Mateo Tank 24" fill line **inactive**, 2 pumps on at SMPS	5 MGD system demand, 177.9 lake level, San Mateo Tank 24" Fill line **active**, 2 pumps on at SMPS	5 MGD system demand, 177.9 lake level, San Mateo Tank 24" Fill line active, **3 pumps on at SMPS**	Scen 1C, but 185.1' lake level	Scen 1C, but KPS On	Scen 2, but KPS On	Scen 1C, with System Improvements (additional SMPS pump, replace 8,500 LF pipe with 24" pipe along Novata Blvd)	Scen 5 but KPS On	Scen 6 but no pipeline improvements (Add SMPS Pump #4)
Scenario Objective:		Check San Mateo fill line effect (2 pumps on)	Check San Mateo fill line effect (2 pumps on)	Baseline (3 pumps active) for 177.9' lake elevation	Baseline	KPS On	KPS On	System Improvements	System Improvements, KPS On	Add SMPS #4 Only, KPS On
	Low NMWD System Demand							add another pump, increase flow to stafford		
	Scenario	**1A**	**1B**	**1C**	**2**	**3**	**4**	**5**	**6**	**7**
Inputs	**NMWD System Demand**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Inputs	**Stafford Lake Level (ft)**	177.9	177.9	177.9	185.1	177.9	185.1	177.9	177.9	177.9
Inputs	**System Improvements?**	No	No	No	No	No	No	Yes	Yes	Yes
Inputs	**San Marin CV Status**	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed	12" Open, 24" Closed
Inputs	**Frosty Ln CV Status**	Closed	Closed	Closed	Closed	Open	Open	Closed	Open	Open
Inputs	**Kastania PS Status**	Off	Off	Off	Off	On	On	Off	On	On
Inputs	**Kastania PS # Pumps Active**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**1**	**1**
Inputs	**Ignacio PS Demand (MGD)**	0.0	0.0	0.0	0.0	7.0	7.0	0.0	7.0	7.0
Inputs	**San Marin PS # Pumps Active**	**2**	**2**	**3**	**3**	**3**	**3**	**4**	**4**	**4**
Outputs – Zone 1	**Kastania Flow Rate (MGD)**	0.0	0.0	0.0	0.0	22.5	22.5	0.0	22.6	22.6
Outputs – Zone 1	**NMA Flow (MGD)**	14.9	14.9	15.6	15.6	22.5	22.5	16.1	22.6	22.6
Outputs – Zone 1	**Ignacio PS Suction Pressure (psi)**	60.3	60.3	57.9	57.9	51.8	51.8	56.0	51.3	51.4
Outputs – Zone 1	**San Marin CV Pressure (psi)**	66.1	66.1	63.6	63.6	61.9	61.9	61.8	60.6	60.7
Outputs – Zone 1	**San Marin PS Suction Pressure (psi)**	47	47	44	44	43	43	42	41	41
Outputs – Zone 1	**San Marin PS Discharge Pressure (psi)**	112	112	116	116	115	115	119	118	119
Outputs – Zone 1	**San Marin PS Flow Rate (MGD)**	**6.0**	**6.0**	**8.4**	**8.4**	**8.3**	**8.3**	**10.5**	**10.4**	**10.3**
Outputs – Zone 1	**Stafford Lake Fill Rate (MGD)**	**7.2**	**7.2**	**7.2**	**7.2**	**7.2**	**7.2**	**10.0**	**10.0**	**9.1**
Outputs – Zone 1	**School Road PS Flow Rate (MGD)**	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Outputs – Zone 1	**Cherry Hill PS Flow Rate (MGD)**	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Outputs – Zone 1	**Lynwood PS Flow Rate (MGD)**	5.6	5.6	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Outputs – Zone 1	**Atherton Tank Fill Rate* (gpm)**	782	774	-234	-234	-1001	-1001	-1153	-1619	-1665
Outputs – Zone 1	**Lynwood Tank 1 Fill Rate* (gpm)**	-1317	-1317	-1329	-1329	-1325	-1325	-1336	-1344	-1341
Outputs – Zone 1	**Lynwood Tank 2 Fill Rate* (gpm)**	855	854	792	792	814	814	750	706	722
Outputs – Zone 1	**Palmer Drive Tank Fill Rate* (gpm)**	-85	-86	-147	-147	200	200	-208	-143	-103
Outputs – Zone 1	**Amaroli Tank Fill Rate* (gpm)**	-142	-143	-191	-191	86	86	-258	-188	-155
Outputs – Zone 2	**San Mateo Way Tank* (gpm)**	**-418**	**-358**	**1187**	1187	1095	1095	700	636	1525
Outputs – Zone 2	**Trumbull Tank* (gpm)**	-455	-497	-376	-376	-382	-382	-383	-393	-714
Outputs – Zone 2	**Sunset Tank* (gpm)**	2753	2751	2750	2750	2753	2753	2747	2742	2732
Outputs – Zone 2	**Pacheco Tank* (gpm)**	-1474	-1474	-1474	-1474	-1474	-1474	-1474	-1474	-1474
Outputs – Zone 2	**Airbase Tank* (gpm)**	1088	1088	1087	1088	1088	1088	1087	1087	1087
	***Positive = filling, negative = draining**									
	Stafford Lake Fill Valve Upstream Head (ft)	218.8	218.1	219.9	219.9	219.8	219.8	256.7	256.6	177.9
	Headloss Across Stafford Lake Fill Valve (ft)	40.9	40.2	42.0	34.8	41.9	34.7	78.8	78.7	0.0

	Stafford Fill Model Scenarios	Model Notes								
		9 MGD system demand, 199' lake level	9 MGD system demand, 199' lake level	9 MGD system demand, 199' lake level, 3 pumps on at SMPS		9 MGD system demand, 199' lake level, KPS On		9 MGD system demand, 199' lake level, KPS Off, System Improvements	9 MGD system demand, 199' lake level, **KPS On,** System Improvements	Scen 6 but no pipeline improvements (Add SMPS Pump #4)
	High NMWD System Demand									
	Scenario	**1A**	**1B**	**1C**		**3**		**5**	**6**	**7**
Inputs	**NMWD System Demand**	9.0	9.0	9.0		9.0		9.0	9.0	9.0
Inputs	**Stafford Lake Level (ft)**	199.0	199.0	199.0		199.0		199.0	199.0	199.0
Inputs	**System Improvements?**	No	No	No		No		Yes	Yes	Yes
Inputs	**San Marin CV Status**	12" Closed, 24" Open	12" Closed, 24" Open	12" Closed, 24" Open		12" Closed, 24" Open		12" Closed, 24" Open	12" Closed, 24" Open	12" Closed, 24" Open
Inputs	**Frosty Ln CV Status**	Closed	Closed	Closed		Open		Closed	Open	Open
Inputs	**Kastania PS Status**	Off	Off	Off		On		Off	On	On
Inputs	**Kastania PS # Pumps Active**	**0**	**0**	**0**		**1**		**0**	**1**	**1**
Inputs	**Ignacio PS Demand (MGD)**	0.0	0.0	0.0		7.0		0.0	7.0	7.0
Inputs	**San Marin PS # Pumps Active**	**2**	**2**	**3**		3		**4**	**4**	**4**
Outputs – Zone 1	**Kastania Flow Rate (MGD)**	0.0	0.0	0.0		22.7		0.0	22.8	22.6
Outputs – Zone 1	**NMA Flow (gpm)**	16.4	16.4	16.6		22.7		16.7	22.8	22.6
Outputs – Zone 1	**Ignacio PS Suction Pressure (psi)**	54.9	54.9	54.1		51.0		53.5	50.7	51.2
Outputs – Zone 1	**San Marin CV Pressure (psi)**	60.7	60.7	59.9		59.8		59.3	59.1	60.5
Outputs – Zone 1	**San Marin PS Suction Pressure (psi)**	42	42	41		41		39	39	40
Outputs – Zone 1	**San Marin PS Discharge Pressure (psi)**	110	111	115		115		117	117	119
Outputs – Zone 1	**San Marin PS Flow Rate (MGD)**	**5.8**	**5.8**	**8.2**		**8.2**		**10.3**	**10.3**	**10.3**
Outputs – Zone 1	**Stafford Lake Fill Rate (MGD)**	**7.2**	**7.2**	**7.2**		**7.2**		**10.0**	**10.0**	**8.2**
Outputs – Zone 1	**School Road PS Flow Rate (MGD)**	0.8	0.8	0.8		0.8		0.8	0.8	0.8
Outputs – Zone 1	**Cherry Hill PS Flow Rate (MGD)**	0.3	0.3	0.3		0.3		0.3	0.3	0.3
Outputs – Zone 1	**Lynwood PS Flow Rate (MGD)**	5.6	5.6	5.5		5.5		5.5	5.5	5.5
Outputs – Zone 1	**Atherton Tank Fill Rate* (gpm)**	1130	1149	-52		-568		-1268	-1619	-2169
Outputs – Zone 1	**Lynwood Tank 1 Fill Rate* (gpm)**	-1330	-1329	-1345		-1350		-1353	-1364	-1363
Outputs – Zone 1	**Lynwood Tank 2 Fill Rate* (gpm)**	787	789	698		667		645	567	573
Outputs – Zone 1	**Palmer Drive Tank Fill Rate* (gpm)**	-259	-257	-348		-433		-403	-562	-359
Outputs – Zone 1	**Amaroli Tank Fill Rate* (gpm)**	-339	-337	-432		-533		-499	-672	-446
Outputs – Zone 2	**San Mateo Way Tank* (gpm)**	**-824**	**-930**	**634**		632		227	218	1586
Outputs – Zone 2	**Trumbull Tank* (gpm)**	-863	-790	-697		-698		-722	-724	-814
Outputs – Zone 2	**Sunset Tank* (gpm)**	2416	2420	2417		2413		2410	2401	2398
Outputs – Zone 2	**Pacheco Tank* (gpm)**	-1521	-1521	-1521		-1521		-1522	-1522	-1522
Outputs – Zone 2	**Airbase Tank* (gpm)**	940	940	940		940		940	940	939
	***Positive = filling, negative = draining**									
	Stafford Lake Fill Valve Upstream Head (ft)	216	217	219		219		255	255	199
	Headloss Across Stafford Lake Fill Valve (ft)	17	18	20		20		56	56	0

San Marin Valve Pit Bypass Scenarios	Model Notes	
	SM Valve Pit Bypass Configuration 1, 5 MGD system demand, 177.9 lake level, 6 MGD from Stafford WTP, NMA Closed	B1 but Bypass Configuration 2
Scenario Objective:	Config 1: 240 LF 24" PipingEvaluate Zone 1 System Pressures/Flows through	Evaluate Zone 1 System Pressures/Flows through Bypass

	Low NMWD System Demand		
	Scenario	**B1**	**B2**
Inputs	**NMWD System Demand**	5.0	5.0
	Stafford Lake Level (ft)	177.9	177.9
	System Improvements?	No	No
	San Marin CV Status	All Valves Closed	All Valves Closed
	Frosty Ln CV Status	Closed	Closed
	Kastania PS Status	Off	Off
	Kastania PS # Pumps Active	**0**	**0**
	Ignacio PS Demand (MGD)	0.0	0.0
	Stafford PS # Pumps Active	2	2
	San Marin PS # Pumps Active	2	2
Outputs - Zone 1	**Kastania Flow Rate (MGD)**	0.0	0.0
	NMA Flow (MGD)	0.0	0.0
	San Marin CV Pressure (psi)	94.9	94.9
	San Marin PS Suction Pressure (psi)	**38**	**27**
	San Marin PS Discharge Pressure (psi)	113	112
	San Marin PS Flow Rate (MGD)	**5.4**	**4.7**
	Stafford WTP Production Rate (MGD)	**6.0**	**6.0**
	Stafford Discharge HGL (ft)	235	235
	School Road PS Flow Rate (MGD)	0.8	0.8
	Cherry Hill PS Flow Rate (MGD)	0.3	0.3
	Lynwood PS Flow Rate (MGD)	5.5	5.5
	Atherton Tank Fill Rate* (gpm)	-4054	-3747
	Lynwood Tank 1 Fill Rate* (gpm)	-1351	-1342
	Lynwood Tank 2 Fill Rate* (gpm)	662	714
	Palmer Drive Tank Fill Rate* (gpm)	-431	-394
	Amaroli Tank Fill Rate* (gpm)	-495	-457

***Positive = filling, negative = draining**