SRWA
Stanislaus Regional Water Authority

STANISLAUS REGIONAL WATER AUTHORITY
156 S Broadway, Ste. 230, Turlock, CA 95380
209-668-5540 (p) 209-668-5668 (f)

Board Meeting Agenda

September 22, 2016 at 10:00 a.m.
2nd Floor – Yosemite Conference Room
156 S. Broadway, Turlock CA

Chair	Vice Chair	Director	Director
Gary Soiseth	**Chris Vierra**	**Ken Lane**	**Amy Bublak**

Interim General Manager	Board Secretary	Interim General Counsel
Michael Brinton	**Tish Foley**	**Phaedra A. Norton**

NOTICE REGARDING NON-ENGLISH SPEAKERS: The Stanislaus Regional Water Authority (SRWA) meetings are conducted in English and translation to other languages is not provided. Please make arrangements for an interpreter if necessary.

EQUAL ACCESS POLICY: If you have a disability which affects your access to public facilities or services, please contact the Board Secretary. The Board is committed to taking all reasonable measures to provide access to its facilities and services. Please allow sufficient time for the Board to process and respond to your request.

NOTICE: Pursuant to California Government Code Section 54954.3, any member of the public may directly address the Stanislaus Regional Water Authority Board on any item appearing on the agenda, including Consent Calendar and Scheduled items, before or during the Board's consideration of the item.

AGENDA PACKETS: Prior to the Stanislaus Regional Water Authority Board meeting, a complete Agenda Packet is available for review on the SRWA's website at www.stanrwa.org and in the Board Secretary's Office at 156 S. Broadway, Suite 230, Turlock, during normal business hours. Materials related to an item on this Agenda submitted to the Board after distribution of the Agenda Packet are also available for public inspection in the Board Secretary's Office. Such documents may be available on the SRWA's website subject to staff's ability to post the documents before the meeting.

1. A. CALL TO ORDER

B. SALUTE TO THE FLAG

2. PROCLAMATIONS, RECOGNITIONS, APPOINTMENTS, ANNOUNCEMENTS & PRESENTATIONS: None

3. A. SPECIAL BRIEFINGS: None

B. STAFF UPDATES

1. Interim General Manager Updates *(Brinton)*
2. Finance Director Report *(Jacobs-Hunter)*

C. CONSULTANT UPDATES:

1. West Yost Associates will provide the Board with a project status update. *(Nakano)*

D. PUBLIC PARTICIPATION: This is the time set aside for members of the public to directly address the Stanislaus Regional Water Authority Board on any item of interest to the public that is within the subject matter jurisdiction of the SRWA and to address the Board on any item on the agenda, including Consent Calendar items. You will be allowed five (5) minutes for your comments. If you wish to speak regarding an item on the agenda, you may be asked to defer your remarks until the Board addresses the matter. No action or discussion may be undertaken on any item not appearing on the posted agenda, except that the Board may refer the matter to staff or request it be placed on a future agenda.

4. DECLARATION OF CONFLICTS OF INTEREST AND DISQUALIFICATIONS

5. CONSENT CALENDAR

Information concerning the consent items listed hereinbelow has been forwarded to each Board member prior to this meeting for study. Unless the Chair, a Board member or member of the audience has questions concerning the Consent Calendar, the items are approved at one time by the Board. The action taken by the Board in approving the consent items is set forth in the explanation of the individual items.

A. *Motion:* Accepting minutes of Regular Meeting of September 8, 2016

6. PUBLIC HEARINGS: None.

Challenges in court to any of the items listed below, may be limited to only those issues raised at the public hearing described in this notice, or in written correspondence delivered to the Stanislaus Regional Water Authority at, or prior to, the public hearing.

7. SCHEDULED MATTERS

A. Request to accept the Technical Memorandum dated September 12, 2016, preliminary pipeline sizing for the treated water transmission mains to the City of Ceres (30-inch diameter) and the City of Turlock (42-inch diameter), sized to deliver the ultimate 45 mgd of treated water supplies of 15 mgd and 30 mgd to the cities of Ceres and Turlock respectively, and for use in the Project environmental analysis. *(West Yost Program Management Team)*

Recommended Action:
Motion: Accepting the Technical Memorandum dated September 12, 2016, preliminary pipeline sizing for the treated water transmission mains to the City of Ceres (30-inch diameter) and the City of Turlock (42-inch diameter), sized to deliver the ultimate 45 mgd of treated water supplies of 15 mgd and 30 mgd to the cities of Ceres and Turlock respectively, and for use in the Project environmental analysis

B. Request to accept the Technical Memorandum dated July 29, 2016 - Public Outreach Plan, which provides a public outreach strategy and the following key initial actions: Conduct stakeholder interviews, review and provide updates for the Project website, develop initial fact sheet, and continue to refine the stakeholder list. *(West Yost Program Management Team)*

Recommended Action:
Motion: Accepting the Technical Memorandum dated July 29, 2016 - Public Outreach Plan, which provides a public outreach strategy and the following key initial actions: Conduct stakeholder interviews, review and provide updates for the Project website, develop initial fact sheet, and continue to refine the stakeholder list

C. Request to accept the Technical Memorandum dated September 7, 2016 – assessment of available historical Tuolumne River water quality presented in the Tuolumne River Historical Water Quality Assessment Technical Memorandum. *(West Yost Program Management Team)*

Recommended Action:
Motion: Accepting the Technical Memorandum dated September 7, 2016 – assessment of available historical Tuolumne River water quality presented in the Tuolumne River Historical Water Quality Assessment Technical Memorandum

D. Request to accept the Technical Memorandum dated September 6, 2016 – recommendation to further evaluate the candidate treatment trains presented in the Available Treatment Process Alternatives Technical Memorandum 1, Part 1. *(West Yost Program Management Team)*

Recommended Action:
Motion: Accepting the Technical Memorandum dated September 6, 2016 – recommendation to further evaluate the candidate treatment trains presented in the Available Treatment Process Alternatives Technical Memorandum 1, Part 1

E. Request to accept the recommendations to proceed with raw water sampling and analysis activities for source water characterization. *(West Yost Program Management Team)*

Recommended Action:
Motion: Request to accept the recommendations to proceed with raw water sampling and analysis activities for source water characterization

F. Request to approve Amendment No. 1 to the Agreement for Special Services with West Yost Associates for Raw Water Sampling and Analysis for an amount not to exceed $105,000; and appropriate $105,000 to account number 950-53-552.43060_012 "Contract Services – Program Management Services" to be funded via equal contributions from SRWA participating agencies. *(Brinton)*

Recommended Action:
Motion: Approving Amendment No. 1 to the Agreement for Special Services with West Yost Associates for Raw Water Sampling and Analysis for an amount not to exceed $105,000

Resolution: Appropriating $105,000 to account number 950-53-552.43060_012 "Contract Services – Program Management Services" to be funded via equal contributions from SRWA participating agencies.

8. MATTERS TOO LATE FOR THE AGENDA: The Brown Act generally prohibits any action or discussion of items not on the posted agenda. However, there are three specific situations in which a legislative body can act on an item not on the agenda:
1) When a majority decides there is an "emergency situation" (as defined for emergency meetings).
2) When two-thirds of the members present (or all members if less than two-thirds are present) determine there is a need for immediate action and the need to take action "came to the attention of the local agency subsequent to the agenda being posted." This exception requires a degree of urgency. Further, an item cannot be considered under this provision if the legislative body or the staff knew about the need to take immediate action before the agenda was posted. A "new" need does not arise because staff forgot to put an item on the agenda or because an applicant missed a deadline.
3) When an item appeared on the agenda of, and was continued from, a meeting held not more than five days earlier.

A legitimate immediate need can be acted upon even though not on the posted agenda by following a two-step process. First, make two determinations: (a) that there is an immediate need to take action and (b) that the need arose after the posting of the agenda. The matter is then "placed on the agenda." Second, discuss and act on the added agenda item.

9. BOARD ITEMS FOR FUTURE CONSIDERATION

10. BOARD COMMENTS: Board members may provide a brief report on notable topics of interest. The Brown Act does not allow discussion or action by the legislative body.

11. NEXT MEETING DATE: *October 6, 2016 – Special Meeting / Workshop*

12. CLOSED SESSION: None.

13. ADJOURNMENT

STANISLAUS REGIONAL WATER AUTHORITY
156 S. Broadway, Ste. 230, Turlock, CA 95380
209-668-5540 (p) 209-668-5668 (f)

September 22, 2016

Item 3.B.1.

To: SRWA Board

From: Michael Brinton, Interim General Manager

Subject: Interim General Manager Report

The members of the Technical Advisory Committee (TAC) have continued to meet with West Yost Associates and their sub-consultants on various items in preparation of the design of the raw water supply infrastructure, water treatment facility, regional treated water transmission mains and local distribution system. The items covered since the last SRWA Board meeting includes the following:

- Scheduled meeting with Gualco to prepare for SRF and legislative delegation meetings.
- Finalized Historical Raw Water Quality, Treatment Process Alternatives, and Source Water Characterization Sampling Plan Technical Memorandums.
- Reviewed Scope of Services for Right of Way Acquisition and Surveying needs to support the Wet Well design and construction, and Project.
- Reviewed Public Outreach Implementation Plan.
- Contacted City of Lodi for possible site visit to the Water Treatment Plant.
- Reviewed technical memo regarding water velocity in transmission pipelines.

Mr. Nakano will provide a more in depth review of these items. I will be happy to answer any questions.

SRWA
Stanislaus Regional Water Authority

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September 8, 2016
10:00 a.m.
2nd Floor – Yosemite Room
156 S. Broadway, Turlock CA

DRAFT Minutes
Regular Meeting
SRWA Board

1. **A. CALL TO ORDER:** Vice Chair Vierra called the meeting to order at 10:03 a.m.
PRESENT: Director Lane, Director Bublak, Vice Chair Vierra
ABSENT: Chair Soiseth

B. SALUTE TO THE FLAG

2. **PROCLAMATIONS, PRESENTATIONS, RECOGNITIONS, ANNOUNCEMENTS & APPOINTMENTS**

A. _Appointment_: Chair Vierra recommended that Tish Foley be appointed to the position of Board Secretary effective September 1, 2016.

Action: Motion by Director Lane, seconded by Director Bublak, appointing Tish Foley to the position of Board Secretary effective September 1, 2016. Motion carried 3/1 by the following vote:

Director Lane	Director Bublak	Vice Chair Vierra	Chair Soiseth
Yes	Yes	Yes	Absent

3. **A. SPECIAL BRIEFINGS:** None

B. STAFF UPDATES:

1. Interim General Manager Mike Brinton provided an overview of items discussed at recent Technical Advisory Committee (TAC) meetings, including Transmission Pipeline Sizing, Water Quality Assessment and Treatment Process Alternatives.

2. Finance Director Kellie Jacobs-Hunter provided information on revenue and expenditures for Fiscal Year 2016-17 through October, 2016.

3. Interim General Counsel Phaedra Norton provided an overview of Teleconferencing under the Brown Act and Procedure for Establishing a Meeting Quorum. Ms. Norton noted this process is permissible for the Board and reminded Board members if they could not physically attend a meeting they had the option to notify the Board Secretary of their desire to teleconference from another location.

C. CONSULTANT UPDATES:

1. West Yost Associates Gerry Nakano provided a project status update, including a review of the Design-Bid-Build delivery options and noted this information will be the subject of a Special Workshop scheduled for October.

D. PUBLIC PARTICIPATION: None

4. DECLARATION OF CONFLICTS OF INTEREST AND DISQUALIFICATIONS: None

5. CONSENT CALENDAR:

Action: Motion by Director Bublak, seconded by Director Lane, to adopt the consent calendar. Motion carried 3/1 by the following vote:

Director Lane	Director Bublak	Vice Chair Vierra	Chair Soiseth
Yes	Yes	Yes	Absent

A. *Motion:* Accepting minutes of Regular Meeting of August 11, 2016.

6. PUBLIC HEARINGS: None

7. SCHEDULED MATTERS:

A. Interim General Manager Mike Brinton presented the staff report on the request to approve an Agreement with West Yost Associates for Wet Well Design Services for the Surface Water Supply Project in an amount not to exceed $390,159; appropriate $390,160 to account number 950-53-552.51800_001 "Wet Well Design and Construction Management" for Wet Well Design Services to be funded via contributions from SRWA participating agencies.

Vice Chair Vierra opened public participation. There being no public response, Vice Chair Vierra closed public participation.

Action: Motion by Director Bublak, seconded by Director Lane, Approving an Agreement with West Yost Associates for Wet Well Design Services for the Surface Water Supply Project in an amount not to exceed $390,159. Motion carried 3/1 by the following vote:

Director Lane	Director Bublak	Vice Chair Vierra	Chair Soiseth
Yes	Yes	Yes	Absent

Action: Resolution No. 2016-006, Appropriating $390,160 to account number 950-53-552.51800_001 "Wet Well Design and Construction Management" for Wet Well Design Services to be funded via contributions from SRWA participating agencies was introduced by Director Bublak; seconded by Director Lane, and carried 3/1 by the following vote:

Director Lane	Director Bublak	Vice Chair Vierra	Chair Soiseth
Yes	Yes	Yes	Absent

B. Interim General Manager Michael Brinton presented the staff report on the request to accept the Technical Memorandum dated August 22, 2016 – Accepting preliminary pipeline sizing for the treated water transmission mains to the City of Ceres (30-inch diameter) and the City of Turlock (42-inch diameter), sized to deliver the ultimate 45 mgd of treated water supplies of 15 mgd and 30 mgd to the cities of Ceres and Turlock respectively, and for use in the Project environmental analysis.

West Yost Associates Gerry Nakano reviewed the analysis process and TAC recommendation. After discussion regarding the size and velocity of transmission mains to the Cities of Ceres and Turlock, the Board requested to continue this item until the next meeting and requested West Yost provide additional information regarding decreased water flow rates during the winter months.

Action: Motion by Director Lane, seconded by Director Lane, to table this item to the September 22, 2016, Regular Board Meeting. Motion carried 3/1 by the following vote:

Director Lane	Director Bublak	Vice Chair Vierra	Chair Soiseth
Yes	Yes	Yes	Absent

C. Interim General Manager Mike Brinton presented the staff report on the composition of the Technical Advisory Committee (TAC) and the composition of the Government Relations/Public Affairs Working Group.

Action: None – Information Only

8. MATTERS TOO LATE FOR THE AGENDA: None

9. BOARD ITEMS FOR FUTURE CONSIDERATION: None

10. BOARD COMMENTS: None

11. NEXT MEETING DATE: September 22, 2016 – *Regular Meeting*

12. CLOSED SESSION: None

13. ADJOURNMENT: Meeting was adjourned by unanimous vote at 10:36 a.m.

RESPECTFULLY SUBMITTED

DRAFT

Tish Foley
Board Secretary

SRWA
Stanislaus Regional Water Authority

Item 7A
Board Synopsis
September 22, 2016

From: West Yost Program Management Team

Prepared by: Polly Boissevain, West Yost Associates

1. ACTION RECOMMENDED:

Motion: Accepting the Technical Memorandum dated September 12, 2016, preliminary pipeline sizing for the treated water transmission mains to the City of Ceres (30-inch diameter) and the City of Turlock (42-inch diameter), sized to deliver the ultimate 45 mgd of treated water supplies of 15 mgd and 30 mgd to the cities of Ceres and Turlock respectively, and for use in the Project environmental analysis.

2. DISCUSSION OF ISSUE:

As discussed and requested at the September 8, 2016 Board meeting, additional hydraulic evaluations were conducted to determine the pipeline velocities in the proposed treated water transmission main sizes during low flow demand periods. The attached Technical Memorandum titled: Low Flow Velocity Calculations for Transmission Pipeline Alternatives for the SRWA Surface Water Supply Project summarizes our findings and conclusions. While velocities are initially a little lower than optimal for both the smaller and larger pipeline sizes, velocities in the smaller pipeline size are higher, and as demands increase (even during low flow periods), pipeline velocities increase into the more optimal ranges. (Results of the previous analysis are documented in the *Recommended Transmission Pipeline Sizing for the SRWA Surface Water Supply Project* Technical Memorandum (TM) presented to the TAC on August 15, 2016).

Based on these additional (and our previous hydraulic evaluations), the TAC and PM Team are still recommending that the pipeline sizes for the regional transmission system be a 42-inch diameter pipeline to Turlock and 30-inch diameter pipeline to Ceres. These sizes meet the hydraulic performance criteria, and provide some limited flexibility to serve other potential participants.

3. FISCAL IMPACT / BUDGET AMENDMENT:

Transmission system sizing impacts the overall project capital costs, which will be determined as part of Phase 1 of the project, and the power costs, which will be an on-going project expense. The August 15, 2016 TM presents an annual cost analysis evaluating capital cost re-payment and power costs. The recommended alternatives were found to be the most cost-effective alternatives which meet the needs of both cities.

4. **INTERIM GENERAL MANAGER'S COMMENTS:**

Supports moving forward with the recommended transmission main sizes.

5. **ENVIRONMENTAL DETERMINATION:** N/A

6. **ALTERNATIVES:**

Increasing the recommended transmission pipeline sizes will increase the Project's capital costs, and corresponding costs to existing and future customers, but will provide more flexibility to be able to provide supplies to serve other potential participants, if supplies and capacity are still available at the time of their request.

WEST YOST ASSOCIATES
Consulting Engineers

REGISTERED PROFESSIONAL ENGINEER
POLLY L. BOISSEVAIN
No. C36164
Exp. 6-30-18
CIVIL
STATE OF CALIFORNIA

TECHNICAL MEMORANDUM

DATE:	September 12, 2016	Project No.: 693-20-16-01 SENT VIA: EMAIL
TO:	SRWA Technical Advisory Committee	
FROM:	Polly Boissevain, PE, RCE #36134	
REVIEWED BY:	Gerry Nakano, PE, RCE #29524	
SUBJECT:	Low Flow Velocity Calculations for Transmission Pipeline Alternatives for the SRWA Surface Water Supply Project	

This Technical Memorandum (TM) presents velocity calculations estimated in the proposed SRWA treated water transmission pipelines during low demand periods. This analysis was requested at the SRWA Board Meeting of September 9, 2016, where the item to approve transmission pipeline diameters for Ceres and Turlock was continued to the next Board meeting (September 22, 2016), so that the Board could consider the additional information contained in this TM.

The Preliminary Phasing and Water Treatment Plant Sizing TM, dated June 16, 2016, presented example monthly surface water deliveries to Turlock and Ceres based on Phase 1 and Phase 2 capacity requests. Example monthly deliveries are based on the following assumptions:

- Monthly use patterns are based on historical average monthly production for Ceres (2000 through 2016) and Turlock (2005 through 2015);
- Monthly deliveries are based on projected annual demands for 2025 (Phase 1) and buildout (2035 for Ceres and 2040 for Turlock) for Phase 2;
- Surface water deliveries are maximized; and
- Minimum groundwater production of 2 million gallons per day (mgd) for Ceres and 3 mgd for Turlock, based on operating wells two hours/day to maintain water quality for wells without treatment systems, and six hours/day for wells with treatment systems.[1]

[1] Turlock currently has four wells that are operated continuously: Wells 4, 8, 20 and 30, for water quality purposes, with a total daily capacity of 6.6 mgd. Calculations assume that once Turlock is using surface water, these wells could be retired. The minimum amount of 3 mgd is based on operating all other wells for two hours/day.

Figure 1 shows an example of normal year monthly deliveries of surface water for 2025. Normal year deliveries assume full contract deliveries of surface water.

January has the lowest demands and correspondingly, the lowest monthly deliveries of surface water. January delivery estimates were used to calculate pipeline velocities for the alternative size pipelines. These calculations are summarized in Table 1 for 2020 through 2040.

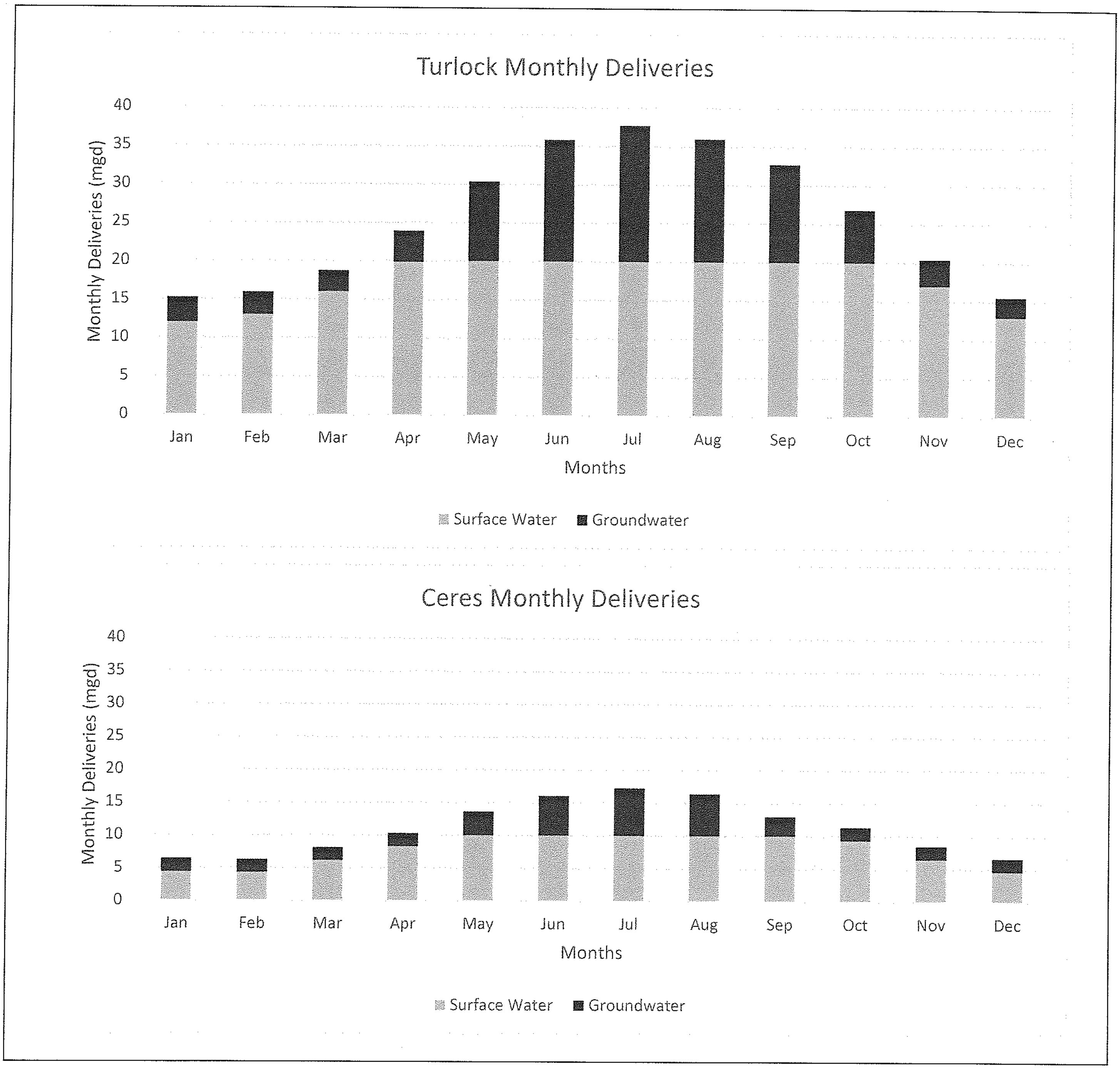
Table 1. Transmission Pipeline Velocities for Lowest Delivery Month

	2020	2025	2030	2035	2040
Ceres Transmission Pipeline					
Estimated January Delivery, mgd[(a)]	3	4	6	7	7
Velocity for 30-inch diameter, ft/s	1.0	1.4	1.8	2.3	2.3
Velocity for 36-inch diameter, ft/s	0.7	1.0	1.3	1.6	1.6
Turlock Transmission Pipeline					
Estimated January Delivery, mgd[(a)]	11	12	14	16	18
Velocity for 42-inch diameter, ft/s	1.8	1.9	2.3	2.6	2.9
Velocity for 48-inch diameter, ft/s	1.4	1.5	1.7	2.0	2.2

(a) Assumes that 2.0 mgd of groundwater would be conjunctively used to meet Ceres demands, and 3 mgd of groundwater would be conjunctively used to meet Turlock demands, so deliveries shown are for surface water only.

For the Ceres transmission pipeline, velocities are about 30 percent lower for the larger diameter pipeline. For the Turlock transmission pipeline, velocities are about 25 percent lower. Although overall velocities are low for each of the alternatives evaluated, smaller pipelines with higher velocities will help in the management of water quality under lower demand conditions.

The Recommended Transmission Pipeline Sizing for the SRWA Surface Water Supply Project TM, dated August 22, 2016 recommended selection of a 30-inch diameter transmission pipeline for Ceres and a 42-inch diameter transmission pipeline for Turlock, because they are the most cost-effective diameters evaluated, and could accommodate some flow increases beyond the planned design flowrates, which would allow participation by other small regional project partners with demands less than 1 mgd. Based on this supplemental analysis, West Yost Associates continues to recommend these transmission pipeline diameters for the project.



Notes:

1. Turlock average surface water delivery 18 mgd (19,700 AFY); average groundwater delivery 8 mgd (9,100 AFY).
2. Ceres average surface water delivery 8 mgd (8,700 AFY); average groundwater delivery 3 mgd (3,100 AFY).

SRWA

WEST YOST ASSOCIATES

Figure 1

Example Normal Year Deliveries, Year 2025

SRWA
Surface Water Supply Project

From: West Yost Program Management Team

Prepared by: Patti Ransdell, Circlepoint

1. **ACTION RECOMMENDED:**

Motion: Accepting the Technical Memorandum dated July 29, 2016 - Public Outreach Plan, which provides a public outreach strategy and the following key initial actions: Conduct stakeholder interviews, review and provide updates for the Project website, develop initial fact sheet, and continue to refine the stakeholder list.

2. **DISCUSSION OF ISSUE:**

The Public Outreach Plan (Plan) for the Stanislaus Regional Water Authority Surface Water Supply Project (Project) will initially address outreach during the first phase of this Project, and identify different outreach tools to keep stakeholders and the public consistently informed. The primary goal of the Plan is to increase the public's overall awareness of the Project, and convey the need for the Project and the benefits it will bring the communities it serves. The public outreach program will build recognition and awareness by providing honest, up-to-date information as it is happening.

Recommended next steps and the timing for implementation of the Plan are detailed below.

<u>Stakeholder Interviews</u>

As part of the Project public outreach planning, feedback from key stakeholders/community leaders will be sought via one-on-one interviews to ensure that community issues and concerns are incorporated into the process. We recommend conducting approximately 10 interviews with key stakeholders (including agricultural and industry representatives), who will be identified by Board and TAC members. The stakeholder responses will help to identify community issues related to the Project and the most effective ways to outreach to the public. The information gathered through the stakeholder interviews will be used to further prepare and enhance the Project's public outreach efforts.

These interviews will be completed by SRWA Board Members with participation by Circlepoint in a few of the early interviews, if desired by the Board Members. Circlepoint will help develop 10-15 questions to ask the key stakeholders. A summary of the interviews will be used to guide the outreach efforts, and will allow the team to make adjustments as needed to our strategy.

The one-on-one interviews will take place well before the Proposition 218 process begins. Feedback gleaned from the interviews will inform the outreach needed before and during the Proposition 218 process.

<u>Maintain Stakeholder List</u>

An initial stakeholder list has already been developed during Phase One of the project, and it should continue to be maintained and updated. The stakeholder list is set up in tiered categories, with tier one including key decision makers, project partners, funding agencies, and affected rate payers, and tier two includes other interested parties and regulatory agencies.

The tiers were developed with assistance from the Technical Advisory Committee (TAC) and help determine which outreach activities are needed for specific stakeholder groups.

<u>Collateral Materials</u>

A Project fact sheet should be developed soon after the stakeholder interviews are conducted and message points have been developed. Ultimately there will likely be a need for a general Project fact sheet, and a fact sheet with information about Project funding. The fact sheets will be useful for meetings with politicians and funding agencies as well as the Public. The fact sheet should be prepared in both English and Spanish to reflect the diversity of the communities the Project will serve.

<u>Website Update</u>

The website is an important channel to provide Project information and should be updated as often as possible for it to maintain relevancy. To that end, we will be reviewing the site and making recommendations for updates. It is recommended that the website be modified so that it is immediately engaging, interactive, and intuitive. Users should be able to quickly identify the information they are seeking and additional features, such as graphics, photos, schedules and Project maps should be utilized to invite users to further explore the site. To keep the website current, we advise developing a six-month "look-ahead" editorial calendar that outlines opportunities for information updates, new photos, meeting announcements, and progress updates.

The updates will include our recommendations for new pages, and copy and graphics updates. Once we've reviewed the site, we will provide updated copy and graphics to the website consultant for posting on the site. The website will be reviewed at least monthly for necessary updates.

A schedule for the implementation of these activities is attached as Figure 1.

3. **FISCAL IMPACT / BUDGET AMENDMENT:**

No impact, as the cost for implementing these initial public outreach measures is included in West Yost's Program Management budget (including contingency) previously approved by the Board.

4. **INTERIM GENERAL MANAGER'S COMMENTS:**

Supports moving forward with the recommended Public Outreach Plan strategy.

5. **ENVIRONMENTAL DETERMINATION:** N/A

6. **ALTERNATIVES:**

Modify the recommended public outreach strategy to either delete or amend the initial activities and/or implementation schedule. Deciding not to implement any of the recommended Public Outreach Plan elements could lead to the public not being properly informed about this Project.

circlepoint

ITEM 7B - Attach

TECHNICAL MEMORANDUM

DATE:	July 29, 2016	Project No.: 693-20-16-01 SENT VIA: EMAIL
TO:	SRWA TAC	
FROM:	Patti Ransdell, Circlepoint	
REVIEWED BY:	Lindsay Smith, West Yost Associates, RCE #72996 Gerry Nakano, West Yost Associates, RCE #29524	
SUBJECT:	Stanislaus Regional Water Authority Surface Water Supply Project Public Outreach Plan	

PROJECT OVERVIEW AND GOALS

For a number of years, the Cities of Ceres and the Turlock have been working together with Turlock Irrigation District (TID) on development of a Surface Water Supply Project (Project) and associated facilities (i.e., wet well, raw water supply pipeline, treatment facilities, treated water transmission pipelines, storage tanks, booster pumps and interface with local distribution systems), that would pump water from the Tuolumne River, treat it to drinking water standards, and then deliver it to the service area boundaries of the two cities for municipal and industrial uses.

The Project will provide existing water purveyors with a long-term, reliable water supply source that will allow for the conjunctive use of groundwater and surface water supplies, diversify the cities' water supply portfolios and help keep pace with the projected future development and economic growth of the participating Cities in the south County area (the portion of Stanislaus County south of the Tuolumne River).

This Public Outreach Plan (Plan) for the Project will initially address outreach during the first phase of this Project, Project Definition and facilities planning, and identify different outreach tools to keep stakeholders, groups, and the public consistently informed.

This Plan is a living document; as tactics are implemented, the outreach team will make updates and adjustments to the Plan so that it is relevant throughout the life of the Project.

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IDENTIFIED CONCERNS AND BENEFITS

Benefits that are specific to different stakeholder groups must be considered – while the Project will benefit all, stakeholder groups prioritize benefits differently. While residents will be most concerned about potential rate increases, water aesthetic and taste impacts, and drought preparedness, regulators will be interested in meeting regulations while protecting the environment. It is important that the concerns and benefits are openly communicated to the audiences in order for them to understand the need for the Project, and the benefits it provides.

Concerns

The Stanislaus Regional Water Authority (SRWA) Technical Advisory Committee (TAC) identified some potential stakeholder concerns. They include:

- Customer rate impacts and what is being done to decrease the impacts (i.e., grant and low interest loans, Project phasing, designing the Project for the needs of the two cities, etc.);
- Water quality impacts when the new surface water source is introduced to the current groundwater (GW) supply source;
- Difference in taste and odor from existing GW supply;
- Allocations are fair from a cost sharing perspective;
- Traffic impacts due to construction of finished water and local distribution pipelines;
- Impacts to the environment; and,
- Agricultural communities' concerns about the reliability of their water supply portfolio.

Benefits

One of the keys to countering concerns is to share information about the Project benefits. An initial assessment of Project benefits includes:

- Groundwater aquifer replenishment,
- Diverse water supply portfolio,
- Reliable conjunctive-use system,
- Drought preparedness water supplies,

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- Ability to meet water quality regulations (i.e., the groundwater system is struggling to meet pending water quality regulations),
- Decrease in hardness and mineral content in both delivered water quality and in wastewater effluent discharges,
- Benefits to ag community associated with "make-up" water (i.e., recycled water from the wastewater treatment plants), and
- Increased flows in the Upper Tuolumne River will benefit aquatic species.

We will use these identified Project benefits as we develop our messaging.

OUTREACH PLAN GOALS

The primary goal of the Plan is to increase the public's overall awareness of the Project, as well as the need for the Project and the benefits it will bring the communities it serves. The public outreach program will build recognition and awareness by providing honest, up-to-date information as it is happening. The outreach messages will be consistent, concise, and easily recognizable. It is also important for the messages to be bilingual to reach a greater audience and be culturally relevant to each customer. To meet this primary goal, the following objectives must be met:

- Reinforce where stakeholders get their Project information (squelch rumors) to ensure that each city shares a consistent and concise message about the project,
- Explain the costs of reliable and clean water in a clear and concise manner,
- Support the Proposition 218 process with clear and easy to understand materials,
- Provide support for the SRWA Board decision making process, and
- Increase awareness of the Project prior to construction to help mitigate potential construction disruptions.

KEY AUDIENCES

We will work with the SRWA team to identify Project stakeholders. The development of a stakeholder list is underway. It can be helpful to categorize stakeholders using tiers. Some tiers will have a higher level of Project engagement than others. Stakeholder groups will have different concerns and will perceive the Project benefits differently. Identifying different groups and tiers will help us identify potential problems and concerns that may arise from different points of view. This will also help clarify messaging points by helping to individualize messages when possible. The following is a suggested break down of tiers:

Tier 1 (Key Decision Makers, Project Partners, Funding Agencies, Affected Rate Payers)

These stakeholders will likely get more "touches" from Project team members in the form of small group meetings. Stakeholders from Tier 1 will be part of the group we draw from for Opinion Leader interviews. This group will likely have involvement of some sort throughout the life of the Project.

Tier 2 (Interested Parties, Regulatory Agencies, etc.)

These stakeholders will likely check in and out of the Project as it progresses. While they will not serve as opinion leaders or key stakeholders, their support is vital. It is important to keep these groups informed through less personal and individual means (unlike Tier 1).

A summary of stakeholder tiers is included below.

Tier 1 Stakeholders

- Stanislaus Regional Water Authority (Board)
- City of Ceres Officials
- City of Turlock Officials
- Stanislaus County Board of Supervisors
- Turlock Irrigation District
- Stanislaus County Farm Bureau
- Agricultural Center County Farm Advisors
- Agricultural Commissioner
- Stanislaus County Groundwater Forum
- Stanislaus County Agricultural Advisory Board
- Stanislaus County Groundwater Issues Forum Technical Advisory Committee
- Turlock Irrigation District Customers
- Residents within the proposed service area (cities of Ceres and Turlock and any other future project partners)
- Manufacturers and Food Processors within the proposed service area
- Railroad Companies
  — BNSF

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Tier 2 Stakeholder

- CA Department of Water Resources
- Central Valley Flood Protection Board
- State and federal funding agencies
- Other regulatory agencies
- State Water Resources Control Board
- Educational Institutions
  - California State University, Stanislaus
- Neighborhood Associations
- Taxpayer groups
- Business Groups
  - Turlock Chamber of Commerce
  - Ceres Chamber of Commerce
- Media
  - Ceres Courier
  - Turlock Journal
  - Modesto Bee
- Other potential partners
  - Denair
  - Hughson
  - Hilmar
- Elected Officials Representing
  - Federal
  - State
- Religious Groups
- Latino Community
  - Latino Community Roundtable of Stanislaus County

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PUBLIC OUTREACH TACTICS

A number of different tactics can be used to reach the Project stakeholders, but not all tools will work effectively with all audiences – targeted outreach is more effective. The audience and message should always be taken into account when choosing an outreach tool. Also, outreach work should always sync with technical work (example: a public workshop should not be held without new information for the public). The Project needs to be represented consistently in all messages and materials. The color, logo, and font should always be similar and the story should be told in the same way every time in order to reinforce the benefits of the Project in the minds of the public. All outreach should be truthful and clearly identify impacts or potential impacts and provide information on what it being done to mitigate them. Circlepoint will work to develop a Public Outreach calendar that identifies timing and implementation of different tools based on the Project schedule. The following tools are available for use throughout the Project and should be strategically chosen based on Project milestones:

One-on-One Interviews with Opinion Leaders

As part of the Project public outreach planning, feedback from key stakeholders will be sought to ensure that community issues and concerns are incorporated into the process. The stakeholder responses will help to identify community issues related to the Project and the most effective ways to outreach to the public. The information gathered through the stakeholder interviews will be used to further prepare and enhance the Project's Public Outreach Plan.

These interviews will be completed by SRWA Board Members and Circlepoint staff at the beginning stages of the Project. Circlepoint will help develop 10-15 questions to ask the Opinion Leaders and will provide these to the SRWA Board Members. A summary of the interviews will be used to guide the outreach efforts, and will allow the team to make adjustments as needed to our strategy.

The one-on-one interviews will take place well before the Proposition 218 process begins. Feedback gleaned from the interviews will inform the outreach needed before and during the Proposition 218 process.

Messaging

High-level messages should be simple, meaningful, and have personal relevance. These high-level messages are designed to serve as the overarching narrative for general audiences. The Core Messages outlined in this Plan encompass the purpose and need for the Project and provide a high-level overview of how implementation of the proposed Project will provide benefits for residential, municipal/industrial and agricultural customers.

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These messages are delivered using a variety of communications channels, including the following:

Collateral Materials

This includes newsletters, bill inserts, and fact sheets. The type of materials distributed will be determined by the technical milestone and will vary throughout the Project process. Ideally, a fact sheet will be developed early in the Project. Fact sheets can be placed at the public counters in both Turlock and Ceres, can be taken to public meetings, and be handed out at presentations given by SRWA staff. This can be updated as technical milestones are achieved. The first fact sheet should be developed early in the Project, after the one-on-one stakeholder interviews are conducted, and before any public meetings are held. Fact sheet topics could include: Project description (including Project benefits) and water quality and water supply/drought preparedness.

Newsletters can be done on a bi-annual basis, and will provide an update on the overall process. Newsletters can be printed, or developed as an e-newsletter, or both. Because newsletters tend to be more labor intensive to develop, they should be the second choice of collateral materials to be developed.

Bill inserts can be developed later in the Project and can be used to reinforce project message points, or direct readers to the Project website for more detailed information about specific items like water quality or taste.

These materials must be clearly written, and should be developed for both English and Spanish speakers.

Traditional and Social Media

Traditional media still plays an essential role in educating the public on important local issues and recent events. SRWA should continue to issue press releases, submit op/ed pieces in local print media and pursue traditional press coverage with local news channels and newspapers, including articles in local homeowner association or other community generated newsletters.

Social media will also play a role in engaging broader audiences. SRWA should provide content to the existing Turlock Facebook page and should consider establishing a Twitter feed when construction is in the planning stages. If Ceres sets up a Facebook page, Project focused content should be provided as well. Ideally, SRWA could set up and maintain its own Facebook page after the Proposition 218 process is completed.

Another venue to consider is providing information to NextDoor, a neighborhood-based private social network, which should also be utilized for sharing meeting announcements, Project updates, and general Project information.

Website

The online presence for the Project should be enhanced. The existing SRWA website should be updated during Phase 1 of the Project. The website is an important channel to provide Project information and should be updated as often as possible for it to maintain relevancy. It is recommended that the website be modified so that it is immediately engaging, interactive, and intuitive. Users should be able to quickly identify the information they are seeking and additional features, such as graphics, photos, schedules and Project maps should be utilized to invite users to further explore the site. To keep the website current, we advise developing a six-month "look ahead" editorial calendar that outlines opportunities for information updates, new photos, meeting announcements, and progress updates. Circlepoint will provide Content Management Systems (CMS), navigation, and Search Engine Optimization strategy recommendations

In addition to making recommendations for improving the website, Circlepoint has the capability to update the current website. After the website improvement recommendations have been made to, and approved by the SRWA Board, we would develop a schedule to develop and roll out the updates, and provide regular content and site maintenance.

Workshops, Public Meetings and Community Events

We recommend an ongoing series of community meetings, workshops, and attendance at local events. In order to reach a broader audience, it is important to use tools other than printed or electronic materials. The core objectives of the Plan are to engage broader audiences and educate the public about the Project. Community events built around education and discussion can meet these objectives simultaneously. Our experience shows that delivering messages in-person makes the project more real and personal as it allows attendees the opportunity to ask the questions most important to them.

These meetings are described below.

Traditional Community Meetings/Workshops

Throughout the life of the Project, SRWA should continue to host community meetings and workshops. SRWA should consider non-traditional meeting formats, similar to the open house format, in order to promote ongoing public dialogue and agency collaboration. These meetings can be tied to City Council meetings, initially used as a means to provide past research and other options to explain the current Project decisions. As the project design progresses, public workshops can be held to allow attendees an opportunity to learn more about project elements such as the pipeline alignments and construction activities that may have an impact on residents. These workshops provide both Project designers and residents an opportunity to discuss the potential, temporary effects of the Project and the best way to address those impacts.

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These meetings will keep the public informed and can be announced through news releases, advertisements, and social media platforms. Informational sessions can be held to inform the public of upcoming Project milestones.

Stakeholder Group Meetings

These meetings will target specific interest groups such as the agricultural community as a means to provide information on topics which are of interest to them. These will be more focused and also tied to milestones or key technical decision points. We recommend providing periodic presentations by West Yost to the Ceres City Council, Turlock City Council, and TID Board to discuss various Project elements and/or progress.

Speakers Bureau

A speaker's bureau pairs local stakeholder groups with people who can attend their meetings and speak about the Project. A speaker's bureau is ongoing and requires that key SRWA staff or TAC members attend stakeholder groups' meetings to provide an update on the proposed Project and to address specific issues and questions that the group might have. We recommend that SRWA develop a list of key stakeholder groups such as the Rotary, Kiwanis, homeowners' associations, chambers of commerce and farm bureau or similar organizations, and reach out to them to determine if they would be interested in learning more about the Project. We would prepare a toolkit that includes a master PowerPoint presentation, audience specific messaging and talking points, and relevant Project materials (e.g., fact sheets or FAQs) for the presenters to use at the meetings.

Ideally, the speaker's bureau would be implemented later in Phase 1, after appropriate materials have been developed, and the stakeholder interviews have been conducted to better tailor and add further definition to the outreach efforts.

Tabling Sessions at Public Events

Tabling sessions provide outreach to stakeholders that might not engage otherwise. Collateral information can be shared at public events such as fairs and community events. Circlepoint will create a calendar of events, for TAC approval, at which to have an SRWA presence.

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Survey

SRWA could consider completing a public survey at the beginning of the Project outreach process to set a benchmark for public awareness and perception of the Project. A survey done in the middle of the Project allows us to make necessary adjustments to our outreach strategy. Surveys can be done online via services like Survey Monkey and a link can be included on the SRWA website, as well as the websites for both Turlock and Ceres. The survey can be advertised via email blasts, news releases, and Facebook and other social media platforms. Intercept surveys could be considered and conducted at public places such as grocery stores, drug stores, parks, and public events in order to reach residents we might not otherwise engage in the Project.

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Stanislaus Regional Water Authority

Item 7C
Board Synopsis
September 22, 2016

From: West Yost Program Management Team

Prepared by: Andy Smith, West Yost Associates

1. **ACTION RECOMMENDED:**

Motion: Accepting the Technical Memorandum dated September 7, 2016 - assessment of available historical Tuolumne River water quality presented in the Tuolumne River Historical Water Quality Assessment Technical Memorandum.

2. **DISCUSSION OF ISSUE:**

As part of the Quick Start Plan, the TAC and Project Management (PM) Team have reviewed and summarized available historical raw water quality data from the Tuolumne River. These data and a summary of their implications on the SRWA Surface Water Supply Project were presented in the Tuolumne River Historical Water Quality Assessment Technical Memorandum (TM), which was finalized on September 7, 2016.

A summary of the major discussion topics, as well as an outline of findings, is provided below. The complete TM is also attached.

State and Federal Drinking Water Regulations
The design and performance of surface water treatment facilities are regulated by a number of regulations including: Primary and Secondary Maximum Contaminant Levels; Surface Water Treatment Rules; the Disinfectants and Disinfection Byproducts Rule; the Total Coliform Rule; the Lead and Copper Rule; and a variety of requirements pertaining to currently unregulated contaminants.

Potential Contamination Sources
Several sources of potential contamination exist upstream of or adjacent to the Project's intake location, the existing infiltration gallery, and may affect the quality of raw water treated by the Project, including:

- City of Waterford wastewater treatment plant
- Dairy, poultry and ranching operations
- Groundwater influences
- Recreational areas
- Pesticide and herbicide application in agricultural areas

Review of Historical Water Quality Data
Available historical data were obtained from a variety of sources, including the United States Geological Survey, Modesto Irrigation District, Turlock Irrigation District, the State Water Resources Control Board, and the Department of Water

Resources. Data referenced in the TM were collected from a total of 12 sites along the Tuolumne River. The TM provides a detailed assessment of each of 20 parameters measured in the available datasets, broadly grouped into the following categories:

- General parameters
- Nutrients
- Disinfection byproduct-related parameters
- Metals
- Microbial parameters
- Pesticides and other synthetic organic compounds
- Asian clams / invasive mollusks

Summary of Water Quality Implications on Treatment

In general, the available raw water quality from the Tuolumne River is excellent. However, the following parameters may present treatment issues, and will be studied in further detail during planning raw water quality sampling and analysis activities:

- Disinfection byproducts
- Cryptosporidium
- Pesticides and synthetic organic compounds
- Aesthetics
- Invasive mollusks

3. FISCAL IMPACT / BUDGET AMENDMENT:

No additional Tuolumne River raw water quality data are known to be available and relevant to this Project, and no additional historical water quality work is being recommended. Therefore, no added fiscal or budget impacts are anticipated.

4. INTERIM GENERAL MANAGER'S COMMENTS:

Supports moving forward with the acceptance of this summary of the available historical raw water quality for the Tuolumne River, as presented in the TM as a basis for ongoing, planned evaluations of treatment process alternatives.

5. ENVIRONMENTAL DETERMINATION:

N/A

6. ALTERNATIVES:

N/A

ITEM 7C - Attach

TECHNICAL MEMORANDUM

Stanislaus Regional Water Authority Surface Water Supply Project
Historical Water Quality Assessment

Draft Date: August 12, 2016
Final Date: **September 7, 2016**

To: Stanislaus Regional Water Authority (SRWA)
Technical Advisory Committee (TAC)

From: Trussell Technologies, Inc. and West Yost Associates

Authors: Sangam K. Tiwari, Ph.D., P.E. (Trussell Technologies)
Elaine W. Howe, P.E. (Trussell Technologies)

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R. Rhodes Trussell, Ph.D., P.E. (Trussell Technologies)
Celine C. Trussell, P.E. (Trussell Technologies)

Subject: **Tuolumne River Historical Water Quality Assessment**

0 TABLE OF CONTENTS

1 INTRODUCTION

The Stanislaus Regional Water Authority (SRWA), a joint powers authority between the Cities of Turlock and Ceres (Cities), is embarking on a new water supply project to provide treated surface water to the Cities to supplement their existing groundwater supply. The source water for this new water treatment plant (WTP) is the Tuolumne River. The proposed intake is an existing infiltration gallery located four to five feet below the river bottom.

As part of the source water characterization process, historical water quality data collected along the Tuolumne River at locations between Don Pedro Reservoir and the confluence of Dry Creek at Modesto were reviewed. These water quality data and any observed temporal or spatial trends in water quality are provided within this technical memorandum (TM). This TM has the following layout:

1. Project Location and Background
2. Applicable State and Federal Drinking Water Regulations
3. Potential Contaminant Sources
4. Review of Historical Water Quality Data
5. Summary of Water Quality Implications on Treatment Options

The historical water quality assessment will be used as a guide to develop a water quality monitoring plan and to select the appropriate treatment process for SRWA's new WTP.

2 PROJECT LOCATION AND BACKGROUND

The source water for this project is the Tuolumne River. The Tuolumne River originates in Yosemite National Park high in the Sierra Nevada mountain range as two streams and converges in Tuolumne Meadows (Figure 1). The River then meanders northwest with spectacular drops through the Tuolumne Canyon and receives flow from various creeks before widening into Hetch Hetchy Reservoir (formed by O'Shaughnessy Dam). The River exits Yosemite National Park and enters the Stanislaus National Forest. The main Tuolumne River tributaries join within the reach between Hetch Hetchy Reservoir and Don Pedro Reservoir (formed by New Don Pedro Dam) (SFPD, 2008). Don Pedro Reservoir impounds the Upper Tuolumne River Watershed flows from the Sierra Nevada and is operated by the Turlock and Modesto Irrigation Districts. The Tuolumne River enters the Lower Tuolumne River Watershed as it enters La Grange Dam, which is two miles downstream of the New Don Pedro Dam. The Lower Tuolumne River Watershed is shaded in light green in Figure 2. The watersheds for Turlock Lake and the Lower Tuolumne River include steep grassland and woodland of the Sierra Nevada foothills on the far eastern side, transitioning to the plains of the Central Valley downstream. Approximately 17% of the watersheds are dedicated to agriculture (Brown and Caldwell, 2008a). At the New Don Pedro Dam, the Tuolumne River is divided into three flow streams – the Turlock Irrigation District (TID) Canal, the Modesto Irrigation District (MID) Canal (flow only diverted during winter months), and about half of the flow is allowed to continue as the Tuolumne River (MID, 2015). Dry Creek is the last major tributary (just north of the City of Modesto) before the Tuolumne River terminates at the San Joaquin River southwest of San Joaquin River National Wildlife Refuge (SFPD, 2008).

The existing infiltration gallery is located in the Lower Tuolumne River watershed, approximately 25 miles upstream of the confluence of the Tuolumne River with the San Joaquin River (Brown and Caldwell, 2008a). The location of this infiltration gallery within the Lower Tuolumne River Watershed is shown in Figure 2. The infiltration gallery location relative to the Cities of Hughson and Waterford is shown in Figure 3, with an enlargement of the site location shown in Figure 4.

The SRWA plans to construct a new 30 mgd surface water treatment plant to provide high quality, treated water to the Cities of Ceres and Turlock, to supplement their current groundwater supplies. The intake for this new WTP is the previously constructed infiltration gallery, with piping already in-place below the riverbed (Figure 4). This piping is comprised of sixteen (16), 45-foot long sections of 24-inch slotted pipe, covered by four to five feet of pea gravel, washed rock and river cobble. The wet well and raw water pump station to which these pipes will ultimately be connected has not yet been constructed.

Since there are no nearby WTPs directly[1] on the Tuolumne River, characterization of the source water quality will be an important part of the design process. The characterization presented in this TM will facilitate selection and construction of a cost-effective and efficient treatment process capable of producing a stable supply of high-quality potable water to the Cities of Ceres and Turlock.

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[1] The Modesto Regional Water Treatment Plant, operated by MID, has its intake in the southwest point of Modesto Reservoir. The source water for the Modesto Reservoir is the Tuolumne River which is diverted from La Grange Reservoir at the La Grange Dam and diversion structure. This diversion structure is approximately 26 miles upstream of the location of the infiltration gallery. The Reservoir water quality is different from the River water quality due to long storage time and seasonal stratification and turnover.

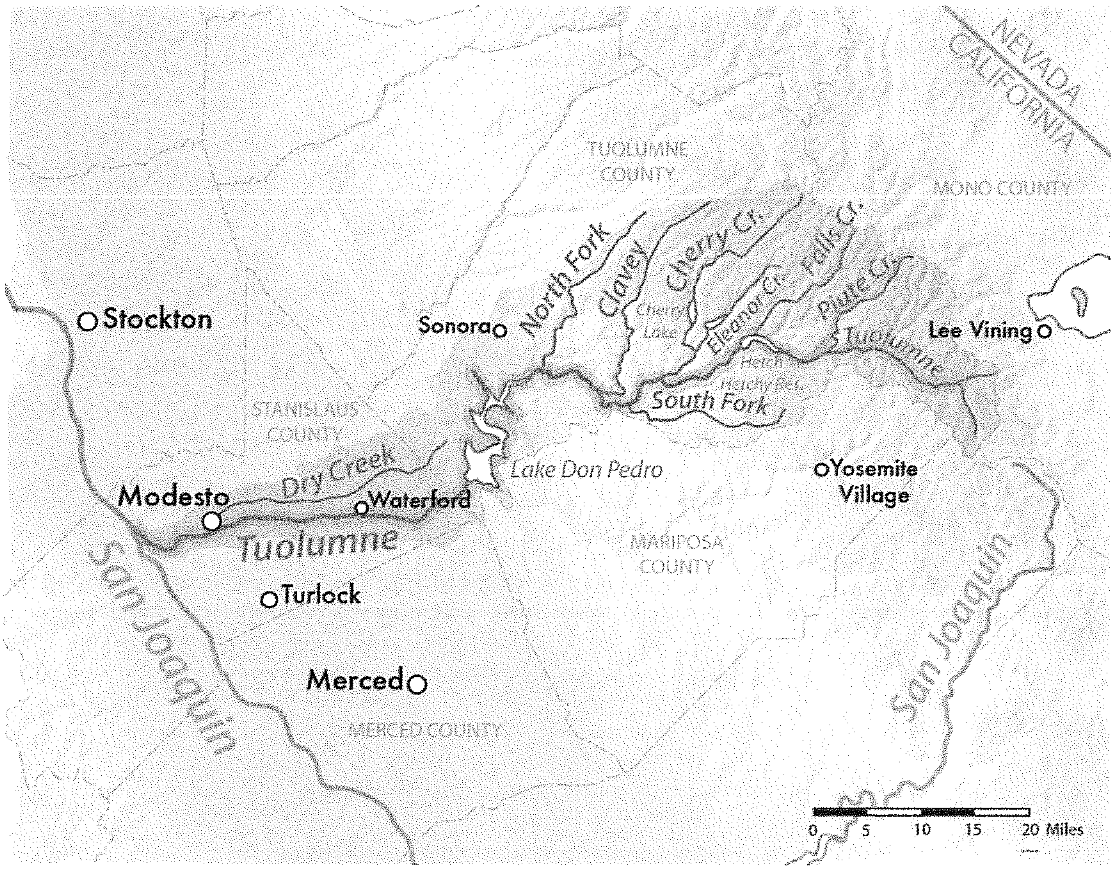

Figure 1. Overall Course of the Tuolumne River (USGS website)

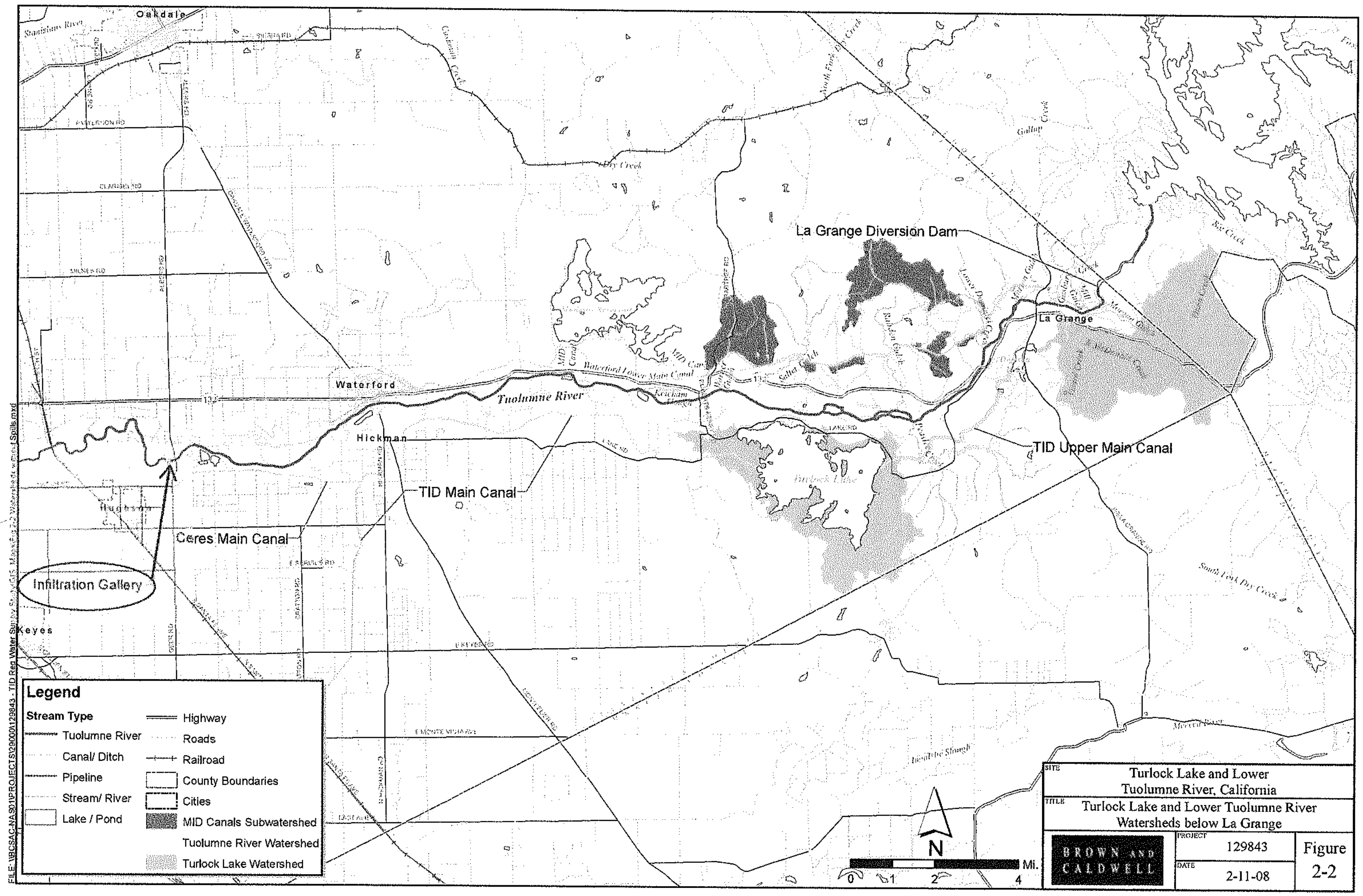

Figure 2. Lower Tuolumne River Watershed (Brown and Caldwell, 2008a)

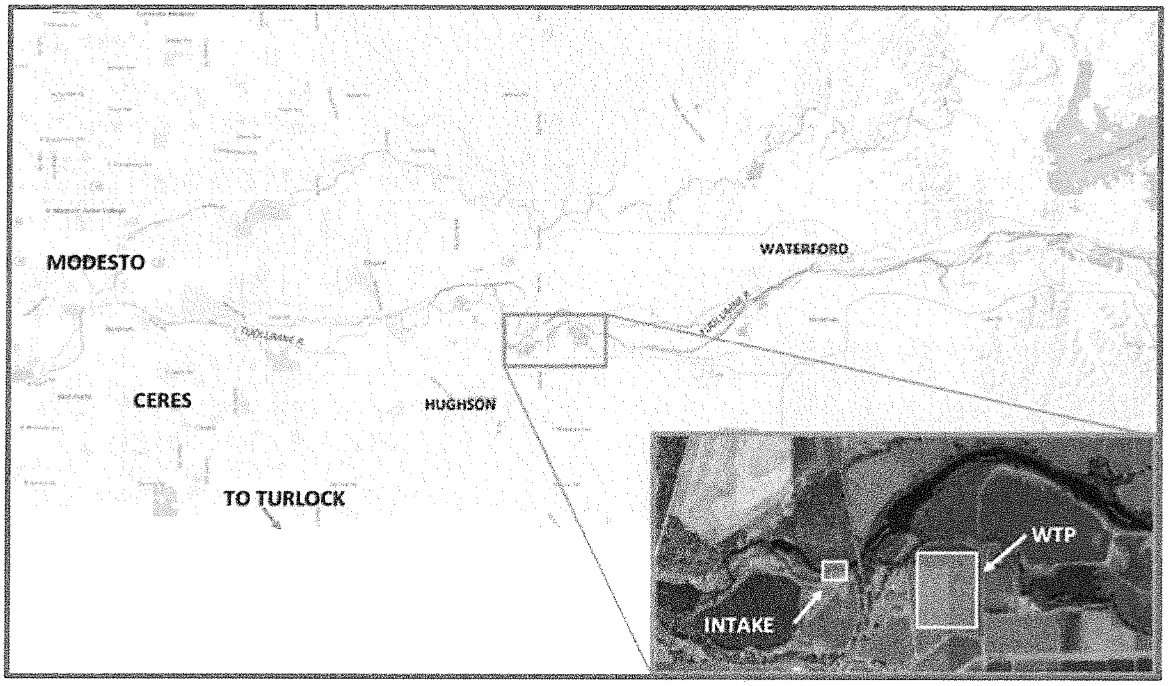

Figure 3. Infiltration Gallery Location on the Tuolumne River

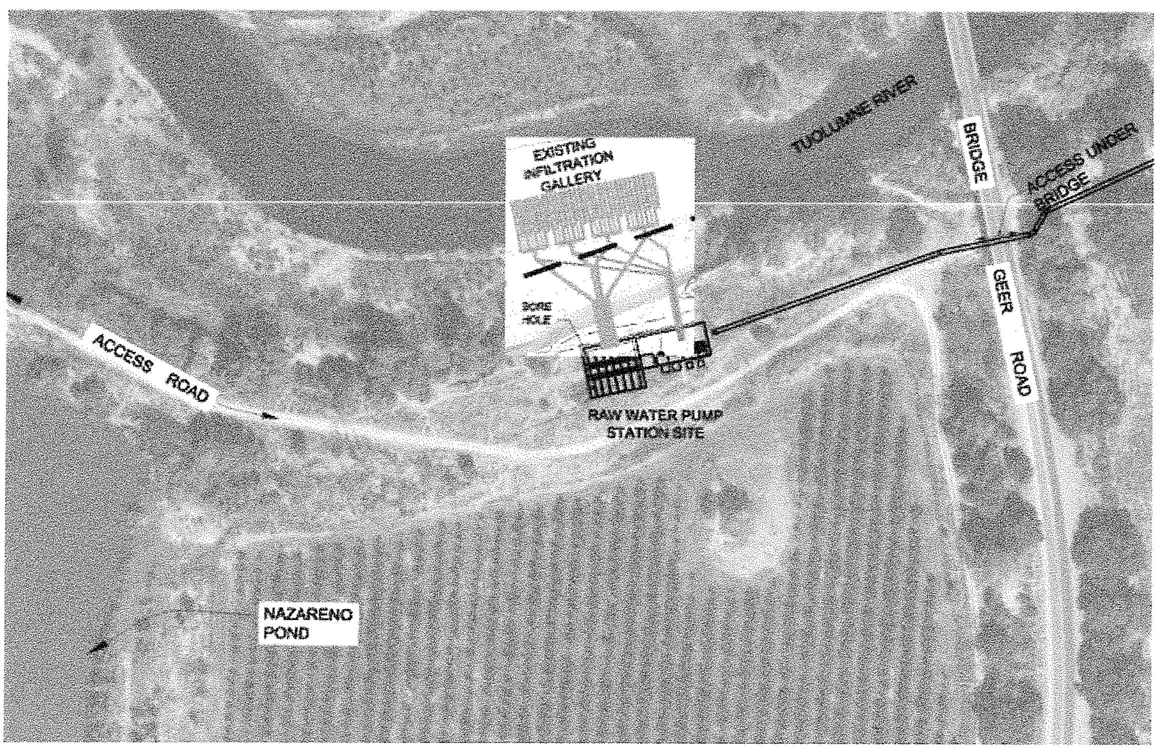

Figure 4. Enlargement of Infiltration Gallery Location on the Tuolumne River

3 STATE AND FEDERAL DRINKING WATER REGULATIONS

The SRWA's future surface water treatment facility will be subject to all applicable state and federal drinking water regulations. The following is a list of standards which define the maximum contaminant levels (MCLs) that the United States Environmental Protection Agency (USEPA) and the State of California (as specified in Title-22 of the California Code of Regulations (CCR)) have legislated for the drinking water industry to ensure the public's health and safety:

§64431	Maximum Contaminant Levels – Inorganic Chemicals
§64442	MCLs and Monitoring - Gross Alpha Particle Activity, Radium-226, Radium-228, and Uranium
§64443	MCLs and Monitoring - Beta Particle and Photon Radioactivity
§64444	Maximum Contaminant Levels – Organic Chemicals
§64449	Secondary Maximum Contaminant Levels and Compliance
§64533	Maximum Contaminant Levels for Disinfection Byproducts
§64426.1	Total Coliform Maximum Contaminant Level
§64674	Lead and Copper – Large Water System Requirements

In addition to the MCLs, treatment techniques have been legislated which regulate microbial removal through filtration and microbial inactivation through disinfection (§64652). The raw water quality will determine how these treatment techniques are applied, and will influence the design of the SRWA's future WTP.

Treatment techniques have also been legislated for removal of DBP precursor material, as measured by Total Organic Carbon (TOC) (§64535). The percentage of TOC to be removed through treatment is determined by source water TOC and alkalinity. Historical river water quality data for these parameters is also discussed in this TM, and potentially will have a large impact on process train selection for the future WTP.

3.1 Primary and Secondary Maximum Contaminant Levels (MCLs)

Primary MCLs (pMCL) are legally enforceable limits that regulate contaminant levels based on toxicity and adverse human health effects. Secondary MCLs (sMCL) are guidelines rather than enforceable limits; they are based on aesthetics and are labeled by the regulations as "consumer acceptance contaminant levels." Tables extracted from the Title 22 CCR for all constituents that have primary and secondary MCLs are provided in Appendix A (CCR, Updated July 16, 2016).

One contaminant that will soon have a MCL is 1,2,3-Trichloropropane (1,2,3-TCP). This contaminant has had a California Division of Drinking Water (DDW) notification level (NL) of 0.005 µg/L since 1999. On July 20, 2016, DDW released a recommendation establishing a MCL for 1,2,3-TCP of 0.005 µg/L—the same as the current NL—because this compound is a known carcinogen.

All contaminants with a pMCL and sMCL, including 1,2,3-TCP, are included in the Draft Source Water Characterization Sampling Plan (Trussell Technologies, July 14 2016) and will be sampled quarterly for one year.

3.2 Surface Water Treatment Rules

There has been a series of four federally mandated Rules that have been promulgated with the intent of preventing waterborne diseases caused by pathogenic microorganisms, starting with the Surface Water Treatment Rule (SWTR). These Rules established treatment techniques to remove and/or inactivate microbial contaminants through effective filtration and disinfection. While they are detailed and complex, the following discussion provides a brief synopsis as it relates to the potential treatment train for the SRWA.

The SWTR was promulgated in 1989. It required that all public water systems (PWS) using surface water or groundwater under the direct influence of surface water, which practice conventional or direct filtration, to:

1. Achieve 4-log (99.99%) removal/inactivation of viruses and 3-log (99.9%) removal/inactivation of *Giardia lamblia*,
2. Maintain a disinfectant concentration of at least 0.2 mg/L at the entrance to the distribution system, and maintain a detectable disinfectant residual throughout the distribution system, and
3. Maintain a combined filter effluent turbidity less than 0.5 NTU.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) was promulgated in 1998 and built on the treatment techniques required by the SWTR. In order to address *Cryptosporidium*, the IESWTR required PWSs that filter to achieve a 2-log removal of *Cryptosporidium* by increasing the stringency of the combined filter effluent turbidity standards to 0.3 NTU. *Cryptosporidium* are highly resistant to traditional disinfection practices using chlorine and/or chloramines, so the required 2-log removal is through filtration and not inactivation.

The Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), promulgated in 2002, made the 2-log *Cryptosporidium* removal requirement applicable to small systems servicing less than 10,000 people.

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), promulgated in 2006, requires utilities to monitor their source water on a monthly basis for *Cryptosporidium*, *E. coli*, and turbidity. Depending on the maximum running annual average (RAA) *Cryptosporidium* concentration, the water is placed in a “Bin” which dictates the level of treatment required to achieve the required log removal/inactivation of *Cryptosporidium*. Bin classification is summarized below in Table 1.

Table 1. Bin classification for filtered public water systems indicating the *Cryptosporidium* removal required under the LT2ESWTR

Bin	Cryptosporidium Concentration (oocysts/L)	Treatment Requirements for Conventional Filtration	Treatment Requirements for Direct Filtration
1	<0.075	No additional treatment	No additional treatment
2	0.075 to <1.0	1-log	1.5-log
3	1.0 to <3.0	2-log	2.5-log
4	≥3.0	2.5-log	2-log

In addition to stipulating the overall requirements, these rules require a multi-barrier treatment approach to ensure effective microbial treatment. The specific treatment credit awarded for pathogen *removal* depends on the filtration technology applied, and the credit awarded for pathogen *inactivation* depends on the disinfectant type, dose and contact time. As such, regardless of the removal credit attained, at least 0.5-log *Giardia* inactivation and 2-log virus inactivation must be provided through disinfection.

DDW has authority to require greater levels of pathogen treatment based on source water quality. DDW has stated it plans to follow the DDW Surface Water Treatment Rule (SWTR) guidance document[2] with regard to log treatment requirements for *Giardia* and viruses:

Total coliform (monthly median):

- If <1000 /100 mL, then 3-log or 4-log treatment requirements for *Giardia* and viruses, respectively
- If >1000 /100 mL, then 4-log or 5-log treatment requirements for *Giardia* and viruses, respectively

E. coli (monthly median):

- If <200 /100 mL, then 3-log or 4-log treatment requirements for *Giardia* and viruses, respectively
- If >200 /100 mL, then 4-log or 5-log treatment requirements for *Giardia* and viruses, respectively

The minimum microbial reduction requirements, as mandated by DDW and the USEPA are summarized in Table 2.

[2] "Appendix B, Guidelines for Determining when Surface Waters will Require More than the Minimum Levels of Treatment Defined in the Surface Water Treatment Regulations"

Table 2. Overall regulatory pathogen removal/inactivation requirements

Pathogen	DDW Removal/Inactivation Requirements
Cryptosporidium (Bin 1)	2-log
Giardia	3-log
Viruses	4-log

3.3 Disinfectants and Disinfection Byproducts Rule

The Disinfectants and Disinfection Byproducts Rule (D/DBPR) was legislated to minimize the public's exposure through drinking water to potentially carcinogenic disinfection byproducts (DBPs). The rule was promulgated in two parts. The Stage 1 D/DBP Rule, promulgated in 1999, established:

- MCLs for two groups of organic DBPs—total trihalomethanes (TTHMs) and haloacetic acids (HAA_5);
- MCLs for two inorganic DBPs—bromate and chlorite;
- Treatment techniques for the effective removal of DBP precursor material, measured as TOC; and,
- Maximum residual disinfectant levels (MRDLs) for chlorine, chloramines, and chlorine dioxide.

The Stage 1 D/DBP Rule MCLs are summarized in Table 3. Compliance is based on a system-wide running annual average (RAA).

Table 3. MCLs for the Disinfection Byproducts

Disinfection By-Product	MCL (mg/L)
Total Trihalomethanes (TTHM)	0.08
- Chloroform	
- Bromodichloromethane	
- Dibromochloromethane	
- Bromoform	
Haloacetic Acids (HAA5)	0.06
- Mono-, di-, and trichloroacetic acids	
- Mono- and dibromoacetic acids	
Chlorite	1.0
Bromate	0.010
Disinfectants	**MRDL (mg/L)**
Chlorine	4.0 (as Cl2)
Chloramine	4.0 (as Cl2)
Chlorine Dioxide	0.8 (as ClO2)

The treatment technique for TOC removal is referred to as "enhanced coagulation". The amount of TOC removal required by the D/DBP Rule is a function of the source water TOC concentration and alkalinity, as summarized in Table 4. The D/DBP Rule also provides "alternative compliance criteria" which systems have the option of meeting for compliance in lieu of the TOC removal requirement. These alternative compliance criteria are:

1. System's source water TOC is <2.0 mg/L
2. System's treated water TOC is <2.0 mg/L
3. System's source water TOC is <4.0 mg/L and alkalinity is >60 mg/L (as $CaCO_3$), and the system's TTHM and HAA5 compliance samples are <40 µg/L and <30 µg/L, respectively.
4. System's TTHM concentration is <40 µg/L and HAA5 concentration is <30 µg/L, with only free chlorine for primary disinfection and residual maintenance.
5. System's source water Specific Ultraviolet Absorption (SUVA) prior to any treatment is ≤2.0 L/mg-m; and
6. System's treated water SUVA is ≤2.0 L/mg-m.

Meeting any of the above six requirements permits the utility to avoid the enhanced coagulation TOC removal requirement.

Direct filtration systems are not required to comply with the Enhanced Coagulation treatment requirements, but the System must still comply with the DBP MCLs.

The Stage 2 D/DBP Rule requires each system to conduct an "initial distribution system evaluation (IDSE)" to determine locations within their distribution system that represent the highest concentrations of DBPs, and to modify their monitoring and reporting requirements to include these locations. The Stage 2 D/DBP Rule requires calculation of locational running annual averages (LRAA) rather than system-wide RAA as had been used in the Stage 1 Rule. The RAA allowed some areas of the system to have higher DBP concentrations, while still complying with the regulations. The LRAA is more stringent because it ensures all locations in the distribution system are in compliance with the MCLs.

Table 4. TOC Removal Required Under the Stage 1 D/DBP Rule

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0-60	>60-120	>120
>2.0 – 4.0	35%	25%	15%
>4.0 – 8.0	45%	35%	25%
>8.0	50%	40%	30%

3.4 Total Coliform Rule

The Total Coliform Rule (TCR) was published in 1989 and became effective in 1990. The Revised Total Coliform Rule (RTCR) was published on February 13, 2013. PWSs were required to comply with requirements of the RTCR by April 1, 2016. The TCR requires public water systems to collect a specific number of samples from their distribution system (based on the size of their system) to monitor for total coliform. Compliance is based on the presence or absence of total coliform. If a sample tests positive for total coliform, it must also be tested for fecal coliform or *E. coli*. A sample that tests positive for fecal coliform or *E. coli* is considered an acute violation.

The RTCR introduces an MCL goal (MCLG) of zero for *E. coli,* and an MCL for *E. coli* based on monitoring results for total coliforms and *E. coli*. The RTCR also eliminates the MCLs and MCLGs for total coliforms (and fecal coliforms) included in the TCR. The measurement of Total Coliform was developed at the turn of the century as an indicator of the presence of fecal contamination (Smith, 1893). From the beginning it was clear that some members of the coliform group (the organisms that test positive as coliform organisms) are not actually fecal in origin. The fecal coliform test was developed in the 1960s as a test that more narrowly targeted members of the coliform group that are of fecal origin, but even that test was not still specific for the main organism found in human feces, namely *Escherichia coli* (*E. coli*). In recent decades a specific test for the *E. coli* organism, itself, has been developed and has seen widespread use. Under the TCR, total coliform-positive samples trigger an assay for either fecal coliforms or *E. coli*. The RTCR eliminates fecal coliform tests, replacing them with direct measurement of *E. coli* as an indicator of fecal contamination.

Perhaps the most significant change in the RTCR is the requirement of corrective action and a coliform treatment technique. Under the coliform treatment technique, total coliforms serve as an indicator of a potential pathway of contamination. It requires a system to conduct an assessment of their system when monitoring results indicate the system may be vulnerable to contamination, based on exceeding a specified frequency of total coliform occurrence. A simple Level 1 self-assessment or a more detailed Level 2 assessment may be required depending on how severe and how frequent the contamination. Any sanitary defects identified in the Level 1 or Level 2 assessments must be corrected. Example sanitary defects include cross-connection and backflow issues; operator issues; distribution system issues; storage issues; and disinfection issues like failure to maintain the disinfectant residual throughout the distribution system.

The RTCR also makes changes to the public notification requirements. Under the TCR, public notification is required for detection of total coliforms. Under the RTCR, public notification would no longer be required upon detection of total coliforms. Instead, a Tier 1 public notification (PN) is required when the *E. coli* MCL is violated. A Tier 2 PN is required when there is a treatment technique violation. A Tier 3 PN is required in the case of monitoring or reporting violations.

3.5 Lead and Copper Rule

The lead and copper rule (LCR), promulgated by the USEPA in 1991, established action levels for lead and copper concentrations in potable water. The four basic requirements of this rule for water suppliers are (1) to optimize treatment to control corrosion in the distribution system and in customers' plumbing, (2) determine concentrations of lead and copper at the taps of customers with lead service lines or lead solder in their plumbing, (3) rule out the source water as a source of significant lead levels, and (4) provide public education about lead if action levels are exceeded. The LCR requires PWS to monitor for lead and copper at the entry to their distribution system and at taps throughout the distribution system (the number of monitoring points is based on system size and the monitoring should target taps in homes/buildings that are at high risk of lead and copper contamination). The action level for lead is 0.015 mg/L and the action level for copper is 1.3 mg/L, both based on 90^{th} percentile levels. If 90^{th} percentile concentrations exceed these action levels, the utility must evaluate and implement one of the prescribed corrosion control treatment strategies, which include alkalinity and pH adjustment, calcium hardness adjustment, and the addition of a phosphate or silicate based corrosion inhibitor.

In 2007, the USEPA promulgated seven short-term regulatory revisions and clarifications to the LCR, which targeted monitoring, treatment processes, public education, customer awareness, and lead service line replacement (USEPA, 2007). These minor revisions did not change the action levels, MCLG, or basic requirements of the LCR.

In July 2016, EPA published a memo providing recommendations on how public water systems should address lead and copper sampling details in a comprehensive document, *The Optimal Corrosion Control Treatment Evaluation Technical Recommendations Document,* which provides technical recommendations that both systems can use to comply with Lead and Copper Rule (LCR) corrosion control treatment requirements and effective evaluation and designation of optimal corrosion control treatment (OCCT). The technical recommendations in the new document are based on new science and implementation experience. Key topics covered are:

1. Influence of oxidation-reduction potential (ORP) on lead and copper release, and importance of Pb(IV) compounds for systems with lead service lines (LSLs).
2. Importance of aluminum, manganese, and other metals on formation of lead scales and lead release.
3. Impact of physical disturbances on lead release.
4. Mechanisms and limitations of using blended phosphates for corrosion control.
5. Target water quality parameters (WQPs) for controlling copper corrosion.
6. Impacts of treatment changes, particularly disinfectant changes, on corrosion and corrosion control.

3.6 Water Quality Criteria for Unregulated Contaminants

Monitoring may be necessary for certain unregulated contaminants. Both the DDW and the EPA maintain lists of unregulated contaminants that may be on the regulatory horizon. These lists are: (a) DDW's list of compounds with Notification Levels (NL) or Archived Notification Levels (aNLs) and (b) EPA's current Contaminant Candidate List (CCL) with the associated Unregulated Contaminant Monitoring Rule (UCMR).

3.6.1 DDW Notification Levels and Archived Notification Levels

DDW has established health-based notification levels for certain chemicals associated with actual contamination of drinking water supplies. Contaminants with notification levels currently lack MCLs, but may be regulated in the future. If, after several years, an MCL is not adopted for a specific chemical, its notification level is then archived. Notification levels are advisory in nature and not legally enforceable standards. Nevertheless, if a contaminant is detected in a finished water above the NL then DDW recommends consumer notification, and if the measured contaminant concentration exceeds the NL response level, then further action is recommended by DDW.

3.6.2 Candidate Contaminant List (CCL)

The EPA is mandated by the Safe Drinking Water Act (SDWA) to publish a list of candidate contaminants being considered for regulation every five years. This list is referred to as the Candidate Contaminant List (CCL). Candidates on this list are not currently regulated, but are either known or suspected to occur in PWSs. After being listed on a CCL, supporting data is evaluated to determine whether or not it is sufficient for regulatory determination. Data needs are evaluated in three categories—health effects, occurrence, and analytical methods. If insufficient occurrence data exist and regulation seems probable, candidates can be added to the list of constituents monitored under the Unregulated Contaminant Monitoring Rule (UCMR).

The EPA has published three CCLs and a draft of the fourth CCL which was published February 2015. Monitoring for non-UCMR CCL constituents is not required.

3.6.3 Unregulated Contaminant Monitoring Rule (UCMR)

The EPA uses the UCMR to collect occurrence data for contaminants known or suspected to exist in source waters and which pose a human health risk. Most of the contaminants on the UCMR list were initially on a CCL, and were selected due to a lack of occurrence data. The EPA can require PWS to monitor for as many as 30 contaminants under the UCMR, and the monitoring list is reevaluated every 5 years. Information gathered under the UCMR is used in establishing future contaminant MCLGs and MCLs. EPA proposed the fourth UCMR list in December 2015, with a proposed sampling time frame between March 2018 and November 2020.

4 POTENTIAL CONTAMINATING SOURCES

The following potential sources of contamination were identified in the TID Watershed Sanitary Survey (WSS) of the Lower Tuolumne River and Turlock Lake (Brown and Caldwell, 2008a), online visual searches using Google Earth (US Dept. of State Geographer © 2016 Google) between La Grange Dam and the infiltration gallery, and correspondence with Terry Scanlan of SPF Water Engineers on June 17, 2016. A land use map is provided in Figure 6 (extracted from the 2008 TID WSS). Locations of the main potential contaminating activities are shown in Figure 7, and discussed below:

- City of Waterford Wastewater Treatment Plant (WWTP). This is the only municipal WWTP in this reach of the River that could impact water quality at the infiltration gallery site; the remainder of the study area uses septic systems for wastewater disposal. The location of the aeration ponds and percolation basins are shown in Figure 8. The WWTP has a capacity of 1 mgd and an average flow of approximately 0.585 mgd. The facility uses four reinforced concrete aeration ponds (128,000 ft^2) on the North side of the River, followed by storage ponds. The effluent from the storage ponds is pumped to four drying beds/percolation basins across (South side) the Tuolumne River. As of 2006, the facility met existing requirements of the Central Valley Regional Water Quality Control Board, but upgrades were needed to meet secondary treatment standards and future discharge standards (City of Waterford, 2006).

- Dairy, Poultry and Ranch Operations[3]. There are a number of dairy, poultry, and ranch operations near the bank of the River: J & T Cattle Co. Bret Warner Ranch, Right Fork Cattle Co., Golding Farms, Hayes Ranch, Donald & Patricia Mason Farm, Sunset Farms, Alberto Dairy, Michel Ranch and Dairy, Foster Poultry Farms, and Jeg Ranch. Only the larger operations are shown in Figure 7.

- Geer Road Landfill. The Geer Road Landfill, which is closed now, is located ¼ mile north of, and directly across the river from the infiltration gallery. The extent of this inactive landfill is shown in Figure 9. As discussed in the 2008 TID WSS, although there are no active solid waste or hazardous waste disposal facilities within the study area, this closed landfill continues to be regulated by Regional Water Quality Control Board (RWQCB) waste discharge requirements during its closure (Brown and Caldwell, 2008a). SPF Water Engineering completed a preliminary investigation of the potential impact of this closed landfill on

[3]According to the United States Department of Agriculture (USDA, 2012), Stanislaus County ranks 7th among California's 58 counties in total value of agricultural products sold, 4th in value of livestock, poultry, and their products, and 3rd in value of sales for both poultry and eggs, as well as milk from cows (4th overall in the United States). In addition to livestock, the top three crops, in terms of land area, grown locally include almonds (3rd in the state and U.S.), forage land (hay and haylage, grass silage, and greenchop; 10th in the state and 84th in the U.S.), and corn for silage (3rd in the state and 4th in the U.S.). In terms of land use, approximately 50% of the county's farmland is pastureland and 44% is cropland.

Tuolumne River water quality (Scanlan, 2016). This landfill is under close surveillance with on-going groundwater remediation and monitoring. Based on the Second Semiannual and Annual 2015 Detection, Evaluation and Corrective Action Monitoring Report, "The 2015 analytical results do not indicate degradation to the Tuolumne River water quality from the landfill" (Tetra Tech BAS, 2016 – Page 23). The sampling locations on the Tuolumne River and the monitoring wells (shallow and deep) in the project vicinity are provided in Figure 5. The shallow groundwater flows southwest to west and the deep groundwater flows west, so the flow path of the groundwater beneath the landfill is towards the Tuolumne River, but downstream of the infiltration gallery site. Toluene was the only VOC detected in the River samples. One detection was upstream of the infiltration gallery (Sampling Location TR-1, 0.11 µg/L laboratory estimate) and the other was downstream of the infiltration gallery (Sampling Location TR-3, 0.096 µg/L laboratory estimate) and were both collected in November 2015. The two detections (out of 20 total samples) were j-flagged because the concentration was above the method detection limit but below the practical quantitation limit, so the reported concentrations are estimates. Additionally, Toluene was not present in the duplicate sample taken at TR-3 and the levels observed were substantially below the pMCL of 150 µg/L (Tetra Tech BAS, 2016).

- Groundwater influences. SPF Water Engineering completed a preliminary investigation of the groundwater quality in the vicinity of the infiltration gallery in June 2016. Using the GeoTracer website, SPF Water Engineers identified the following sites of interest in the vicinity of the infiltration gallery: Western Stone Products (T060990234), multiple contamination sites within the City of Hughson, and the Geer Road Landfill. The Western Stone Products is a leaking underground storage tank site with a closed cleanup status. This site is 1.25 miles east and up gradient of the infiltration gallery. The closed cleanup status suggests low potential for impacts near the infiltration gallery. The contamination sites with the City of Hughson are all located 1.5 to 2.0 miles southwest of the infiltration gallery. The groundwater flows in a westerly direction in this area, so the risk of these contaminants entering the River near the infiltration gallery is low (Scanlan, 2016). See previous bullet for a discussion about the Geer Road Landfill.

- Recreational Areas: There are several recreational areas nearby and in the upper reaches of the Lower Tuolumne watershed, including La Grange Off-Highway Vehicle Use, Basso Bridge River Access, Turlock Lake State Recreational Area, and Fox Grove County Park.

- Pesticide and Herbicide Application to Agricultural Areas[1]: Given the large percentage of the watershed dedicated to agriculture, stormwater and irrigation runoff from these areas is a known source of contamination to the River. The Lower Tuolumne River, downstream of Don Pedro Reservoir, is listed as an impaired water body under USEPA Clean Water Act Section 303(d) (California State Water Resources Control Board, 2010). This designation is largely due to the presence of several pesticides, including chlopyrifos, diazinon, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane - including lindane, endosulfan, and toxaphene), as well as pollution from mercury, water temperature, and an unknown toxicity.

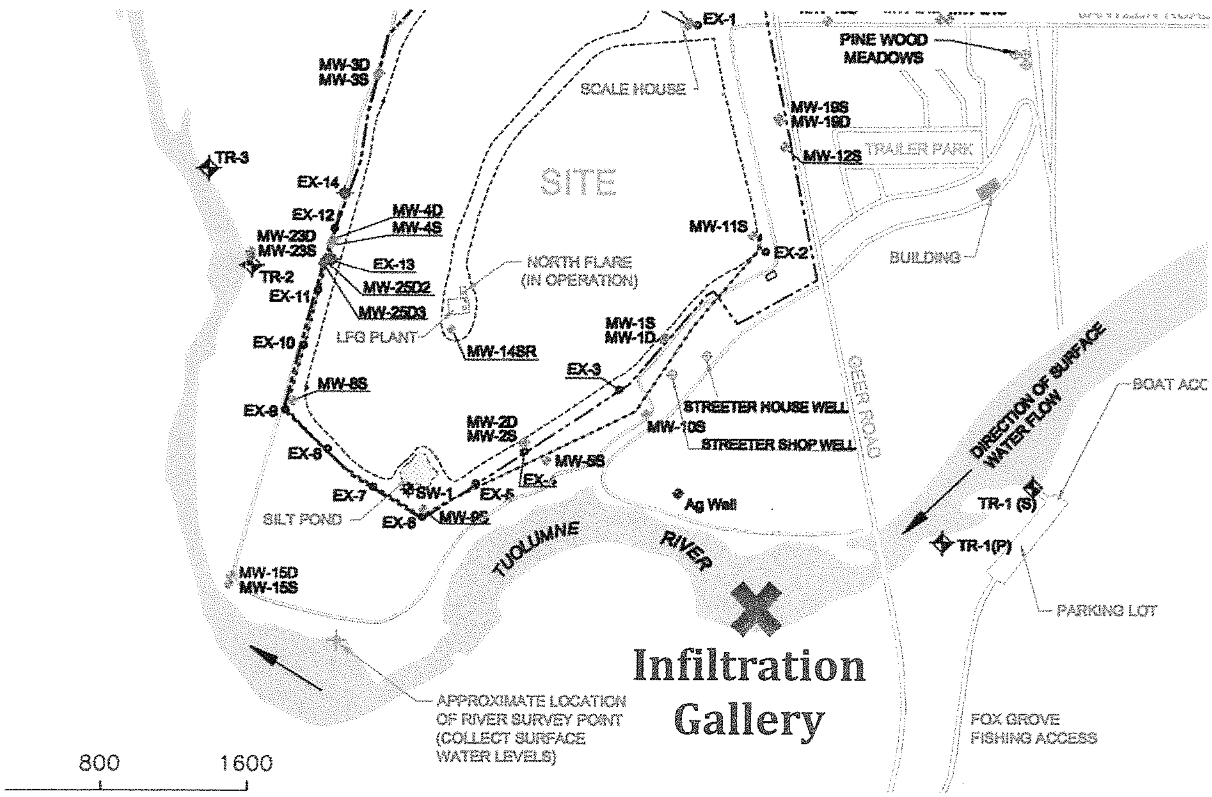

Figure 5. Sampling Locations to Monitor the Closed Geer Road Landfill in Project Vicinity

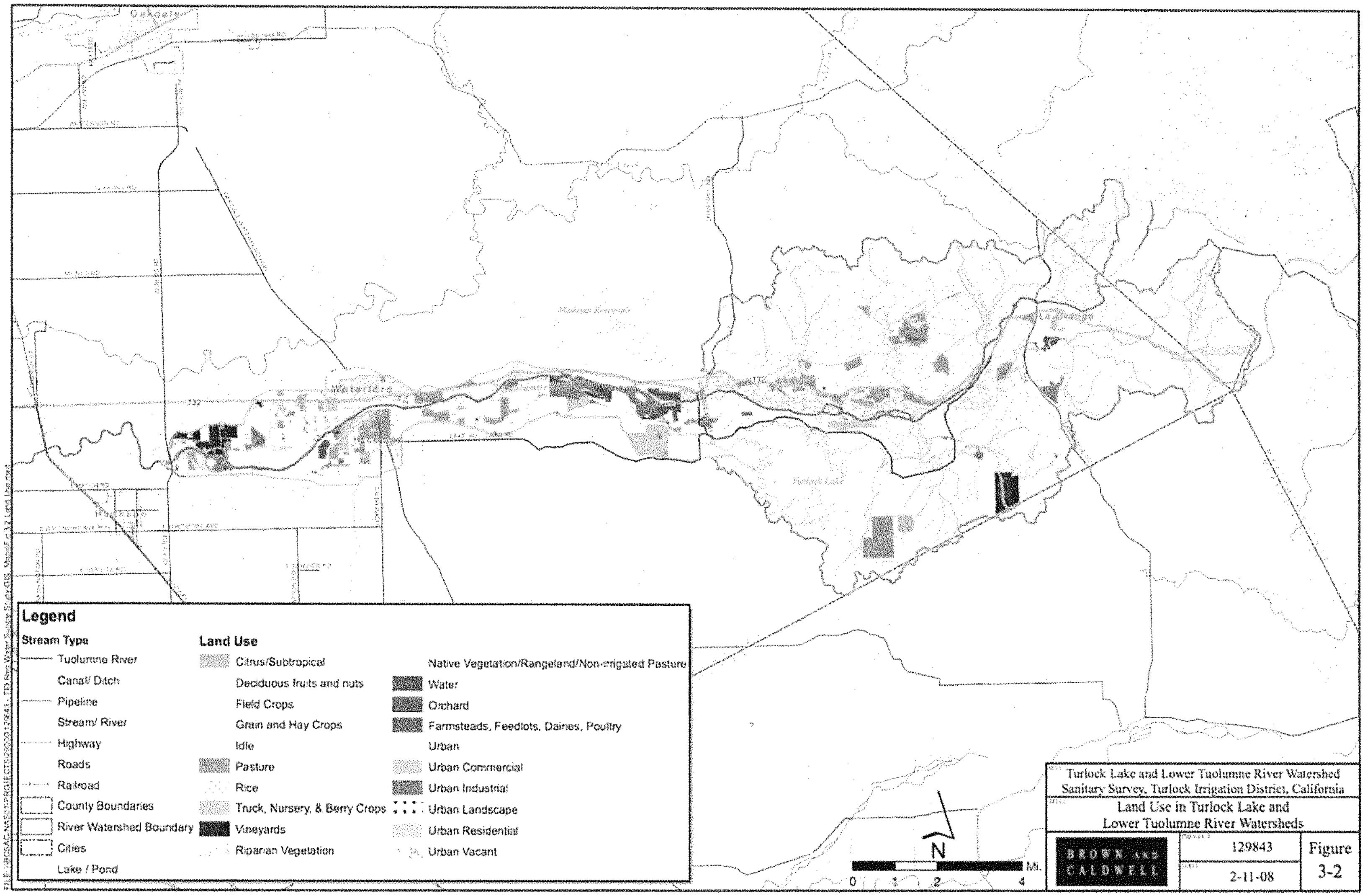

Figure 6. Land Use in Project Vicinity (Brown and Caldwell, 2008a – Screen Capture of Figure 3-2 from 2008 TID WSS)

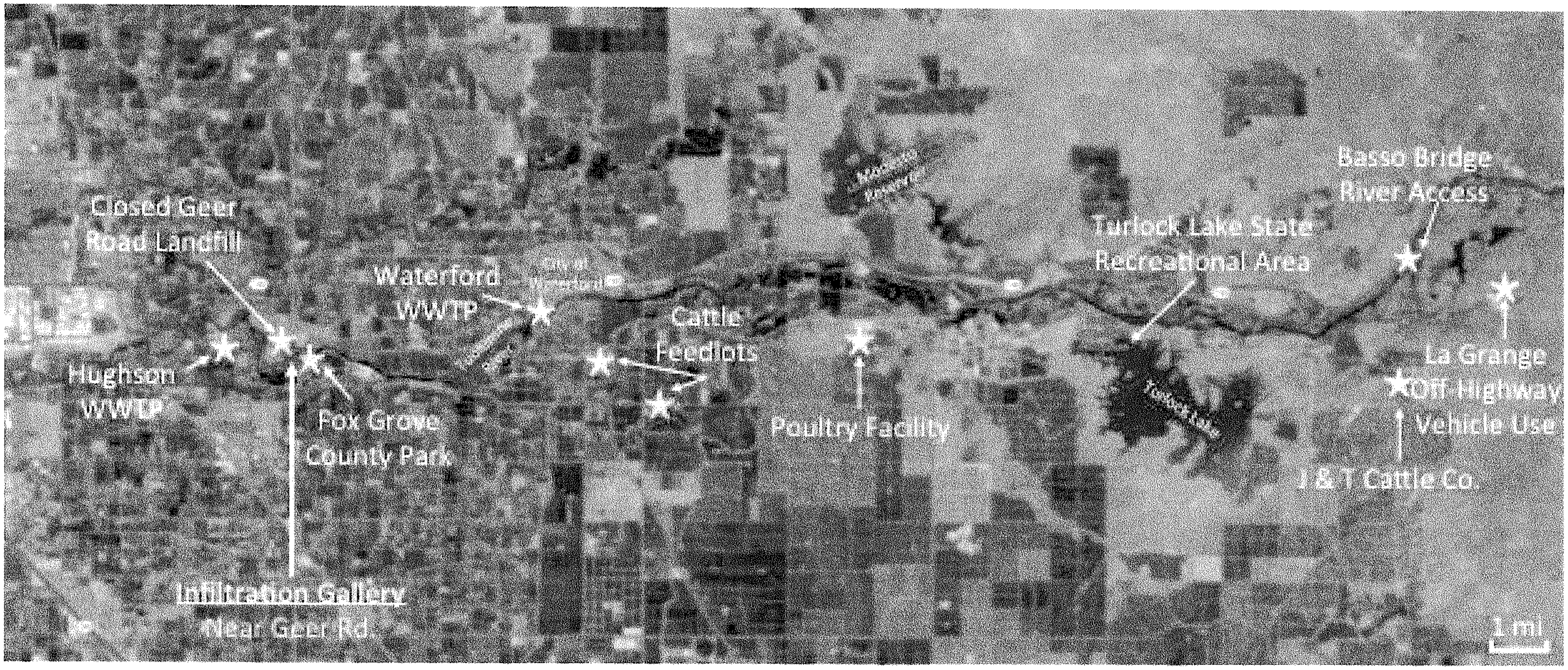

Figure 7. Potential Sources of Contamination in Project Vicinity

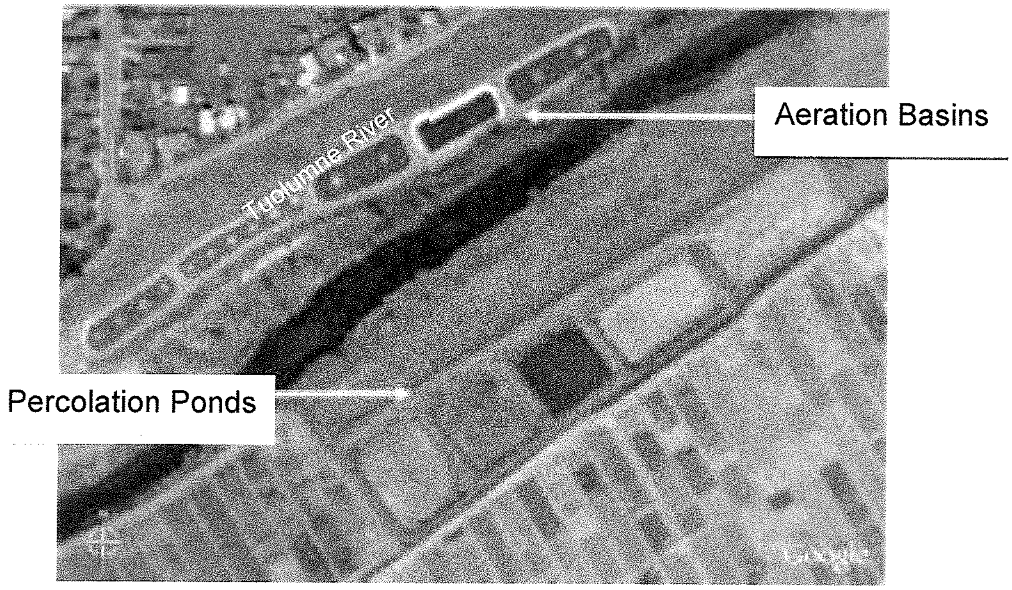

Figure 8. City of Waterford WWTP Aeration Basins and Percolation Ponds

Figure 9. Inactive Geer Road Landfill Highlighted in Yellow

5 REVIEW OF HISTORICAL WATER QUALITY DATA

As part of the source water characterization process, historical water quality data collected on the Tuolumne River at locations between Don Pedro Reservoir and the confluence of Dry Creek at Modesto were reviewed. There are a number of monitoring locations along the Tuolumne River. This summary focuses on the reach between La Grange Dam and the confluence with Dry Creek. This portion of the River includes the infiltration gallery, which will serve as the intake for SRWA's new WTP. The historical data from this reach of the Tuolumne River are expected to be representative of WTP source water, as there are no major influences along this portion. Sampling locations upstream of La Grange Dam and downstream of the Dry Creek confluence are not included due to the influence of dams, reservoirs, inflowing water bodies, and major cities along these portions of the Tuolumne River.

5.1 Sources of Data

Various agencies were contacted and an online search was completed for the compilation of historical data covering the past ten years (2005 through 2015). The majority of the historical data collected were dated prior to 2005. The most substantial data sets were available through watershed sanitary surveys (WSS) generated by Turlock Irrigation District during the original efforts to implement this surface water supply project and their sampling efforts during the 2007-2008 pilot investigation of treatment alternatives (Brown & Caldwell, 2008a; Brown & Caldwell, 2008b). Historical water quality data for the past ten years between La Grange Dam and the confluence of Dry Creek were available from the following sampling efforts:

1. The United States Geological Survey (USGS) collects water quality data nationwide, which are available online via the National Water Information System[4]. The only data available within the last 10 years and within the river reach of interest are 15-minute temperature and river flow data that continues to be collected.
2. MID owns and operates the Modesto Regional WTP, located adjacent to and just to the southwest of Modesto Reservoir. Every five years they prepare a WSS for their water source, which is diverted from La Grange Dam to Modesto Reservoir. MID provided their WSS covering a four-year period from 2009 through 2012. The water quality of their plant intake is somewhat representative of the water quality expected at the infiltration gallery since La Grange Dam is on the Tuolumne River and approximately 20 miles upstream of the infiltration gallery (HDR, 2014).
3. TID prepared a WSS for the Lower Tuolumne River and Turlock Lake in 2008, prior to the formation of the SRWA. The proposed water supply project is now headed by SRWA and water is purchased from TID via a Water Sales Agreement entered by the two agencies in July 28, 2015. These data are most relevant to the proposed project as the monitoring locations were most proximate to the source water. One year of data are provided from May 2006 to May 2007 (Brown and Caldwell, 2008a).
4. The *Turlock Irrigation District Regional Surface Water Supply Pilot Study Report* was prepared by Brown and Caldwell in 2008. This pilot study assessed various treatment options for the purification of Tuolumne River water near the Hughson

[4] http://nwis.waterdata.usgs.gov/ca/nwis/inventory/?site_no=11289650&agency_cd=USGS

WWTP in the vicinity of the infiltration gallery. This study report included raw water quality data collected between September 2006 to March 2007 (Brown and Caldwell, 2008b).

5. *Technical Memorandum Number 3: Treatment Process Evaluation Memorandum* was prepared for TID by Brown and Caldwell in 2007. The data presented in this TM were incorporated into the 2008 TID WSS by Brown and Caldwell (2008a)—listed as item 3 above.
6. TID's extended Monitoring Program, which was conducted as part of the WSS effort from May 2007 to October 2008 (data were provided to SRWA by TID)
7. The State Water Resources Control Board (SWRCB) created the California Environmental Data Exchange Network (CEDEN) in an effort to consolidate water quality data in a central location online[5]. Data for the area and time frame of interest were available through the Statewide Perennial Streams Assessment 2009 and the RWQCB Region 5 Surface Water Ambient Monitoring Program Safe to Swim 2011-2012 and Safe to Swim Annual 2013-2014.
8. The State Water Project Watershed Sanitary Survey (Volume 1 - covering the San Joaquin River Watershed) included some historical water quality data from the Tuolumne River, about 10 miles downstream from the infiltration gallery. These data were and continue to be generated by the City of Modesto's Stormwater Management Program[6] (DWR, 2015). Data were supplied by the City of Modesto from 2004-2016.

5.2 Monitoring Locations

Historical water quality was assessed from the sampling locations described below. Each of the listed locations is shown in Figure 10, and the monitoring agencies and corresponding unique ID associated with the locations are listed in Table 5.

1. USGS California Water Science Center National Water Information System
   ID: A - Upstream of infiltration gallery near Old La Grange Bridge (USGS Station Code: 11289650)

2. MID Modesto Regional Water Treatment Plant (MRWTP) Watershed Sanitary Survey
   ID: B - Inlet to Modesto Reservoir from La Grange Dam
   ID: C - Raw intake from Modesto Reservoir for MRWTP

3. TID Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake, as well as data from additional monitoring completed from May 2007 to April 2008 at infiltration gallery
   ID: D - Upstream of infiltration gallery near Basso Bridge

[5] http://ceden.waterboards.ca.gov/AdvancedQueryTool
[6] http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/san_joaquin/r5-2009-0119_swmp.pdf

ID: E - Upstream of infiltration gallery near Roberts Ferry Bridge
ID: I - At infiltration gallery near Geer Road

4. TID Regional Surface Water Supply Pilot Study Report
   ID: J - Tuolumne River at Hughson WWTP

5. SWRCB CEDEN
   ID: F - Upstream of infiltration gallery, 4 miles upstream of Hickman Road (SWRCB Station Code: 535PS0265)
   ID: G - Upstream of infiltration gallery at Waterford Road (SWRCB Station Code: 535TR5xxx)
   ID: H - Slightly upstream of infiltration gallery at Fox Grove (SWRCB Station Code: 535STC218)
   ID: K - Downstream of infiltration gallery at Ceres River Bluff Park (SWRCB Station Code: 535STC217)
   ID: M - Downstream of infiltration gallery near Modesto City-County Airport at Legion Park (SWRCB Station Code: 535STC216)

6. City of Modesto – Stormwater Management Program
   ID: L - Downstream of infiltration gallery, near Mitchell Road

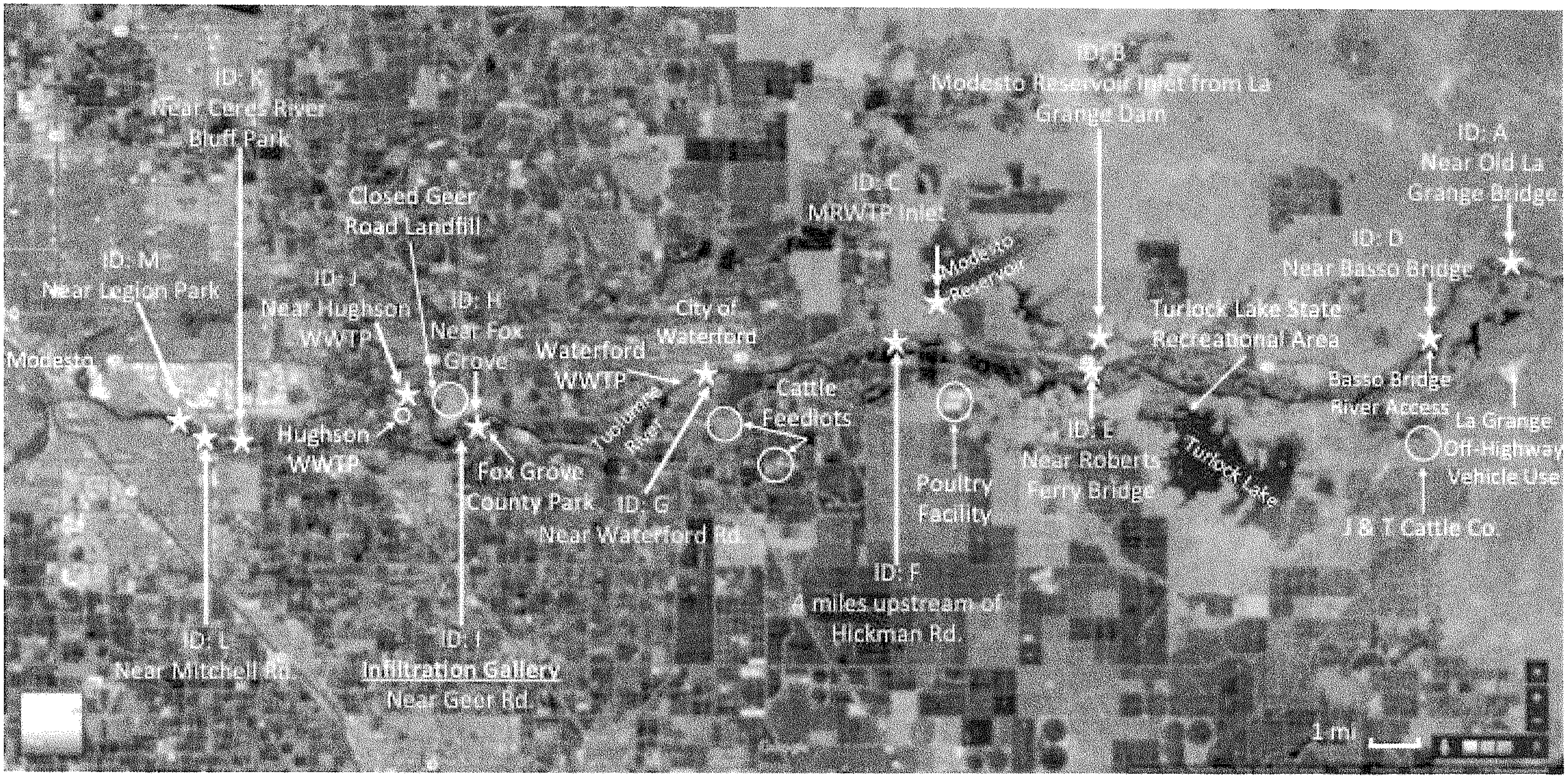

Figure 10. Historic Sampling Locations in Relation to Potential Contaminating Activities

Table 5. Historic Sampling Locations in the Lower Tuolumne River Watershed

Monitoring Agency or Reference Document	Site ID	Approx. Miles from infiltration gallery[1]	Location Description	Monitored Parameters	Monitoring Dates
USGS California Water Science Center National Water Information System	A	+ 23.9	USGS Station Code 11289650; Upstream of infiltration gallery near Old La Grange Bridge	Temperature, Flow from La Grange Dam	Oct 2007 – April 2016
MID Modesto Regional Water Treatment Plant (MRWTP) WSS	B	+ 13.90	Inlet to Modesto Reservoir from La Grange Dam	*Cryptosporidium, Giardia*	May 2009 – Sept 2012
	C	--	MRWTP raw water intake in Modesto Reservoir	General, Turbidity, TOC, Microbiological, *Cryptosporidium, Giardia*, Metals,	Jan 2009 – Dec 2012
TID WSS of the Lower Tuolumne River and Turlock Lake, plus additional monitoring data collected May 2007 to October 2008	D	+ 21.7	Near Basso Bridge	General, Turbidity, Bromide, Nutrients, Fe, Mn, TOC, DOC, DO, Chlorophyll, Microbiological, Pesticides, SOCs	May 2006 - Oct 2008
	E	+ 13.90	Near Roberts Ferry Bridge	General, Turbidity, Bromide, Nutrients, Fe, Mn, TOC, DOC, DO, Chlorophyll, Microbiological, Pesticides, SOCs	May 2006 - Oct 2008
SWRCB California Environmental Data Exchange Network (CEDEN)	F	+ 9.45	SWRCB Station Code 535PS0265; Four miles upstream of Hickman Rd.	General, Turbidity, Nutrients (1 data point)	Aug 2009
	G	+ 5.71	SWRCB Station Code 535TR5xxx; Waterford Road	Field data, Microbiological, *Cryptosporidium, Giardia*	Aug 2010 – Jun 2014
	H	+ 0.1	SWRCB Station Code: 535STC218; Fox Grove	Field data, Microbiological, *Cryptosporidium, Giardia*	Aug 2010 – Jun 2014
TID WSS of the Lower Tuolumne River and Turlock Lake, plus additional monitoring data collected May 2007 to April 2008	I	0	At infiltration gallery near Geer Road	General, Turbidity, Bromide, Nutrients, Fe, Mn, TOC, DOC, DO, Chlorophyll, Microbiological, Pesticides, SOCs	May 2006 - Oct 2008
TID Regional Surface Water Supply Pilot Study Report	J	- 2.54	Tuolumne River at Hughson WWTP	General, Fe, Mn, TOC, Turbidity	Sept 2006 – April 2007
SWRCB California Environmental Data Exchange Network (CEDEN)	K	- 6.96	SWRCB Station Code: 535STC217; Ceres River Bluff Park	Field data, Microbiological, *Cryptosporidium, Giardia*	Aug 2010 – Jun 2014
City of Modesto – Stormwater Management Program	L	- 7.74	Near Mitchell Road	General, Turbidity, Nutrients, Fe, TOC, DO, Microbiological, Pesticides, SOCs	Jan 2005 – Apr 2016
SWRCB California Environmental Data Exchange Network (CEDEN)	M	- 9.86	SWRCB Station Code: 535STC216; Modesto City-County Airport at Legion Park	Field data, Microbiological, *Cryptosporidium, Giardia*	Aug 2010 – Jun 2014

5.3 Tuolumne River Flow Rate near Project Area

River flow rate and rainfall can influence river water quality. Total suspended solids (TSS), turbidity, microbiological parameters and nutrients typically fluctuate throughout the year and are often correlated with rainfall and river flow.

River flows and rainfall data in the project vicinity were characterized using:

- USGS[7] daily flow data from Site A (USGS 11289650, upstream of infiltration gallery near Old La Grange Bridge, just below La Grange Dam)
- NOAA[8] daily rainfall data from Modesto Airport (approximately one mile downstream from the infiltration gallery)

As illustrated in Figure 11, peak stream flows correlate with rainfall events, with rainfall events preceding releases. The following observations are based on the State Water Project WSS San Joaquin Valley water year hydrologic classification indices[9] for runoff:

- 2008 and 2013 were critical dry years
- 2009 was below average
- 2010 was above normal
- 2011 was a wet year
- 2012 was a dry year

[7] http://nwis.waterdata.usgs.gov/ca/nwis/inventory/?site_no=11289650&agency_cd=USGS
[8] https://www.ncdc.noaa.gov/cdo-web/orders?email=sangamt@trusselltech.com&id=764481
[9] Water year classification based on an index for the sum of unimpaired flow the San Joaquin Valley from the SWRCB's Water Rights Decision 1641 (California Department of Water Resources, June 2015).

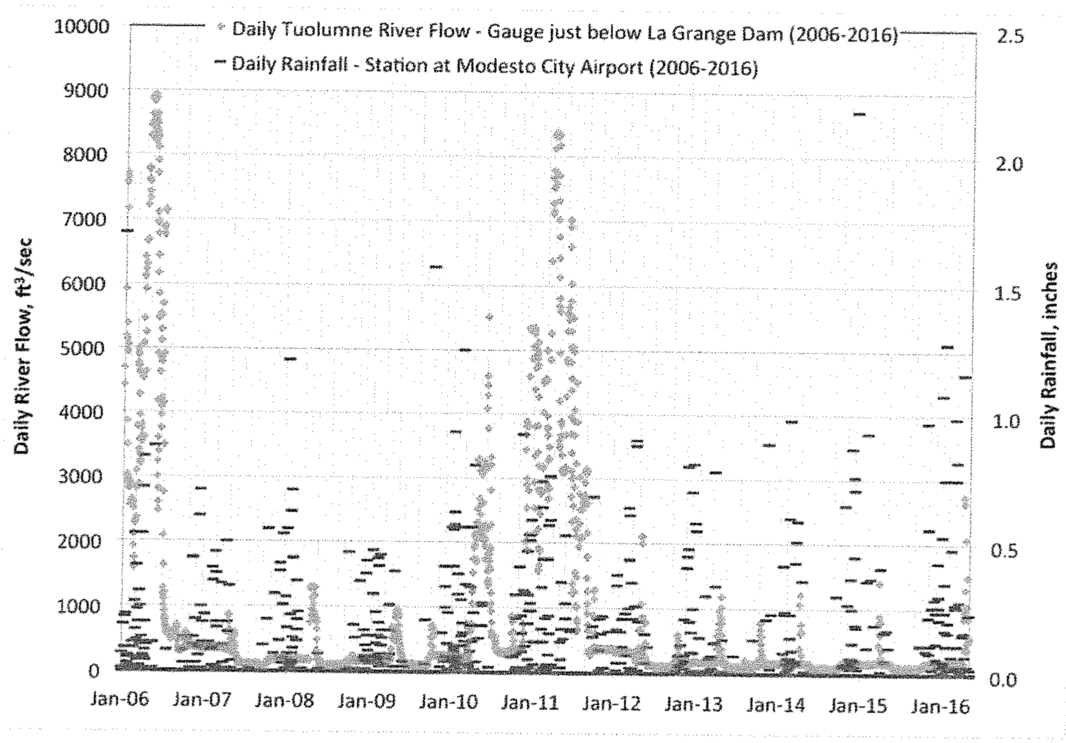

Figure 11. Tuolumne River Flow Rate just Below La Grange Dam and Rainfall at Modesto Airport[10] (2006-2016).

5.4 Water Quality Data

The following section includes a summary of relevant water quality data in the following categories:

- General Parameters
- Nutrients
- DBP-Related Parameters
- Metals
- Microbial Parameters
- Pesticides and other Synthetic Organics Compounds (SOCs)
- Asian Clams (an invasive mollusk)

For each category, tables with statistical summaries and figures with available water quality trends are provided for the infiltration gallery location and other nearby monitoring sites.

[10] (http://nwis.waterdata.usgs.gov/ca/nwis/inventory/?site_no=11289650&agency_cd=USGS) and NOAA (https://www.ncdc.noaa.gov/cdo-web/orders?email=sangamt@trusselltech.com&id=764481)

5.4.1 General Parameters

General water quality parameters are summarized in Table 6. The general parameters are typical of river water quality. Noteworthy observations are provided below:

- **Alkalinity & pH.**
    - The alkalinity of the Tuolumne River at the infiltration gallery location (Site I) is moderately low and ranged from 23 to 80 mg/L as $CaCO_3$, with an average alkalinity of 37 mg/L as $CaCO_3$ (Figure 12). Finished water will likely require stabilization using chemicals such as lime or caustic to adjust the pH and/or increase the finished water buffering capacity in the distribution system.
    - The Modesto Regional WTP intake (Site C) alkalinity is plotted in Figure 13 and has lower alkalinity (averaging 12 mg/L as $CaCO_3$) than that at the infiltration gallery (Site I) (averaging 37 mg/L as $CaCO_3$). (Note: These datasets are from two different time periods.) This difference indicates that the Modesto Regional WTP intake is potentially not representative of the Tuolumne River water quality in the project vicinity, even though the Modesto Region WTP's source water is from the Modesto Reservoir, which is Tuolumne River water diverted from La Grange Dam. The difference is likely caused by differing influences on the reservoir and river systems, such as the reservoir having a greater potential for algal blooms and reservoir stratification/turnover from lateral temperature gradients.
    - The alkalinity generally increases as the water moves downstream, averaging 17 mg/L as $CaCO_3$ at the upstream-most sampling location (Site D – Basso Bridge) and 37 mg/L $CaCO_3$ at the downstream-most sampling location (Site L – Mitchell Rd). This is not an expected trend for the Tuolumne River.
    - The pH at the infiltration gallery location (Site I) ranged from 6.7 to 8.3, with an average of 7.4 (Figure 14). Raw water pH has large fluctuations due to the relatively low alkalinity, which results in limited buffering capacity. Low alkalinity can also be the result of algal blooms.
    - The addition of either alum or ferric coagulants depresses pH, as both of these coagulants are acidic (i.e., coagulants consume 0.5 mg of alkalinity per mg of alum and 0.92 mg of alkalinity per mg of ferric chloride.). With a lower pH, TOC removal is enhanced, thereby reducing DBP formation. However, given the low buffering capacity of the water, if the pH of coagulation is too low, addition of caustic (or other alkalinity source) may be necessary for effective clarification. This possibility can be evaluated by conducting jar tests.

- **Chloride, Conductivity, & Total Dissolved Solids (TDS).**
    - The chloride concentrations of the Tuolumne River at the infiltration gallery (Site I) were very low, ranging from 2.1 to 11.0 mg/L and average 9.2 mg/L. The measurements at the infiltration gallery concur with the single measurement at the Site F (3.3 mg/L), which is 9.5 miles upstream of the

infiltration gallery. These concentrations are substantially below the secondary MCL of 250 mg/L.

- The conductivity of the Tuolumne River at the infiltration gallery (Site I) is low, ranging from 33 to 201 uS/cm and averaging 90 uS/cm (Figure 15). The average concentration is 10-fold lower than the secondary MCL of 900 uS/cm. All sampling locations had similar conductivity, with an overall average of 89 uS/cm.
- TDS gradually increases as the river moves downstream, likely due to increasing human activities (such as agriculture and urbanized areas) downriver. TDS averaged 25 mg/L at the upstream-most sampling location (Site D – Basso Bridge) and 75 mg/L at the downstream-most sampling location (Site L – Mitchell Rd). At the infiltration gallery, the TDS ranged from non-detect (<30 mg/L) to 150 mg/L and averaged 61 mg/L (Figure 16). All historical TDS data assessed for this effort were well below the secondary MCL of 500 mg/L.
- At the infiltration gallery the ratio of TDS to conductivity (using the mean TDS and mean conductivity) is 0.68, which is within the typical range of 0.55 to 0.7 (Eaton et al. 2005). The correlation between TDS and conductivity (Figure 17) is very poor, but is likely skewed by an outlier TDS value (approximately 150 mg/L). Ideally, conductivity can be used as a surrogate for TDS, as conductivity has the advantages of being a more sensitive measurement, and can be measured continuously with online instruments.

- **Hardness.**
  - The hardness of the Tuolumne River at infiltration gallery (Site I) is low, ranging from 23 to 53 mg/L as $CaCO_3$ and averaging 39 mg/L as $CaCO_3$. This is classified as soft water. Approximately half of the hardness is from calcium (average 9.2 mg/L as Ca or 23 mg/L as $CaCO_3$) and the other half from magnesium (average 4.4 mg/L as Mg or 18 mg/L as $CaCO_3$).

- **Dissolved Oxygen.**
  - The dissolved oxygen (DO) concentration of the Tuolumne River at the infiltration gallery location (Site I) ranged from 7.9 to 14.5 mg/L, with an average concentration of 10.6 mg/L. Seasonal fluctuations are apparent in Figure 18. The coldest temperature measured that also had a corresponding DO measurement was 8.4 deg C and the corresponding DO was 12.9 mg/L; the oxygen saturation at 8.4 deg C is 11.7 mg/L (Tchobanoglous et al., 2003). The warmest temperature measured was 27.7 deg C and the corresponding DO was 9.02 mg/L; the oxygen saturation at 27.7 deg C is 7.9 mg/L (Tchobanoglous et al., 2003). The DOs for both the low- and high-temperature days are higher than the saturation concentration, meaning that the system is super-saturated—more evidence of algal blooms. If the water has a DO that is substantially

below the oxygen solubility at a corresponding temperature, this can result in anoxic conditions, which has water quality implications such as naturally occurring iron and manganese converting from solid to the dissolved form.

- Overall, the Tuolumne River in the project vicinity is well-oxygenated. Well-oxygenated water sources ensure that naturally occurring metals in the solid form, such as iron and manganese, are not reduced and released in the soluble form, which is more difficult to treat. Iron and manganese often occur together in surface water sources. In reducing environments (e.g., anaerobic conditions were ions gain electrons), these metals are relatively soluble, however in well-oxygenated environments, the iron should be present in its oxidized state, Fe(III), and the manganese may be in its oxidized state, Mn(IV). Iron is oxidized by oxygen quickly, on the order of minutes to hours, whereas manganese oxidizes slowly, on the order of days to weeks, so manganese is often found in reduced form (soluble) in natural systems even when iron is not.

- **Total Suspended Solids (TSS) & Turbidity.**
  - Turbidity at the infiltration gallery site is low—consistently less than 7.5 NTU—and does not seem to exhibit seasonal fluctuations (Figure 19). It is difficult to tell, however, if or by how much the turbidity increases in response to a significant storm event. Additionally, filtration through the rock and gravel media above the infiltration gallery is expected to reduce storm related turbidity spikes should they occur in the River. Raw water turbidity will be measured twice per month during the Source Water Monitoring Program.
  - As shown in Figure 20, the turbidity of the River water remains low even during high River flows and periods of rain[11]. Water from Modesto Reservoir at the Modesto Regional WTP intake measured higher turbidities than the other sites assessed along the Tuolumne River. The difference is likely caused by reservoir influences (e.g., algae and potential reservoir turnover).
  - TSS measured low at all sites. All TSS measurements taken by TID were below the 5 mg/l detection limit except one sample taken at the infiltration gallery location (Site I) on February 6, 2008, which measured 62 mg/L.
  - The solids loading at the WTP is expected to be low based on the low TSS and low turbidity historically recorded in the project vicinity. The solids loading can be estimated from jar tests designed to determine the optimal coagulation/flocculation configuration.

- **Temperature.**

[11] River flow rates are correlated with rain events – shown in Figure 11

- There are substantial historical temperature data available. These data indicate temperature tends to vary considerably from site to site without an apparent trend as the River moves downstream.
- At the infiltration gallery, large seasonal temperature changes were observed, falling to as low as 4 deg C (39.2 deg F) and peaking at 28 deg C (82.4 deg F).

- Figure 21 shows seasonal temperature fluctuations.

Table 6. General Water Quality Parameter Statistics

		Sampling Location on Tuolumne River (in order of upstream to downstream, with sample location *I* = Infiltraiton Gallery)												
Label on Map in Figure 3-6 >>>		*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*
Analytes General Water Quality	**Statistics**	Near Old La Grange Bridge[1]	Modesto Reservoir Inlet[2]	MRWTP Intake[2,3]	At Basso Bridge[4]	At Robert Ferry Bridge[4]	4 miles upstream of Hickman Rd.[5]	At Waterford Rd.[6]	At Fox Grove[7]	At Infiltration Gallery near Geer Rd.[4]	TID Pilot Study; At Hughson WWTP[3,8]	At Ceres River Bluff Park[9]	Near Mitchell Rd.[3,10]	At Legion Park[11]
	Sampling Period	Oct 2007-Apr 2016	May 2009-Sep 2012	Jan 2009-Dec 2012	May 2006-Oct 2008	May 2006-Oct 2008	Aug 2009	Aug 2010-Jun 2014	Aug 2010-Jun 2014	May 2006-Oct 2008	Sep 2006 - Apr 2007	Aug 2010-Jun 2014	Jan 2005-Feb 2016	Aug 2010-Jun 2014
	Sampled By	USGS	Modesto Irrigation District	Modesto Irrigation District	Turlock Irrigation District	Turlock Irrigation District	CEDEN	CEDEN	CEDEN	Turlock Irrigation District	Turlock Irrigation District	CEDEN	City of Modesto/State Water Project	CEDEN
Alkalinity, Total mg/L as $CaCO_3$	Min			8	13	15	36			23	27		18	
	Max			16	34	28	36			80	36		67	
	Median			12	16	20	n/a			37	32		39	
	Mean			12	17	20	36			37	32		37	
	N			1415	17	17	1			40			28	
Calcium mg/L	Min			6.0						5.0				
	Max			13.0						11.0				
	Median			8.0						9.2				
	Mean			8.2						9.2				
	N			1411						23				
Chloride mg/L	Min						3.29			2.10				
	Max						3.29			11.00				
	Median						n/a			4.80				
	Mean						3.29			5.12				
	N						1			5				
Chlorophyll a mg/L	Min				0	0				0				
	Max				0	0				4.1				
	Median				0	0				0				
	Mean				0	0				0.4				
	N				23	23				23				
Color [12] Color units	Min									<1	2			
	Max									10	10			
	Median									5				
	Mean									4	5.8			
	N									14				
Conductivity uS/cm	Min				33	35	65	30	30	33		40	8	40
	Max				162	68	65	70	190	201		170	1060	160
	Median				67	45	n/a	47	110	77		100	103	100
	Mean				78	46	65	49	95	90		96	131	101
	N				24	24	1	8	15	67		9	30	9
Hardness mg/L as $CaCo_3$	Min			9.1	14	17	21.6			23			12	
	Max			13.0	18	22	21.6			53			53	
	Median			12.0	17	21	n/a			40			39	
	Mean			11.6	16	20	22			39			34	
	N			7	11	11	1			34			27	
Magnesium mg/L	Min			0.89						2.2				
	Max			1.30						5.6				
	Median			1.20						4.3				
	Mean			1.16						4.4				
	N			7						23				
Odor [13] TON	Min									<1				
	Max									4				
	Median									<1				
	Mean									1				
	N									13				
Oxygen, Dissolved mg/L	Min				10.32	9.87	4.08	7.05	7.09	7.93		7.40	6.81	7.00
	Max				12.88	12.11	4.08	7.27	17.60	14.49		18.50	11.18	14.48
	Median				11.14	11.27	n/a	7.16	7.64	10.53		7.71	9.14	7.14
	Mean				11.26	11.32	4.08	7.16	8.97	10.60		10.33	9.07	8.94
	N				24	24	1	2	9	66		4	30	4

Table 6. General Water Quality Parameters Statistics (*continued*)

		Sampling Location on Tuolumne River (in order of upstream to downstream, with sample location *I* = Infiltraiton Gallery)												
Label on Map in Figure 3-6 >>>		*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*
Analytes General Water Quality	Statistics	Near Old La Grange Bridge[1]	Modesto Reservoir Inlet[2]	MRWTP Intake[2,3]	At Basso Bridge[4]	At Robert Ferry Bridge[4]	4 miles upstream of Hickman Rd.[5]	At Waterford Rd.[6]	At Fox Grove[7]	At Infiltration Gallery near Geer Rd.[4]	TID Pilot Study; At Hughson WWTP[3,8]	At Ceres River Bluff Park[9]	Near Mitchell Rd.[3,10]	At Legion Park[11]
Sampling Period		Oct 2007-Apr 2016	May 2009-Sep 2012	Jan 2009-Dec 2012	May 2006-Oct 2008	May 2006-Oct 2008	Aug 2009	Aug 2010-Jun 2014	Aug 2010-Jun 2014	May 2006-Oct 2008	Sep 2006 - Apr 2007	Aug 2010-Jun 2014	Jan 2005-Feb 2016	Aug 2010-Jun 2014
Sampled By		USGS	Modesto Irrigation District	Modesto Irrigation District	Turlock Irrigation District	Turlock Irrigation District	CEDEN	CEDEN	CEDEN	Turlock Irrigation District	Turlock Irrigation District	CEDEN	City of Modesto/State Water Project	CEDEN
pH pH units	Min			6.51	6.56	6.86	8.6	7.4	7.4	6.73		7.0	6.1	7.5
	Max			7.33	8.54	8	8.6	8.3	11.4	8.29		11.1	8.8	10.1
	Median			6.97	7.75	7.55	n/a	7.96	7.9	7.41		7.9	7.3	8.0
	Mean			6.94	7.72	7.52	8.60	7.93	8.1	7.41		8.2	7.2	8.1
	N			1420	24	23	1	9	16	68		10	30	10
Silica[13] mg/L as SiO_2	Min				6	7	16			8				
	Max				22	26	16			26				
	Median				8	9	n/a			11				
	Mean				8	9	16			11				
	N				24	24	1			24				
Sodium mg/L	Min			1.3										
	Max			1.6										
	Median			1.4										
	Mean			1.4										
	N			5										
Solids, Total Dissolved mg/L	Min			13.3	<10	13				<30			28	
	Max			28.8	42	61				150			135	
	Median			18.0	25	30				64			71	
	Mean			18.6	25	31				61			75	
	N			1206	24	24				54			30	
Solids[12], Total Suspended mg/L	Min				<5	<5	< 0.9			<5			2	
	Max				<5	<5	< 0.9			62			17	
	Median				<5	<5	n/a			<5			6	
	Mean				<5	<5	< 0.9			7			7	
	N				4	4	1			37			31	
Sulfate mg/L	Min						1.47			2.3				
	Max						1.47			6.5				
	Median						n/a			3.0				
	Mean						1.47			3.5				
	N						1			5				
Temperature deg C	Min	9.0		6.5	10.8	9.9	22.6	13.0	12.8	4.4		14.4	9.6	15.0
	Max	18.7		21.4	13.7	15.7	22.6	25.0	27.5	27.7		27.7	27.2	28.7
	Median	11.4		15.4	12.6	13.4	n/a	19.8	24.3	15.2		21.7	14.8	22.6
	Mean	11.6		14.4	12.3	13.2	22.6	19.5	22.0	16.0		21.3	15.9	21.9
	N	218821		1419	23	24	1	8	15	70		10	30	10
Turbidity NTU	Min			2.0	0.45	0.79	0.89	0.70	0.72	0.62	0.75	1.02	0.6	0.75
	Max			23.3	2.01	1.85	0.89	1.48	3.56	7.32	8.70	3.74	9.5	2.10
	Median			5.0	0.96	1.22	n/a	0.90	1.62	2.01		1.59	1.7	1.26
	Mean			6.6	0.98	1.26	0.89	0.99	2.13	2.25	2.80	1.81	2.3	1.26
	N			1420	24	24	1	7	11	72		7	31.0	7

1 USGS California Water Science Center National Water Information System. USGS Station Code: 11289650.
2 MID Modesto Regional Water Treatment Plant (MRWTP) Watershed Sanitary Survey.
3 Minimum and maximum estimated from a graph or extracted from text in which data are discussed (indicated by gray cells).
4 TID Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake & data from additional monitoring completed from May 2007 to April 2008.
5 SWRCB CEDEN. Station Code: 535PS0265.
6 SWRCB CEDEN. Station Code: 535TR5xxx.
7 SWRCB CEDEN. Station Code: 535STC218.
8 TID Regional Surface Water Supply Pilot Study Report
9 SWRCB CEDEN. Station Code: 535STC217.
10 State Water Project WSS. Data source: City of Modesto – Stormwater Management Program.
11 SWRCB CEDEN. Station Code: 535STC216.
12 When data set contained a mix of non-detect and detected values, the MRL was used in calculating statistics.
13 Dissolved was measured for location F, otherwise it is not specificied.
14 Some coliform concentrations were reported as >2419.6 MPN/100mL. In determining the statistics, this value was used.
15 Range given since report provided average for differnet treatment schemes tested
16 When calculating the statistic, if a value was non-detect, the value was assumed to be equal to zero.
17 During pilot testing, total iron was tested. Other data sources do not specifiy dissolved versus total.

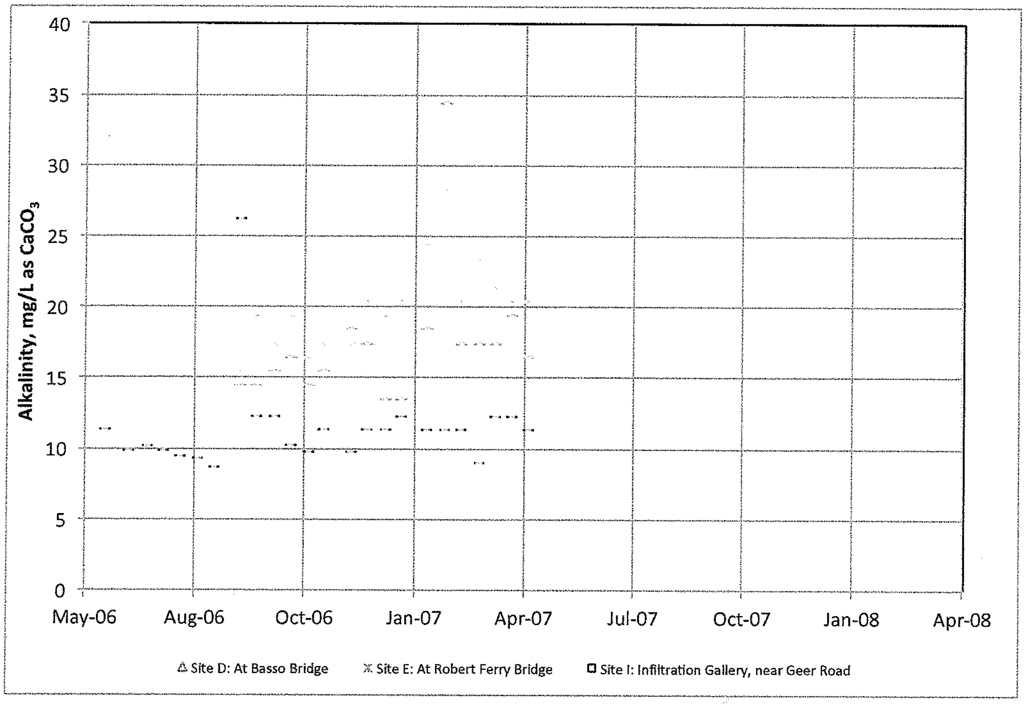

Figure 12. Alkalinity of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

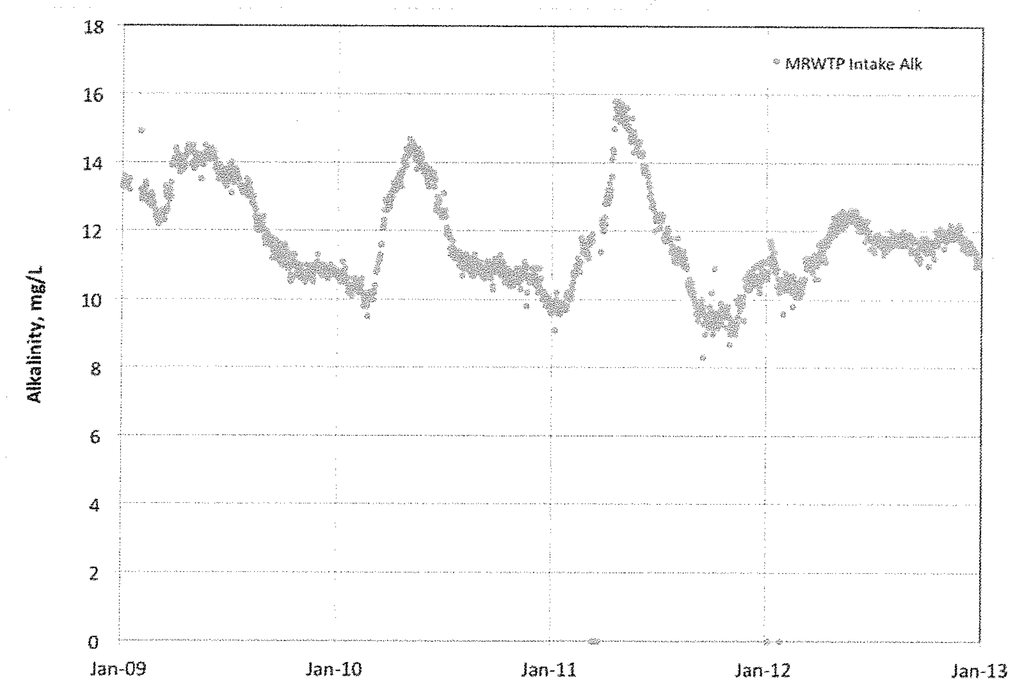

Figure 13. Alkalinity from MID MRWTP Intake from Modesto Reservoir

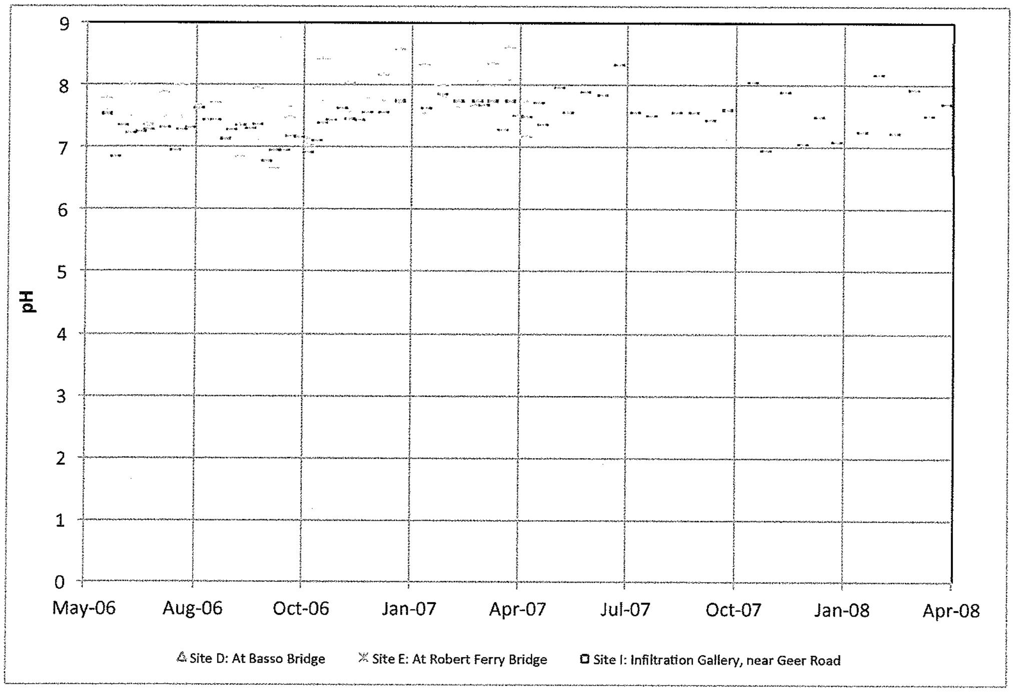

Figure 14. pH of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

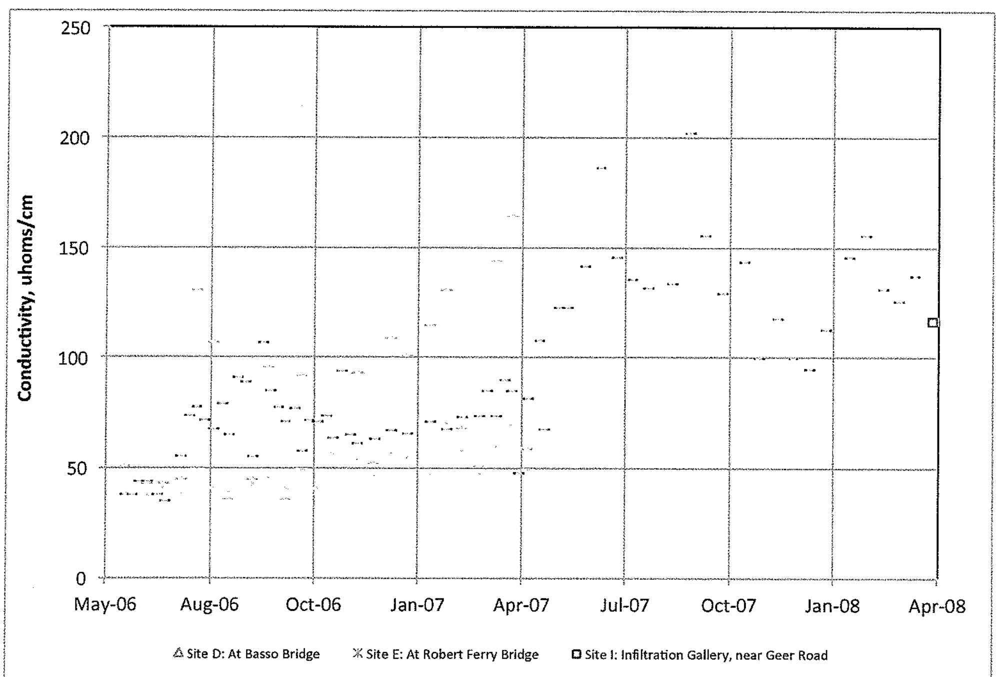

Figure 15. Conductivity of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

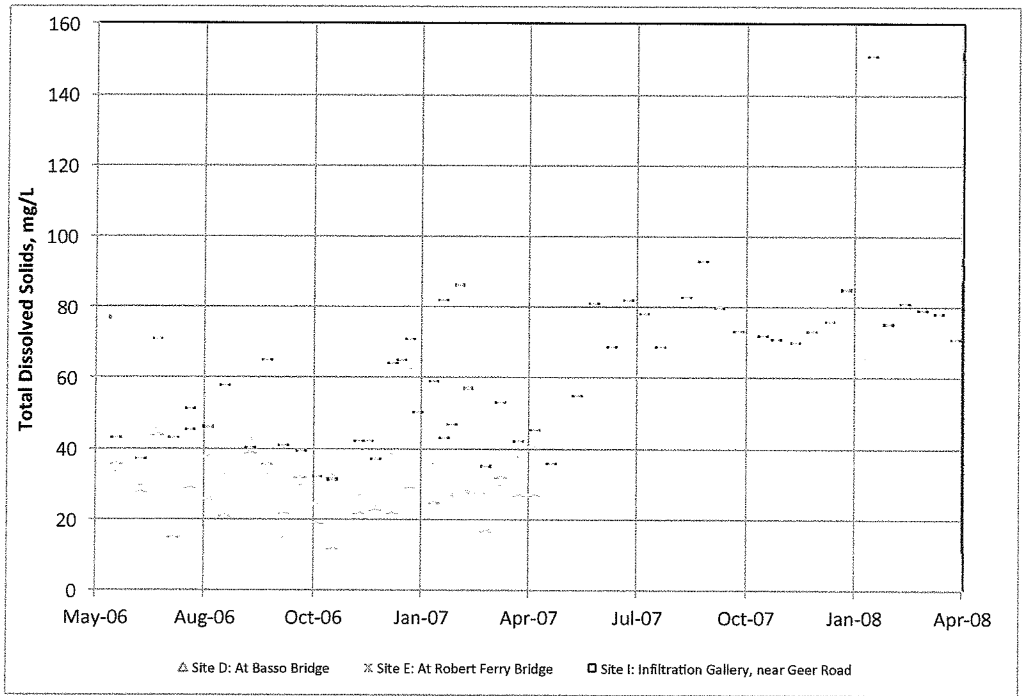

Figure 16. TDS of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

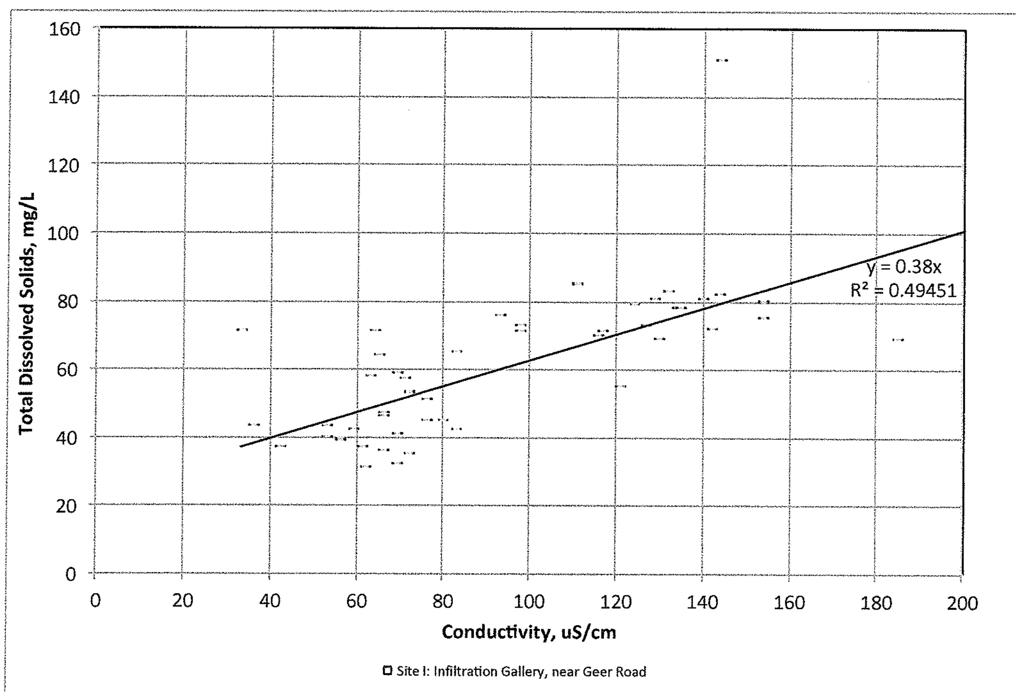

Figure 17. Correlation between TDS and Conductivity Using Paired Data Collected by TID at Site I

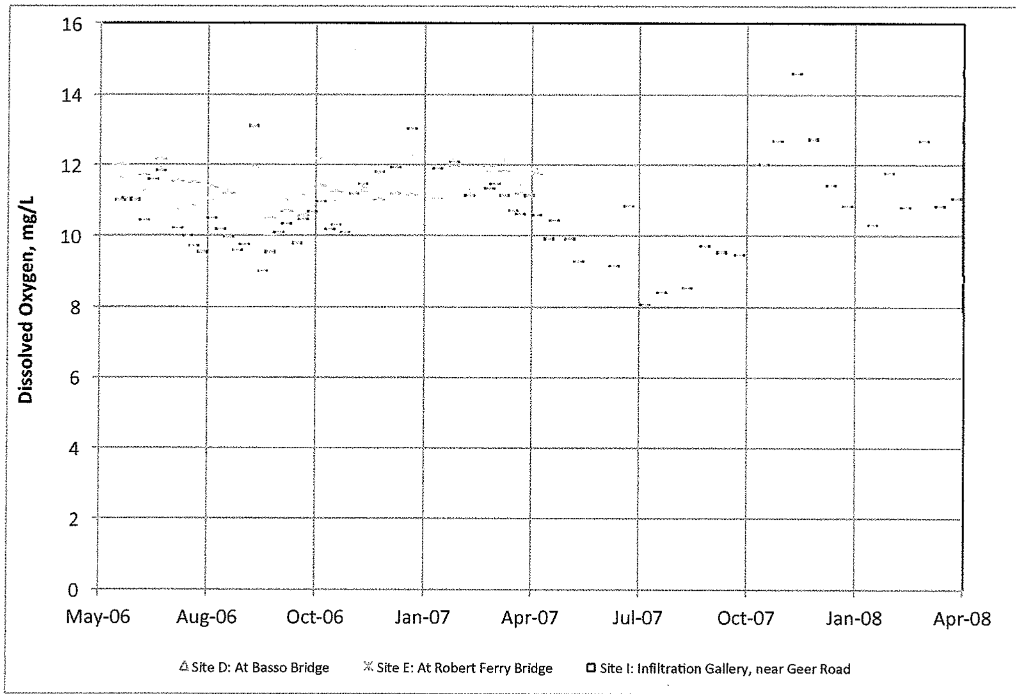

Figure 18. Dissolved Oxygen of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

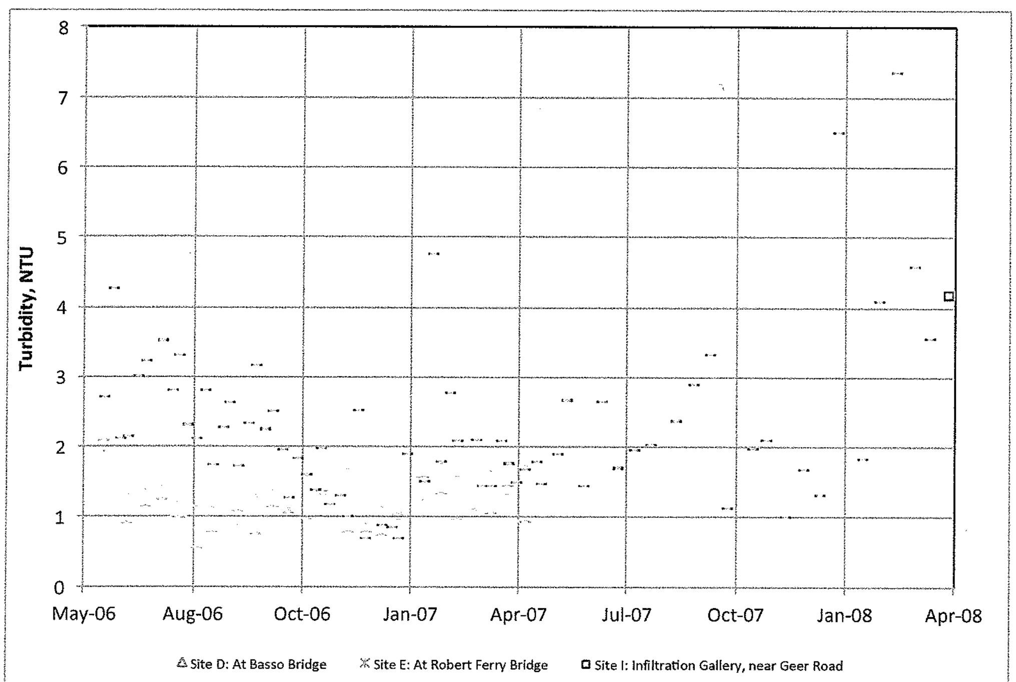

Figure 19. Turbidity of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

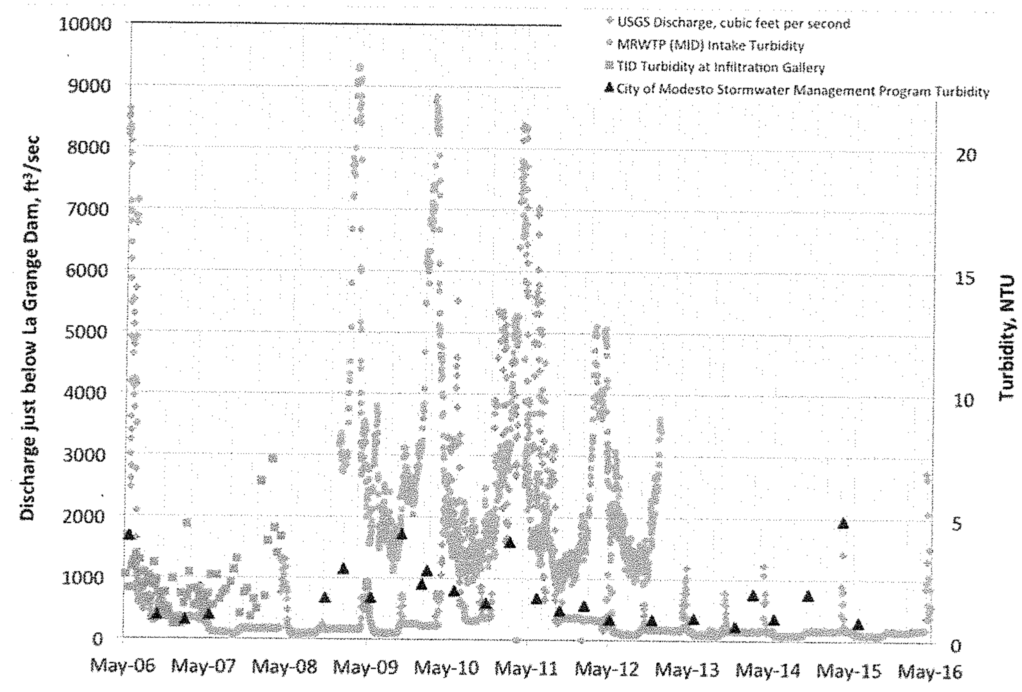

Figure 20. Flow Rate and Turbidity from MID MRWTP Intake, TID Tuolumne River at infiltration gallery, City of Modesto Stormwater Management Program

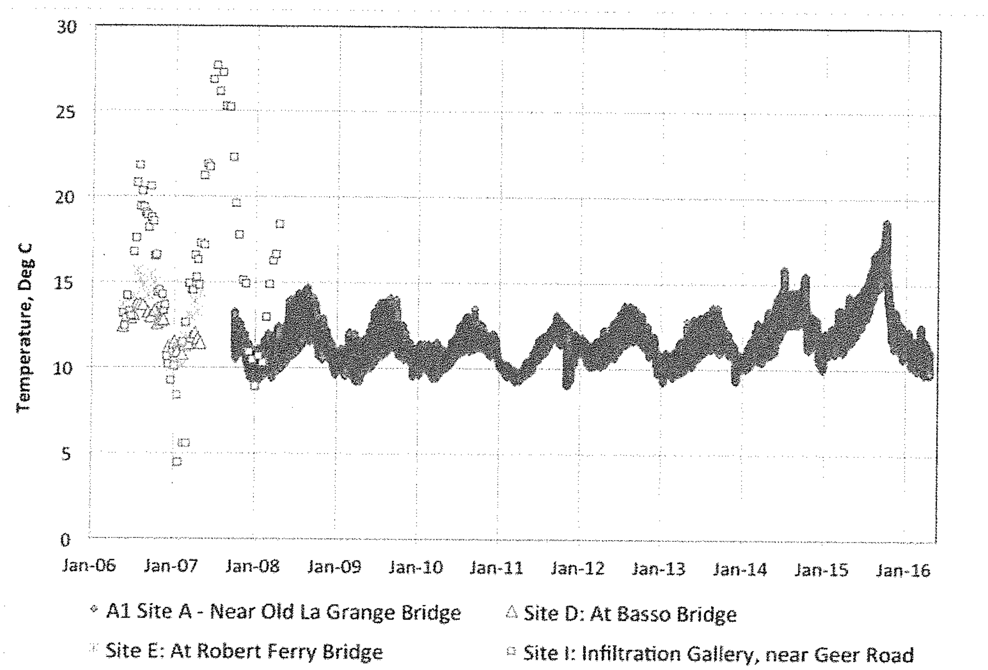

Figure 21. Seasonal Temperature Fluctuations of the Tuolumne River from Site A, Sites D, E and I (infiltration gallery)

5.4.2 Nutrients

Nutrient concentrations are summarized in Table 7. Noteworthy observations are provided below:

- **Nitrogen Species.**
  - All ammonia measurements taken by TID were below the 0.1 mg/L detection limit except one sample taken at Basso Bridge (Site D) on April 18, 2007, which measured 0.1 mg/L – right at the detection limit. The absence of ammonia at the infiltration gallery was expected, since the River is well-oxygenated and ammonia-oxidizing-bacteria (AOBs) are likely converting ammonia to nitrate. The absence of ammonia is beneficial for chlorine disinfection, because there will be no additional chlorine demand exerted.
  - Ammonia was not detected upstream of the infiltration gallery, at either Site D (Basso Bridge) or Site E (Robert Ferry Bridge), but was detected downstream of the infiltration gallery at Site L (near Mitchell Rd.) where concentrations ranged from non-detect (<0.02 mg/L) to 0.30 mg/L and averaged 0.07 mg/L.
  - All six nitrite samples taken at the infiltration gallery were below the method reporting limit (MRL) of 0.1 mg/L as N, and most of the samples at Site L (near Mitchell Rd. – about 7.7 miles downstream of the infiltration gallery) were also below the MRL of 0.1 mg/L as N. Nitrite exerts a substantial ozone demand—3.4 mg/L of ozone for every 1 mg/L of nitrite—which is an important consideration if the selected process train for the new WTP includes ozone. Hence, no ozone demand is expected from nitrite.
  - Nitrate levels are not a regulatory concern since they are well below MCL of 10 mg/L-N at all sites with available historical data. Nitrate was measured below the MRL of 0.1 mg/L-N upstream of the infiltration gallery. At the infiltration gallery, nitrate was detected at concentrations between 0.3 to 0.9 mg/L-N, with an average of 0.5 mg/L-N. Nitrate may correlated with rainfall due to stormwater runoff. However, these data indicate no obvious correlation at the infiltration gallery (Figure 22). The presence of nitrate is indicative of the potential for algae in stagnant areas and in turn the potential for associated taste and odor (T&O) events. At the SRWA's June 29th, 2016 meeting with DDW, DDW staff mentioned that in recent years algae has been observed in locations where it previously had not. So, the selected treatment train may need to include treatment for algae related T&O compounds.

- **Phosphorous.**
  - All phosphorous measurements taken by TID were below the 0.05 mg/L detection limit. High levels of phosphorus could indicate potential wastewater or fertilizer contamination, and the potential for algae blooms.

Table 7. Nutrient Statistics

		Sampling Location on Tuolumne River (in order of upstream to downstream, with sample location *I* = Infiltraiton Gallery)												
		A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*
Analytes Nutrients	**Statistics**	Near Old La Grange Bridge[1]	Modesto Reservoir Inlet[2]	MRWTP Intake[2,3]	At Basso Bridge[4]	At Robert Ferry Bridge[4]	4 miles upstream of Hickman Rd.[5]	At Waterford Rd.[6]	At Fox Grove[7]	At Infiltration Gallery near Geer Rd.[4]	TID Pilot Study; At Hughson WWTP[3,8]	At Ceres River Bluff Park[9]	Near Mitchell Rd.[3,10]	At Legion Park[11]
Sampling Period		Oct 2007-Apr 2016	May 2009-Sep 2012	Jan 2009-Dec 2012	May 2006-Oct 2008	May 2006-Oct 2008	Aug 2009	Aug 2010-Jun 2014	Aug 2010-Jun 2014	May 2006-Oct 2008	Sep 2006 - Apr 2007	Aug 2010-Jun 2014	Jan 2005-Feb 2016	Aug 2010-Jun 2014
Sampled By		USGS	Modesto Irrigation District	Modesto Irrigation District	Turlock Irrigation District	Turlock Irrigation District	CEDEN	CEDEN	CEDEN	Turlock Irrigation District	Turlock Irrigation District	CEDEN	City of Modesto/State Water Project	CEDEN
Ammonia[13] mg/L as N	Min				<0.1	<0.1	< 0.02			<0.1			<0.02	
	Max				0.1	<0.1	< 0.02			<0.1			0.30	
	Median				<0.1	<0.1	n/a			<0.1			0.04	
	Mean				<0.1	<0.1	< 0.02			<0.1			0.07	
	N				11	11	1			11			30	
Nitrate[12] mg/L as N	Min				<0.1	<0.1				0.3			0.09	
	Max				<0.1	<0.1				0.9			1.68	
	Median				<0.1	<0.1				0.4			0.38	
	Mean				<0.1	<0.1				0.5			0.60	
	N				11	11				19			11	
Nitrite mg/L as N	Min						< 0.005			<0.1			<0.01	
	Max						< 0.005			<0.1			0.20	
	Median						n/a			<0.1			<0.01	
	Mean						< 0.005			<0.1			0.03	
	N						1			6			20	
Nitrate + Nitrite mg/L as N	Min						0.0177						0.09	
	Max						0.0177						1.23	
	Median						n/a						0.41	
	Mean						0.0177						0.47	
	N						1						31	
Nitrogen, Total mg/L	Min						0.223							
	Max						0.223							
	Median						n/a							
	Mean						0.223							
	N						1							
Phosphate[13], Ortho mg/L as P	Min						0.0249			<0.05				
	Max						0.0249			<0.05				
	Median						n/a			<0.05				
	Mean						0.0249			<0.05				
	N						1			4				
Phosphorus, Total mg/L as P	Min				<0.05	<0.05	0.0303			<0.05			<0.01	
	Max				<0.05	<0.05	0.0303			<0.05			0.25	
	Median				<0.05	<0.05	n/a			<0.05			0.02	
	Mean				<0.05	<0.05	0.0303			<0.05			0.03	
	N				11	11	1			11			30	

[1] USGS California Water Science Center National Water Information System. USGS Station Code: 11289650.
[2] MID Modesto Regional Water Treatment Plant (MRWTP) Watershed Sanitary Survey.
[3] Minimum and maximum estimated from a graph or extracted from text in which data are discussed (indicated by gray cells).
[4] TID Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake & data from additional monitoring completed from May 2007 to April 2008.
[5] SWRCB CEDEN. Station Code: 535PS0265.
[6] SWRCB CEDEN. Station Code: 535TR5xxx.
[7] SWRCB CEDEN. Station Code: 535STC218.
[8] TID Regional Surface Water Supply Pilot Study Report
[9] SWRCB CEDEN. Station Code: 535STC217.
[10] State Water Project WSS. Data source: City of Modesto – Stormwater Management Program.
[11] SWRCB CEDEN. Station Code: 535STC216.
[12] When data set contained a mix of non-detect and detected values, the MRL was used in calculating statistics.
[13] Dissolved was measured for location F, otherwise it is not specificied.
[14] Some coliform concentrations were reported as >2419.6 MPN/100mL. In determining the statistics, this value was used.
[15] Range given since report provided average for differnet treatment schemes tested
[16] When calculating the statistic, if a value was non-detect, the value was assumed to be equal to zero.
[17] During pilot testing, total iron was tested. Other data sources do not specifiy dissolved versus total.

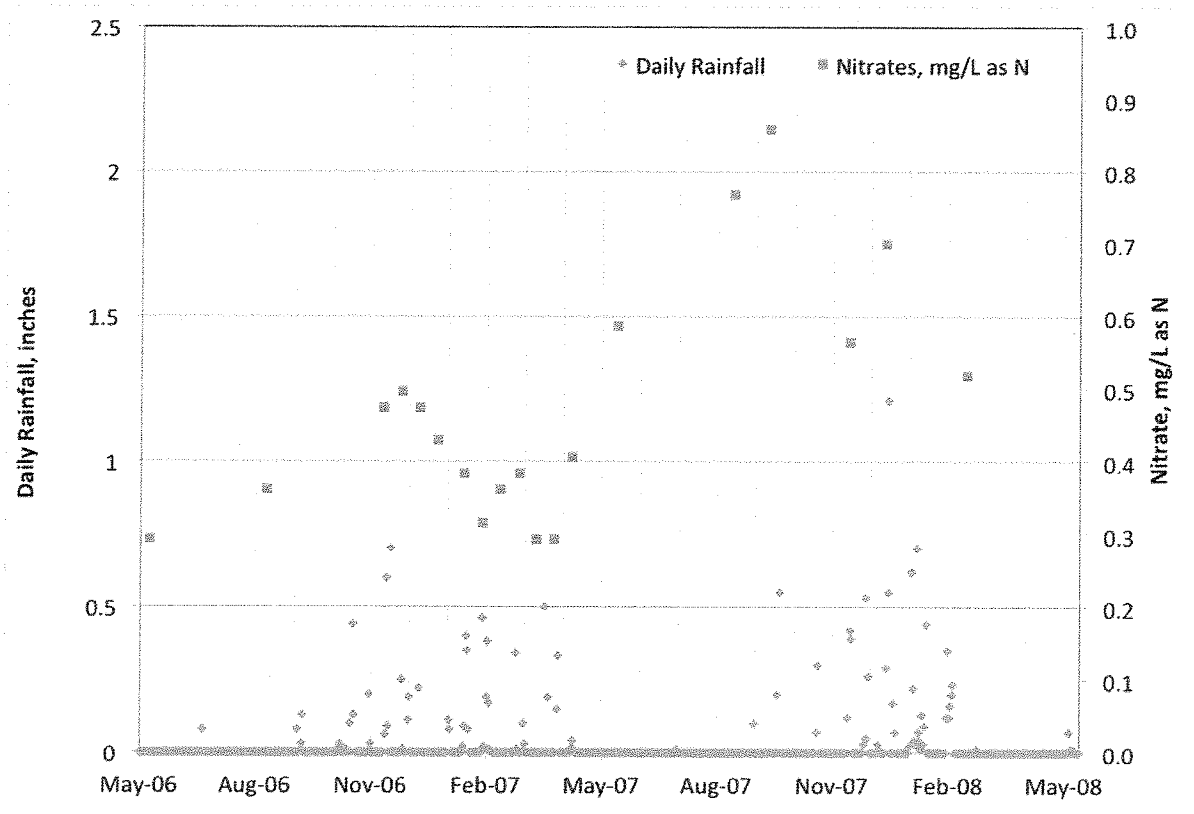

Figure 22. Rainfall and Nitrate of the Tuolumne River at infiltration gallery (Values Plotted At 0.5 mg/L Are Non-Detects)

5.4.3 DBP-Related Parameters

DBP-related parameters are summarized in Table 8. Noteworthy observations are provided below:

- **Bromide**
  - Bromate is a regulated DBP (with an MCL of 0.010 mg/L) that forms during ozonation of a water containing bromide. The formation of bromate is pH-dependent, and less bromate is formed at lower pHs (i.e., < 8.8). So, what is a reasonable raw water bromide limit in order to stay below the bromate MCL? Based solely on stoichiometry, if 100% of the bromide were converted to bromate, 0.006 mg/L of bromide would be needed to form 0.010 mg/L bromate (i.e., its MCL). This is a worst case scenario because in surface waters there would be competition by natural organic matter to form brominated THMs and HAAs. Based on experience, the bromide limit for exceeding the bromate MCL with ozone is typically 0.1 to 0.3 mg/L. The historical data showed bromide was always measured

below the detection limit in the raw water (<0.1 mg/L). Thus, bromate formation in conjunction with ozonation should not be a treatment issue of concern for this water.

- **<u>Dissolved Organic Carbon (DOC) and Total Organic Carbon (TOC).</u>** DOC and TOC are important parameters because they are DBP precursors and therefore affect coagulation and disinfection approaches. Higher levels of chlorination DBPs (i.e., THMs and HAAs) form when free chlorine is used compared with chloramines. The point in the process train where chlorine is applied has a significant impact on the level of DBPs formed. If chlorine is added prior to TOC removal, much higher levels of DBPs form compared to adding chlorine after coagulation/sedimentation (i.e., clarification). Free chlorine is a much more powerful disinfectant than chloramines, so a much longer contact time with a disinfectant is required with chloramines to achieve the required disinfection credit, even though fewer DBPs may form.

  Review of the historical Tuolumne River data, along with review of the DBP formation data presented in the 2008 TID pilot study report (Brown and Caldwell, 2008), indicate the following regarding TOC and DOC:

  - Based on data collected by TID as a part of the WSS effort in 2007-2008, the majority of the TOC is in the dissolved form. The DOC to TOC ratio of time-paired samples was 80% on average with a standard deviation of 18%.
  - TOC concentrations reported at the infiltration gallery location are relatively high and quite variable, as shown in Figure 23. The average TOC concentration at the infiltration gallery site is somewhat higher than upstream and downstream locations (Figure 24). The average concentration at the infiltration gallery was 3.3 mg/L (ranging from 1.4 mg/L – 6.5 mg/L) versus 2.9 mg/L at Robert Ferry Bridge (Site E) approximately 14 river miles upstream, versus 2.0 mg/L at Mitchell Road (Site L) approximately 8 miles downstream near Modesto. The concentrations at the infiltration gallery are high enough that DBP formation will be a concern with free chlorine disinfection, unless significant TOC reduction is achieved during treatment. In order to obtain a better understanding of the TOC levels at this location, and potentially to characterize seasonal and storm-related influences, TOC will be measured monthly for two years as part of the upcoming monitoring program. These data will aid in evaluating TOC removal requirements under the Enhanced Coagulation component of the D/DBP Rule.
  - Based on the mean TOC concentration of 3.3 mg/L and the mean alkalinity of 37 mg/L as $CaCO_3$ at the infiltration gallery, the Stage 1 D/DBP Rule will require that treatment remove at least 35% TOC.

- As a part of the pilot testing completed by TID, percent TOC removal was quantified for three proprietary High Rate Clarifier (HRC) systems alongside a conventional plate settler, using four different coagulants (Brown and Caldwell, 2008). (Note: The plate settler did not operate appropriately possibly due to construction issues, so the percentage TOC removal was not useful.) High-rate clarifiers are designed to operate at a higher loading rate (gpm/sf) and therefore a smaller footprint than conventional sedimentation, often by providing more surface area for settling using inclined plates or tubes. Surface loading rate for conventional rectangular clarifiers is 0.5 to 1.0 gpm/sf, and 2.5 to 6.25 gpm/sf for tube settlers (Crittenden, et al., 2008). The proprietary systems that were pilot tested have proprietary features that allow enhanced settling or floating—as in the case of dissolved air flotation (DAF—of the floc. Each of the HRC systems provided significant TOC removal, although performance varied. TOC removals through clarification ranged from 21% to 51%. From this study, the dissolved air flotation systems (DAF) outperformed the sand ballasted clarification (SBC) system.

- **<u>Disinfection By-Products.</u>**
  - DBP formation is water-specific and highly influenced by the presence of organic carbon and pH. As a part of the pilot testing completed by TID, DBP formation potential was analyzed on the raw water and clarifier effluent. A modified Simulated Distribution System (SDS) procedure was used to simulate DBP formation in a distribution system in terms of applied chlorine dose, pH and sample holding time[12]. According to the 2008 TID pilot report, TTHM and HAA5 formation in samples of raw water (using a 3 mg/L chlorine dose) ranged from approximately 55 to 100 µg/L and 30 to 75 µg/L, respectively – both above the regulatory limit. After high rate clarification, TTHM and HAA5 formation potential never exceeded 50 µg/L and 30 µg/L, respectively, for all HRC systems tested. All measured DBP concentrations were below the pMCL of 80 µg/L for TTHM and 60 µg/L for HAA5 after HRC.
  - Bromate is an ozonation DBP which can form when bromide is present. During the TID pilot study, source water bromide concentrations were non-detect (ND). Bromate formation was not observed during pilot testing, with either pre- or post-ozone disinfection (Brown and Caldwell, 2008).

[12] "Samples were collected after each pilot process, dosed with 3 mg/L Cl_2 and held at approximately 13 degrees (deg) C for five or seven days to assess the DBP formation potential. The pH value of the samples was raised to 8 with calcium bi-carbonate to more closely simulate the pH in the finished water of the full-scale facility. Samples were collected at all locations on the same day to observe the change in the water on those days. After the five and seven day incubation period, chlorine residual, organic carbon, and pH were measured at the site lab and samples were quenched with sodium thiosulfate and sent to the analytical laboratory for analysis of trihalomethane (TTHM) and five regulated halo-acetic acid (HAA5)" (TID Pilot Report, Brown and Caldwell, 2008b).

Table 8. DBP-Related Parameter Statistics

Label on Map in Figure 3-6 >>>		A	B	C	D	E	F	G	H	I	J	K	L	M
		Sampling Location on Tuolumne River (in order of upstream to downstream, with sample location I = Infiltraiton Gallery)												
Analytes DBP-Related Parameters	Statistics	Near Old La Grange Bridge[1]	Modesto Reservoir Inlet[2]	MRWTP Intake[2,3]	At Basso Bridge[4]	At Robert Ferry Bridge[4]	4 miles upstream of Hickman Rd.[5]	At Waterford Rd.[6]	At Fox Grove[7]	At Infiltration Gallery near Geer Rd.[4]	TID Pilot Study; At Hughson WWTP[3,8]	At Ceres River Bluff Park[9]	Near Mitchell Rd.[3,10]	At Legion Park[11]
	Sampling Period	Oct 2007-Apr 2016	May 2009-Sep 2012	Jan 2009-Dec 2012	May 2006-Oct 2008	May 2006-Oct 2008	Aug 2009	Aug 2010-Jun 2014	Aug 2010-Jun 2014	May 2006-Oct 2008	Sep 2006 - Apr 2007	Aug 2010-Jun 2014	Jan 2006-Feb 2016	Aug 2010-Jun 2014
	Sampled By	USGS	Modesto Irrigation District	Modesto Irrigation District	Turlock Irrigation District	Turlock Irrigation District	CEDEN	CEDEN	CEDEN	Turlock Irrigation District	Turlock Irrigation District	CEDEN	City of Modesto/State Water Project	CEDEN
Bromide [12] mg/L	Min				<0.1	<0.1				<0.1				
	Max				<0.1	<0.1				<0.1				
	Median				<0.1	<0.1				<0.1				
	Mean				<0.1	<0.1				<0.1				
	N				13	13				30				
Organic carbon, Dissolved mg/L	Min				1.4	1.2	1.48			1.3	1.5			
	Max				4.1	3.2	1.48			4.0	2.3			
	Median				2.0	2.0	n/a			2.4				
	Mean				2.2	2.0	1.48			2.5				
	N				24	24	1			47				
Organic carbon, Total mg/L	Min			1.2	1.7	1.8				1.4	1.5		1.1	
	Max			3.3	7.7	5.4				6.5	2.3		6.6	
	Median			1.6	2.7	2.6				3.0			1.7	
	Mean			1.7	3.2	2.9				3.3	1.8		2.0	
	N			965	24	24				47			30.00	

1 USGS California Water Science Center National Water Information System. USGS Station Code: 11289650.
2 MID Modesto Regional Water Treatment Plant (MRWTP) Watershed Sanitary Survey.
3 Minimum and maximum estimated from a graph or extracted from text in which data are discussed (indicated by gray cells).
4 TID Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake & data from additional monitoring completed from May 2007 to April 2008.
5 SWRCB CEDEN. Station Code: 535PS0265.
6 SWRCB CEDEN. Station Code: 535TR5xxx.
7 SWRCB CEDEN. Station Code: 535STC218.
8 TID Regional Surface Water Supply Pilot Study Report
9 SWRCB CEDEN. Station Code: 535STC217.
10 State Water Project WSS. Data source: City of Modesto – Stormwater Management Program.
11 SWRCB CEDEN. Station Code: 535STC216.
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13 Dissolved was measured for location F, otherwise it is not specificied.
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15 Range given since report provided average for differnet treatment schemes tested
16 When calculating the statistic, if a value was non-detect, the value was assumed to be equal to zero.
17 During pilot testing, total iron was tested. Other data sources do not specify dissolved versus total.

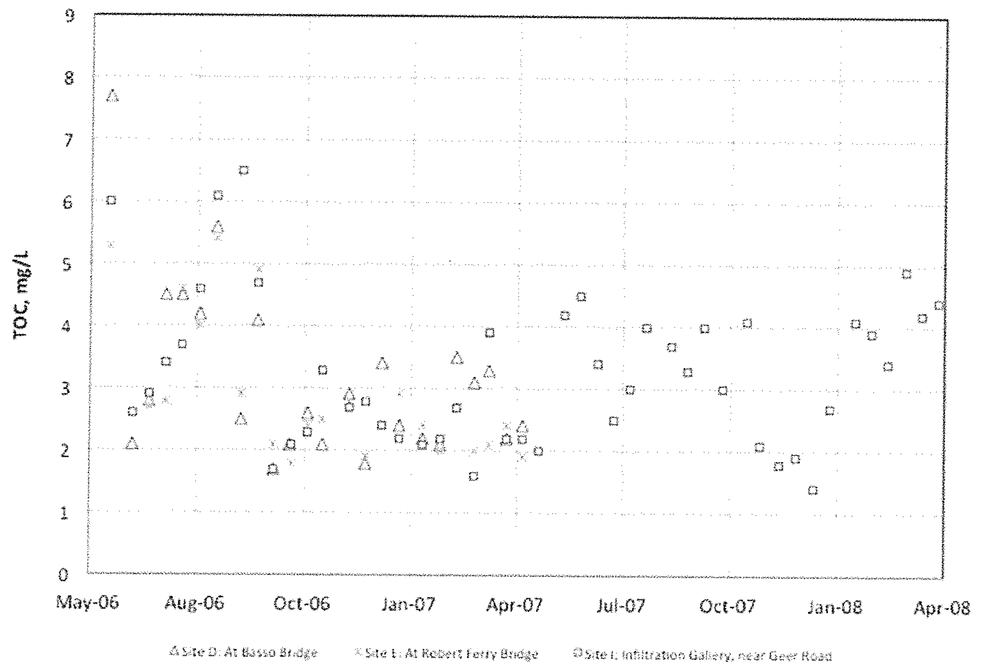

Figure 23. TOC of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (infiltration gallery)

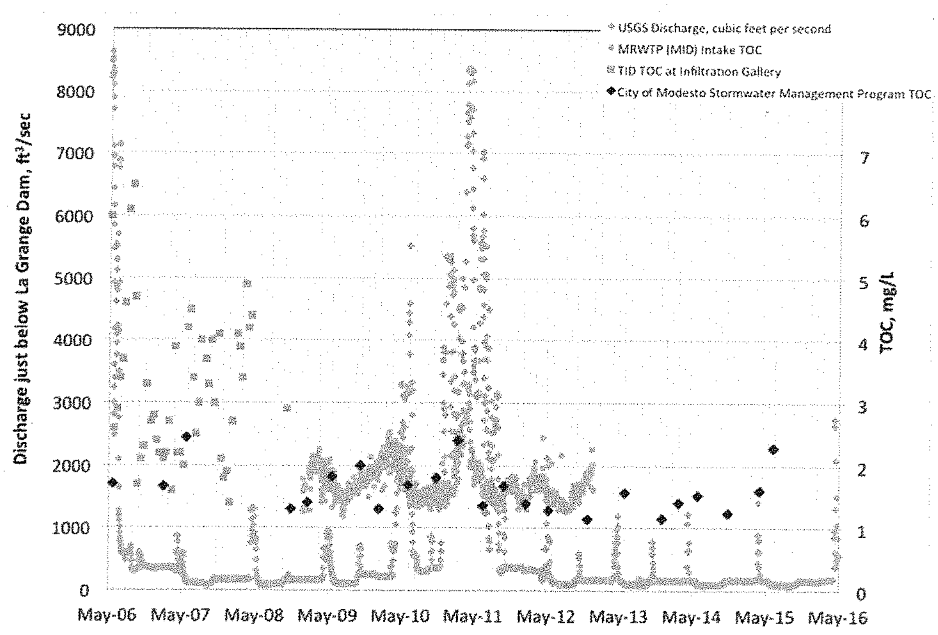

Figure 24. TOC of Modesto Reservoir at MID MRWTP Intake and Tuolumne River at the infiltration gallery and Downstream in Modesto Near Mitchell Road

5.4.4 Metals

Select metals are summarized in Table 9. Noteworthy observations are provided below:

- **Aluminum.**
  - The average total aluminum concentration measured at the infiltration gallery (0.091 mg/L) was slightly lower than that measured downstream of the infiltration gallery near Mitchell Rd (0.124 mg/L). All concentrations measured at both sites were below the 1 mg/L pMCL, but one of the five samples at the infiltration gallery and seven of the 32 samples from the site near Mitchell Road were above the sMCL of 0.2 mg/L. The City of Modesto also measured dissolved aluminum, measuring between non-detect (the dataset did not specify MRL) to 0.015 mg/L. Based on City of Modesto data, most of the aluminum is in the particulate form and should be readily filtered out though conventional treatment (clarification and filtration) to achieve aluminum concentrations that are substantially below both pMCL and sMCL levels. Given the well-oxygenated environment of the Tuolumne River, aluminum should be predominantly in particulate form.

- **Iron.**
  - At the infiltration gallery, total iron concentrations ranged from <0.050 to 6.5 mg/L, with three of these 94 samples above the sMCL of 0.3 mg/L (iron does not have a pMCL). Given that the Tuolumne River in the vicinity of the project is well-oxygenated, the maximum value measured (6.5 mg/L) may be an outlier. In support of this supposition are the facts that the next highest value was 0.380 mg/L, the majority of the data were below the detection limit, and a duplicate sample taken on the same day as the extremely high value (February 6, 2008) was much lower, measuring at 0.130 mg/L.

- **Manganese.**
  - At the infiltration gallery, total manganese concentrations ranged from <0.010 to 0.850 mg/L, with two of the 94 samples above the sMCL of 0.05 mg/L (manganese currently has no pMCL). The maximum value measured may be an outlier because the next highest value was 0.110 mg/L and a duplicate sample taken on the same day as the extremely high value (March 22, 2007) was much lower, measuring at 0.025 mg/L. Nonetheless, these levels are high enough that manganese removal will have to be considered during process train selection.
  - The dissolved fraction of manganese was not available in the historical dataset. Dissolved manganese can be difficult to oxidize and then filter, unlike aluminum and iron. If not removed, this can lead to colored water, staining, and a buildup of manganese on the pipe walls of the distribution system. Additionally, both dissolved and particulate manganese can lead to irreversible fouling of the membrane filtration membranes.

- Because of potential neurological effects in children and infants, manganese has been included on the latest Contaminant Candidate List (CCL4) and Unregulated Contaminant Monitoring Rule (UCMR4) lists.

Table 9. Metals Statistics

Label on Map in Figure 3-6 >>>		A	B	C	D	E	F	G	H	I	J	K	L	M
		Sampling Location on Tuolumne River (in order of upstream to downstream, with sample location I = Infiltraiton Gallery)												
Analytes Metals	Statistics	Near Old La Grange Bridge[1]	Modesto Reservoir Inlet[2]	MRWTP Intake[2,3]	At Basso Bridge[4]	At Robert Ferry Bridge[4]	4 miles upstream of Hickman Rd.[5]	At Waterford Rd.[6]	At Fox Grove[7]	At Infiltration Gallery near Geer Rd.[4]	TID Pilot Study; At Hughson WWTP[3,8]	At Ceres River Bluff Park[9]	Near Mitchell Rd.[3,10]	At Legion Park[11]
	Sampling Period	Oct 2007-Apr 2016	May 2009-Sep 2012	Jan 2009-Dec 2012	May 2006-Oct 2008	May 2006-Oct 2008	Aug 2009	Aug 2010-Jun 2014	Aug 2010-Jun 2014	May 2006-Oct 2008	Sep 2006 - Apr 2007	Aug 2010-Jun 2014	Jan 2005-Feb 2016	Aug 2010-Jun 2014
	Sampled By	USGS	Modesto Irrigation District	Modesto Irrigation District	Turlock Irrigation District	Turlock Irrigation District	CEDEN	CEDEN	CEDEN	Turlock Irrigation District	Turlock Irrigation District	CEDEN	City of Modesto/State Water Project	CEDEN
Aluminum[12] mg/L	Min			0.0001						<0.020			0.015	
	Max			0.0009						0.290			0.310	
	Median			0.0003						0.046			0.105	
	Mean			0.0004						0.091			0.124	
	N			5						5			32	
Barium mg/L	Min									0.02				
	Max									0.10				
	Median									not reported				
	Mean									0.04				
	N									4				
Iron[12, 17] mg/L	Min			0.07	<0.050	0.078				<0.050	0.11		0.091	
	Max			0.79	<0.100	0.130				6.500	0.35		1.100	
	Median			0.27	<0.100	<0.100				<0.100			0.230	
	Mean			0.33	<0.100	0.100				0.188	0.17		0.281	
	N			5	48	48				94			32	
Manganese[12] mg/L	Min			0.007	<0.010	<0.010				<0.010	0.014			
	Max			0.009	0.018	0.019				0.850	0.085			
	Median			0.009	<0.010	<0.010				0.017				
	Mean			0.008	<0.010	0.011				0.029	0.04			
	N			3	48	48				95				

1 USGS California Water Science Center National Water Information System. USGS Station Code: 11289650.
2 MID Modesto Regional Water Treatment Plant (MRWTP) Watershed Sanitary Survey.
3 Minimum and maximum estimated from a graph or extracted from text in which data are discussed (indicated by gray cells).
4 TID Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake & data from additional monitoring completed from May 2007 to April 2008.
5 SWRCB CEDEN. Station Code: 535PS0265.
6 SWRCB CEDEN. Station Code: 535TR5xxx.
7 SWRCB CEDEN. Station Code: 535STC218.
8 TID Regional Surface Water Supply Pilot Study Report
9 SWRCB CEDEN. Station Code: 535STC217.
10 State Water Project WSS. Data source: City of Modesto – Stormwater Management Program.
11 SWRCB CEDEN. Station Code: 535STC216.
12 When data set contained a mix of non-detect and detected values, the MRL was used in calculating statistics.
13 Dissolved was measured for location F, otherwise it is not specificied.
14 Some coliform concentrations were reported as >2419.6 MPN/100mL. In determining the statistics, this value was used.
15 Range given since report provided average for differnet treatment schemes tested
16 When calculating the statistic, if a value was non-detect, the value was assumed to be equal to zero.
17 During pilot testing, total iron was tested. Other data sources do not specifiy dissolved versus total.

5.4.5 Microbial Parameters

Microbial parameters are summarized in Table 10. Noteworthy observations are provided below:

- **Coliforms.**
  - The median total coliform concentration at the infiltration gallery location (between May 2006 and October 2008) was 130 MPN/100mL, based on 73 data points. The CEDEN data had higher total coliform concentrations for both upstream and downstream locations, but with substantially smaller datasets. The median concentrations at Waterford Road (5.7 miles upstream) and Ceres River Bluff Park (7 miles downstream) were >2,417 MPN/100mL, whereas TID data from Basso Bridge (21.7 miles upstream) and Robert Ferry Bridge (13.9 miles upstream) were 17 and 40 MPN/100mL, respectively.
  - Fecal coliform concentrations generally increase as the water moves downstream. Site D (Basso Bridge) had a median of 4 MPN/100mL and Site L (Mitchell Rd.) had a median of 23 MPN/100mL. At the infiltration gallery location, the median was 22 MPN/100mL.
  - The median *E. coli* concentration was 12.7 MPN/100mL. Higher *E. coli* levels were measured upstream and downstream of the infiltration gallery location. A plot of the median, maximum and minimum *E. coli* concentrations between Waterford Road (5.7 miles upstream) and Mitchell Road (7.7 miles downstream) are shown in Figure 26. The same plot would have been provided for total coliform, but there were no data available at the Mitchell Road site and the majority of the CEDEN data at Waterford Road were reported as >2,420 MPN/100mL, because of limited sample volume.
  - Fecal coliform levels were plotted with rainfall to assess the impact of runoff on River water quality. There is a general trend showing increased fecal coliform concentrations after rain events (Figure 25).
  - As discussed in the Proposed RTCR (U.S. EPA 2010), while total coliform bacteria are abundant in the feces of warm-blooded animals, they are also found in soil, aquatic environments and elsewhere, and their presence does not necessarily imply fecal contamination. Fecal coliform bacteria are a subgroup of the total coliform bacteria. While fecal coliform bacteria have traditionally been associated with fecal contamination, the test used to measure these bacteria often includes bacteria that do not originate in the human or mammal gut ((Edberg et al. 2000) as referenced in (U.S. EPA 2010)). *E. coli* are a subset of the fecal coliforms. *E. coli* bacteria almost always originate in the human or mammal gut, and thus are a better indicator of fecal contamination than the fecal coliforms. The median total coliform/fecal coliform and total coliform/*E. coli* ratios

measured for this water are 6 and 10, respectively. These ratios suggest that a small fraction of the coliforms are of fecal origin.

- The SWTR Guidance Manual (USEPA, 1990) provides general guidelines for selecting an appropriate filtration technology based on raw water microbial conditions. According to these guidelines, conventional filtration without pre-disinfection should be effective for a source water with a total coliform concentration <5,000/100 mL, and direct filtration with flocculation should be effective for a source water total coliform concentration <500/100 mL. Regulatory guidelines and requirements were first set using total coliform and were later translated into fecal coliform/*E. coli*, assuming a ratio of five-to-one. Thus a criterion of 5,000 total coliform/100 mL is considered equivalent to 1000 fecal coliform/100 mL, which is considered equivalent to 1000 *E. coli*/100 mL (NRC, 2004). Based on these guidelines and the average total coliform, fecal coliform, and *E. coli* concentrations of this source water at the infiltration gallery (282/100 mL, 62/100mL, and 24/100mL, respectively), conventional filtration and direct filtration should be effective technologies.

- ***Cryptosporidium.***
  - Twenty-three of the 24 *Cryptosporidum* measurements were zero at the infiltration gallery (sampled between May 2006-Oct 2008). On June 21, 2006, *Cryptosporidum* was detected at the detection limit of 0.09 oocysts/L. This results in the highest 12-month mean concentraiton of 0.0075 oocysts/L, which places this water souces in "Bin 1," thus requiring no additional treatment beyond the 2-log removal required under the IESWTR. MID also has "Bin 1" classification. Thus it seems the new treatment facility will be required to achieve at least 3-log removal/inactivation of *Giardia*, 4-log removal/inactivation of virus and 2-log removal of *Cryptosporidium*.
  - Higher *Cryptosporidium* concentrations were detected at Fox Grove (Site H), just upstream of the infiltration gallery, with samples ranging from 0 to 0.258 oocysts/L and averaging 0.055 oocysts/L. However, these data still place the source water in "Bin 1," since the average is <0.075 oocysts/L.

- ***Giardia.***
  - *Giardia* concentrations observed at the infiltration gallery ranged from 0 to 0.80 cysts/L, with a geometric mean of 0.08 cysts/L. (Note: Because several measurements were zero, which cannot be used in the computation of a geometric mean, zeros were replaced with the method reporting limit divided by 2.) A 3-log *Giardia* removal/inactivation is recommended when the average (i.e., geometric mean) cyst concentration is ≤ 0.01 cyst/L. When the source water concentration is between 0.01 and 0.10 cysts/L, the SWTR Guidance Manual (USEPA, 1990) recommends 4-log removal/inactivation. For the water quality at the

infiltration gallery, the Guidance Manual recommends 4-log removal/inactivation. It should be noted that this additional level of treatment (i.e., above the required 3-log removal/inactivation), is not a requirement of either the Federal or State (DDW) regulations—it is only guidelines within the Guidance Manual.

Table 10. Microbiological Parameter Statistics

Label on Map in Figure 3-6 >>>		Sampling Location on Tuolumne River (in order of upstream to downstream, with sample location *I* = Infiltraiton Gallery)												
		A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*
Analytes Microbial	**Statistics**	Near Old La Grange Bridge[1]	Modesto Reservoir Inlet[2]	MRWTP Intake[2,3]	At Basso Bridge[4]	At Robert Ferry Bridge[4]	4 miles upstream of Hickman Rd.[5]	At Waterford Rd.[6]	At Fox Grove[7]	At Infiltration Gallery near Geer Rd.[7]	TID Pilot Study; At Hughson WWTP[3,8]	At Ceres River Bluff Park[9]	Near Mitchell Rd.[3,10]	At Legion Park[11]
Sampling Period		Oct 2007-Apr 2016	May 2009-Sep 2012	Jan 2009-Dec 2012	May 2006-Oct 2008	May 2006-Oct 2008	Aug 2009	Aug 2010-Jun 2014	Aug 2010-Jun 2014	May 2006-Oct 2008	Sep 2006 - Apr 2007	Aug 2010-Jun 2014	Jan 2005-Feb 2016	Aug 2010-Jun 2014
Sampled By		USGS	Modesto Irrigation District	Modesto Irrigation District	Turlock Irrigation District	Turlock Irrigation District	CEDEN	CEDEN	CEDEN	Turlock Irrigation District	Turlock Irrigation District	CEDEN	City of Modesto/State Water Project	CEDEN
Coliform, Fecal MPN/100 mL	Min			0	0	2				0			0	
	Max			56.0	50	80				900			540	
	Median			1.0	4	8				22			23	
	Mean			2.5	8	15				62			73	
	N			1415	24	24				73			32	
Coliform[14], Total MPN/100 mL	Min		43.5	0.0	0	8		866.4	816.4	4		913.9		1732.9
	Max		4106.0	2420.0	240	500		> 2419.6	> 2419.6	>1600		> 2419.6		> 2419.6
	Median		410.6	56.0	17	40		> 2419.6	> 2419.6	130		> 2419.6		> 2419.6
	Mean		733.1	113.6	34	85		2035.6	2148.2	282		2131.69		2350.9
	N		50	1415	24	24		9	16	73		10		10
Cryptosporidium[16] oocysts/L	Min		0	0				0	0	0		0		0
	Max		0	0.10				0	0.258	0.09		0		0
	Median		0	0				n/a	0	0		n/a		n/a
	Mean		0	0				0	0.055	0		0		0
	N		30	48				1	7	24		1		1
E. coli MPN/100 mL	Min		0	0				4.1	3	0		5.2	0	18.7
	Max		134.0	33.8				172.3	461.1	160.0		204.6	500	653.9
	Median		12.0	2.0				23.3	18.5	12.7		22.0	23	47.5
	Mean		26.0	3.8				42.3	53.4	24.0		40.8	53	121
	N		50	50				9	16	24		10	32	10
Giardia cysts/L	Min		0	0				0.195	0	0		0.293		0
	Max		0.10	0.10				0.195	0.129	2.00		0.293		0
	Median		0	0				n/a	0	0		n/a		n/a
	Mean		0.01	0.00				0.195	0.018	0.33		0.293		0
	N		30	48				1	7	12		1		1
Heterotrophic Plate Count cfu/mL	Min			0										
	Max			6800.00										
	Median			33.00										
	Mean			79.60										
	N			587										
Salmonella MPN/100 mL	Min								0					
	Max								0.055					
	Median								0					
	Mean								0.011					
	N								6					

[1] USGS California Water Science Center National Water Information System. USGS Station Code: 11289650.
[2] MID Modesto Regional Water Treatment Plant (MRWTP) Watershed Sanitary Survey.
[3] Minimum and maximum estimated from a graph or extracted from text in which data are discussed (indicated by gray cells).
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[8] TID Regional Surface Water Supply Pilot Study Report
[9] SWRCB CEDEN. Station Code: 535STC217.
[10] State Water Project WSS. Data source: City of Modesto – Stormwater Management Program.
[11] SWRCB CEDEN. Station Code: 535STC216.
[12] When data set contained a mix of non-detect and detected values, the MRL was used in calculating statistics.
[13] Dissolved was measured for location F, otherwise it is not specificied.
[14] Some coliform concentrations were reported as >2419.6 MPN/100mL. In determining the statistics, this value was used.
[15] Range given since report provided average for differnet treatment schemes tested
[16] When calculating the statistic, if a value was non-detect, the value was assumed to be equal to zero.
[17] During pilot testing, total iron was tested. Other data sources do not specifiy dissolved versus total.

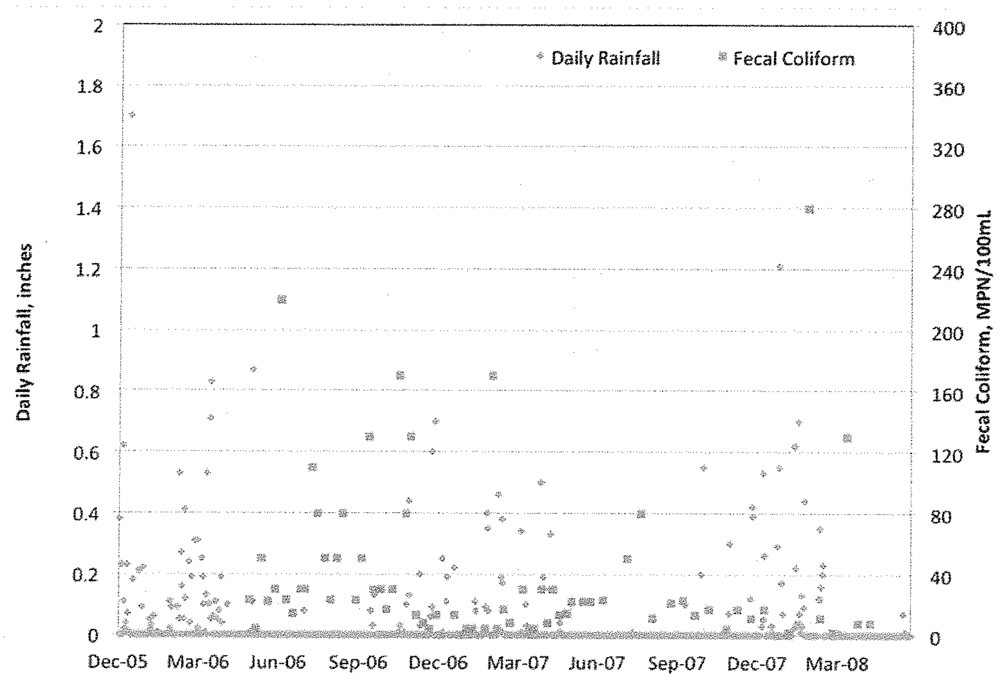

Figure 25. Fecal Coliform at infiltration gallery Location and Daily Rainfall

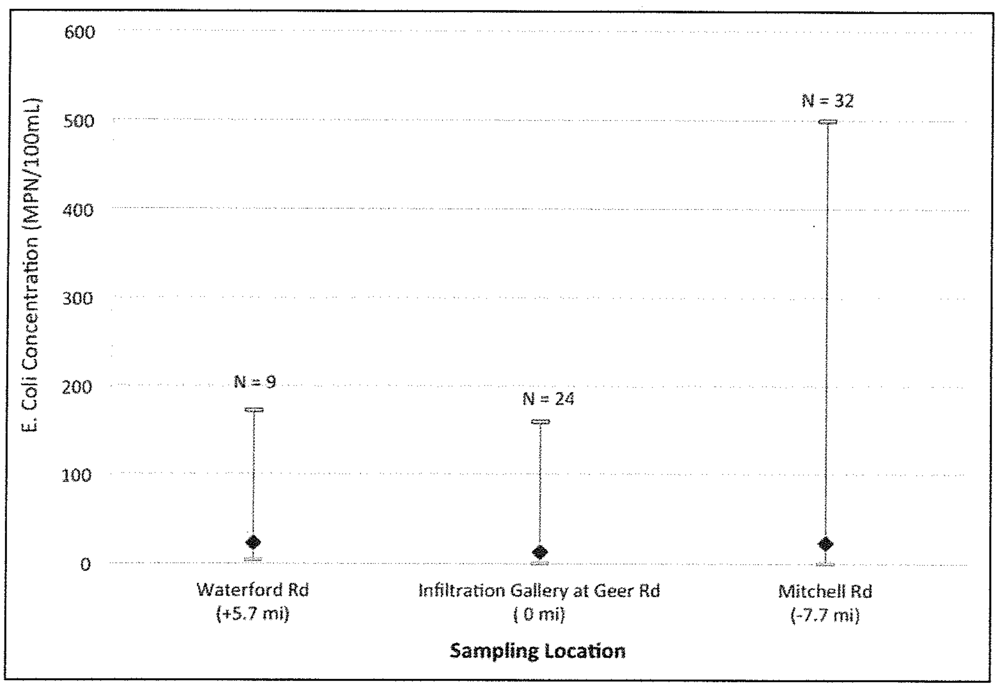

Figure 26. E. Coli Concentrations Measured at the infiltration gallery Location and Upstream and Downstream Locations

5.4.6 Pesticides and other Synthetic Organics Compounds

As stated in the previous section, the Lower Tuolumne River (downstream of Don Pedro Reservoir) is listed as an impaired water body under USEPA Clean Water Act Section 303(d) (California State Water Resources Control Board, 2010). This designation is largely due to the presence of several pesticides, including chlopyrifos, diazinon, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane - including lindane, endosulfan, and toxaphene), as well as pollution from mercury, water temperature, and an unknown toxicity. As of 2014, total maximum daily loads (TMDLs) were established by the RWQCB Central Valley Region to limit diazinon and chlorpyrifos in the San Joaquin River and Sacramento River basins.

The pesticides of local concern for this project were determined through an evaluation of pesticide usage in the local watersheds. CDPR maintains a Pesticide Use Reporting (PUR) database and the most recent available dataset for the project area was from 2014 (CDPR, 2016). The project area was defined using geographic information system (GIS) software (ArcMap 10.3, 2016) to include the Lower Tuolumne River downstream of Don Pedro Reservoir to the confluence with Dry Creek on the east side of Modesto, as well as Turlock Lake, and the Modesto Reservoir. The location information from GIS was used to filter the pesticide use data from the PUR database (CDPR, 2016), from which the top pesticides applied within the project area were determined on the basis of mass (lbs/yr) using a threshold of 5,000 lbs applied per year. These top pesticides are presented in Table 11. The top 5 pesticides used in the project area on a mass basis are further defined by use for specific crops in Table 12. A summary of the detected pesticides and SOCs on the Tuolumne River between La Grange Dam and Modesto are summarized in Table 13. Of the pesticides and SOCs detected, only eight have pMCLs or NLs and of those only diazinon and tert-butyl alcohol were detected above their NL (CDPR and TID Pilot Study and WSS Database). No pesticides were detected above a pMCL. Residential use of Diazinon was outlawed in 2005[13] but is still legal to use on some crops.

The following limited organic- and pesticide-related data were provided by the City of Modesto from their Stormwater Monitoring Program site, downstream of the infiltration gallery:

- Chlorinated Herbicides was ND – sampled on 2/17/16
- Chlorinated Pesticides-PCBs was ND – sampled on 2/17/16
- Organophosphate Pesticides was ND – sampled on 4/8/15
- Regulated Organics was ND – sampled on 4/8/15
- Semi-volatile Organics + PAHs was ND – sampled on 2/17/16
- Volatile Organics was ND – sampled on 4/8/15
- Chlorpyrifos (Dursban) was ND for all samples – 30 samples collected between 1/7/05 to 6/16/15

[13] http://articles.latimes.com/2005/jan/01/nation/na-pest1

- Diazinon was ND for all samples – 30 samples collected between 1/7/05 to 6/16/15

Table 11. Top Pesticides Applied in the Tuolumne River Watershed by Mass (CDPR, 2016)

Chemical Name	Mass Applied (lbs/year)	Area Treated (acres)	Drinking Water Regulations
Mineral Oil [2]	220,210	27,311	N/A
Sulfur [2]	113,438	10,443	N/A
1,3-Dichloropropene	98,091	319	CA PHG: 0.0002 mg/L
Methyl Bromide	90,452	286	CCL4
Glyphosate, Isopropylamine Salt	48,081	31,209	Glyphosate: pMCL: 0.7 mg/L CA PHG: 0.9 mg/L
Copper Hydroxide	47,160	14,212	N/A
Kaolin [2]	34,514	1,105	N/A
Petroleum Oil, Unclassified [2]	33,353	3,283	N/A
Glyphosate, Potassium Salt	31,311	14,160	Glyphosate: pMCL: 0.7 mg/L CA PHG: 0.9 mg/L
Chlorothalonil	20,133	6,826	1-day EPA HA 0.2 mg/L
Mancozeb [1]	10,373	5,219	N/A
Pendimethalin	9,867	4,048	N/A
Oxyfluorfen	8,989	28,536	CCL4
Paraquat Dichloride	8,982	12,122	N/A
2,4-D, Dimethylamine Salt	6,932	7,603	N/A
Chloropicrin	6,753	125	aNL 0.05 mg/L
Copper Sulfate (Basic) [2]	5,167	1,508	N/A
Copper Oxide (Ous) [2]	5,101	1,036	N/A

[1] No method available at Eurofins Eaton Analytical Laboratory

[2] Not considered a synthetic organic chemical

Table 12. Top Five Pesticides Used in the Tuolumne River Watershed by Weight

Pesticide	CAS #	Application	Chemical Used (lbs)	Area Treated (acres)	Drinking Water Regulations
Mineral Oil	64741-56-9	Almond	179,884	21,624	N/A
		Walnut	29,872	4,842	
		Peach	5,545	438	
		Cherry	3,635	292	
		Apple	698	50	
		Other	1,274	116	
Sulfur	7704-34-9	Grape, wine	97,388	8,508	N/A
		Peach	9,363	1,172	
		N-Outdoor Transplants	6,320	692	
		Other	366	72	
1,3-Dichloropropene	542-75-6	Almond	33,783	102	CA PHG: 0.0002 mg/L
		Walnut	29,793	113	
		N-Outdoor Plants in Containers	18,181	54	
		N-Outdoor Transplants	10,657	33	
		Peach	5,677	17	
Methyl Bromide	74-83-9	N-Outdoor Plants in Containers	88,858	273	CCL4
		Almond	1,177	13	
		Walnut	338	–	
		Cherry	40	–	
		Peach	39	–	
Glyphosate, Isopropylamine salt	38641-94-0	Almond	31,726	21,039	Glyphosate: pMCL: 0.7 mg/L CA PHG: 0.9 mg/L
		Walnut	6,636	4,954	
		Corn (Forage - fodder)	2,757	2,146	
		N-Outdoor Plants in Containers	1,982	537	
		Grape, wine	1,488	581	
		Other	3,491	1,952	

Table 13. Summary of Detected Pesticides and SOCs on the Tuolumne River, between La Grange Dam and Modesto

Location	Year	Pesticides & SOCs Detected	Concentration (µg/L)	Regulatory List	MCL/NL (µg/L)	Reference
Between La Grange Dam and Modesto	1995	Diazinon Napropamide Simazine Chlorpyrifos (Dursban) Chlorthal-dimethyl Trifluralin	0.003 – 0.04 0.024 0.069 – 0.22 0.007 – 0.021 0.003 – 0.013 0.007	- NL - None - Primary MCL - UCMR4 - EPA HA - EPA HA	1.2 -- 4 -- -- --	California Department of Pesticide Regulation (CDPR)
Waterford LM Spill; Regional Board Irrigation Lands Monitoring site code: 535MIDWFS	2005 - 2008	Diuron Glyphosate Isoxaben Norflurazon Oryzalin Prodiamine	1.2 – 860 8.1 – 20 5.5 – 9.7 0.084 – 1.4 24 – 170 0.47 – 1.3	- EPA HA; CCL3 - Primary MCL - None - None - None - None	-- 700 -- -- -- --	California Department of Pesticide Regulation (CDPR)
Between La Grange Dam and Modesto	?	Chlorpyrifos (Dursban) Chlorthal-dimethyl Diazinon Malathion Metolachlor Napropamide Simazine	0.04 – 0.032 0.002 – 0.012 0.003 – 2.9 0.031 – 0.16 0.003 – 0.02 0.017 – 0.059 0.038 – 2.2	- UCMR4 - EPA HA - NL - aNL - UCMR2 - None - Primary MCL	-- -- 1.2 160 -- -- 4	CDPR and reported in 2007 TID Treatment Process Evaluation TM
Fox Grove County Park	2007-2008	2,4-Dichlorophenylacetic acid 3,4-Dinitrotoluene Bis(2-Ethylhexyl) Phthalate EPN (ENT) N-Nitrosopyrrolidine Tert-Butyl alcohol (TBA)	0.634 – 3.6 12.2 – 24.2 3.7 1.26 – 3.01 0.009 150	- None - None - Primary MCL - None - None - NL	-- -- 4 -- -- 12	TID Pilot Study and WSS Database

5.4.7 Asian Clams

The only invasive mollusk observed in the Lower Tuolumne River is the Asian Clam (*Corbicula fluminea*). This mollusk can be found in nearly every body of freshwater connected to the San Joaquin Delta (Email correspondence with Pat Maloney in June 2016). Communication with Patrick Maloney (Aquatic Biologist with TID), Jason Guignard (Fisheries Biologist with FishBio), and Kelley Aubushon (Environmental Scientist in the Quagga/Zebra Mussel Program for the California Department of Fish and Wildlife) suggested that Asian clams are found throughout the surface waters of California's Central Valley. None of the sources could confirm the presence of Asian clams on the Tuolumne River in the immediate project area, however. Asian Clams do not adhere to rock or other hard surfaces, but are found at sediment surfaces or slightly buried, existing in the upper 7 cm of sediment, which is significantly shallower than the infiltration gallery (Pat Ryan, Personal Communication, June 2016). Larvae and juvenile clams pass through screens and accumulate in intake piping and water treatment structures. The distribution of these mollusks is tracked by USGS and is prevalent in the project vicinity (Figure 27).

Locally, it is established that Asian clams are present in the Modesto Reservoir, which is the source water for the Modesto Regional WTP. Clam shells have also been observed in the ozone contactor of the conventional half of the Modesto Regional WTP, but not downstream of the ozone contactor since the clams are killed by the ozone (Pat Ryan, Personal Communication, May 2016). The membrane filtration half of the Modesto Regional WTP has been in operation only a limited time in part due to concerns over clam shells cutting or damaging the membranes (Pat Ryan, Personal Communication, May 2016). MID plans to clean the pipeline of silt from La Grange Dam soon and to repeat this cleaning every 5 years so the clams do not have the silt necessary to colonize and grow.

It will be helpful to know if the infiltration gallery can be expected to remove the larvae of Asian Clams from the water. This may be evaluated if pilot infiltration gallery filter tests are conducted.

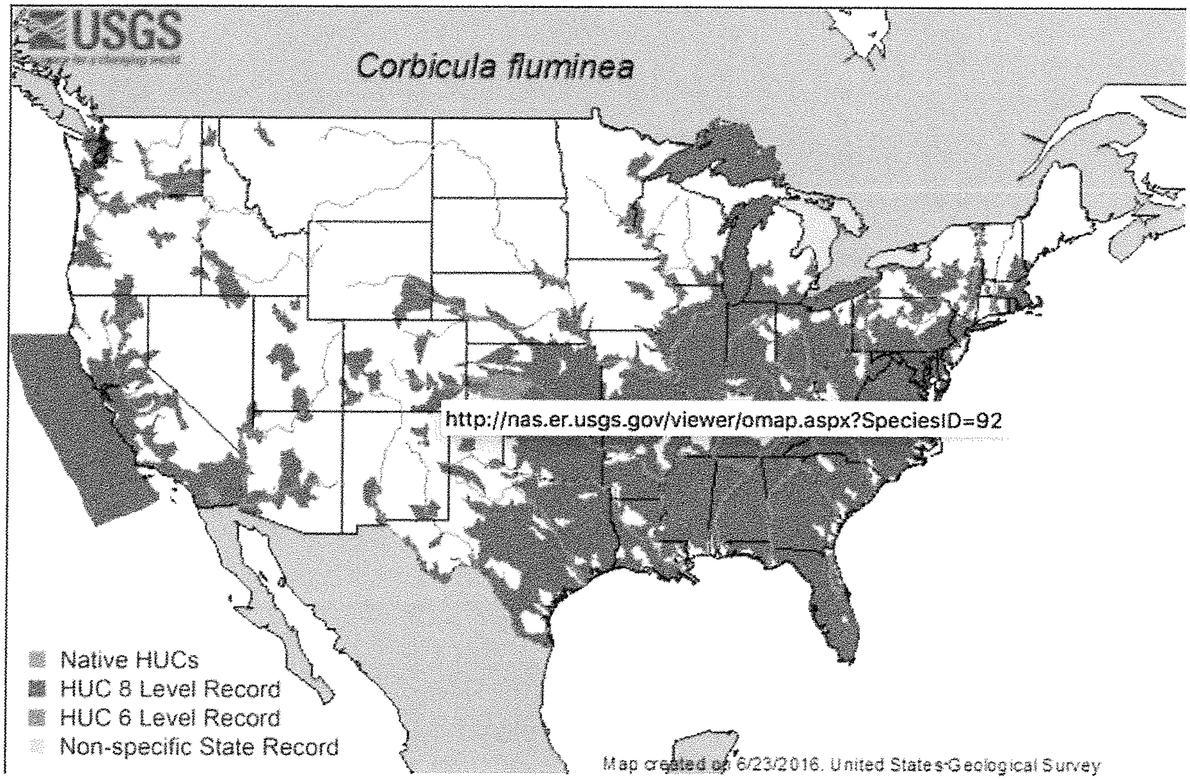

Figure 27. Prevalence of Asian clam (Corbicula fluminea) (Foster et al., 2016)

6 SUMMARY OF WATER QUALITY IMPLICATIONS ON TREATMENT & CONCLUSIONS

Following the May 12, 2016 Treatment Performance Goals Workshop, the TAC identified the following consolidated set of treatment goals for the new WTP. (Note that the goal of meeting all State and Federal drinking water regulations is not explicitly included, as this goal is understood to be a condition for obtaining a drinking water permit):

Employ Reasonably Robust Treatment Train: The treatment train should be robust to accommodate "normal" raw water quality variability, and to accommodate night-time unmanned facility operations. Plant shutdown is acceptable under extreme water quality conditions, since groundwater will remain available.

Use Proven Processes: Choose processes that are successfully operating at other plants. Demonstration testing will be required for membrane filtration, if selected.

Minimize DBP Formation: Choose disinfection and total organic carbon (TOC) removal options that result in lower DBP concentrations. Chloramines will be considered for final disinfection, but only if upstream processes are not expected to sufficiently reduce DBP formation potential.

Design for Unmanned Night Operations: Treatment process complexity and instrumentation and monitoring should be considered in meeting the goal of unmanned facility night operations.

Overall, the Tuolumne River water in the reach where the infiltration gallery is located is of excellent quality. The following parameters were identified as areas that may be treatment issues and must be considered in the upcoming sampling program and design of the SRWA WTP:

- **DBPs.** TOC concentrations indicate potential for DBP formation in excess of MCLs for TTHM (80 µg/L) and HAA5 (60 µg/L) if free chorine is used for disinfection. Additional monitoring will help validate TOC concentrations at the infiltration gallery location. Bench-scale jar testing is recommended to reduce uncertainties and aid in determining the new WTP's optimal coagulation requirements for turbidity removal, TOC removal, and DBP formation potential with both free chlorine and chloramines as possible secondary disinfectants.

- ***Cryptosporidium***. Historical data from the infiltration gallery places the source water in Bin 1. However, there is concern regarding the elevated readings at Fox Grove, immediately upstream of the infiltration gallery. The forthcoming LT2ESWTR 24-month source water monitoring program will define the SRWA's Bin classification. While it is expected the source water will be classified in Bin 1, the WTP should be designed conservatively to provide additional pathogen treatment in case the these or future sampling results place it in Bin 2.

- **Pesticides and SOCs**. Of the pesticides and SOCs detected, only 8 have pMCLs or NLs, and of those, only Diazinon and Tert-Butyl alcohol were detected above their pMCL and NL, respectively. The best treatment process to address low concentrations of pesticides and other SOCs is a combination of ozone and biologically active filtration (i.e., dual media GAC/sand filters).

- **Aesthetics**. There is potential for blue-green algae in the River and the associated taste and odor episodes, or possibly algal toxins, all of which have public acceptance and potential health implications. There are no data to confirm this assumption, however. The forthcoming monitoring plan will investigate algae occurrence. The combination of ozone and biologically active filtration is effective treatment for both T&O and algal toxins.

- **Invasive Mollusks**. While uncertain at this point, mollusks may be an issue based on the presence of Asian Clams in Modesto Reservoir and MID's experience. The potential for mollusks to pass through or accumulate in the infiltration gallery may be researched further through pilot testing.

Based on this review of historical water quality data, a detailed sampling plan was developed to better characterize the quality of the Tuolumne River at the infiltration gallery location. This monitoring data is needed both to facilitate design of the new WTP and for regulatory permitting purposes. The draft Source Water Sampling Plan was submitted to DDW by SRWA on July 21, 2016. After DDW's review, this sampling plan was approved by DDW through email received on July 25, 2016.

The detailed list of parameters included in the Source Water Sampling Plan is provided in Table B-1 in Appendix B of this TM. Based on the review of historical water quality data presented in this TM, additional monitoring is recommended—beyond what is required by DDW for permitting purposes. Whereas the monitoring defined in the DDW-approved plan will fulfill the requirements of the domestic water supply permit application for the WTP and provide information needed for process train selection and treatment system design, it does not address water quality impacts of local cattle and poultry operations or the potential for algae occurrence in the source water.

As discussed in this TM, dairy, poultry, and ranch operations are potential sources of contamination in the Lower Tuolumne River. The use of antibiotics and hormones is prevalent in animal operations, and these compounds can be flushed into the river via stormwater and irrigation runoff. Ranching operations also may introduce nitrogen compounds (e.g., ammonia, nitrate) which, under more stagnant river conditions, can promote the growth of algae. When present in a surface water supply, algae can be especially problematic due to taste and odor implications. In addition, algae and associated cyanotoxins have been increasingly on the regulatory radar, with the United States Environmental Protection Agency (EPA) including ten cyanotoxin chemical contaminants as part of their fourth and latest Unregulated Contaminant Monitoring Rule (UCMR) for water systems utilizing surface water.

Given the presence of animal operations in the project area and evidence of increased algae occurrence, monitoring for select compounds of interest in the source water is needed to understand the water quality impacts on treatment. The additional recommended parameters are highlighted yellow in Table B-1, provided in Appendix B.

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APPENDIX A – Contaminants with a Primary or Secondary MCL Under Title 22 of the California Code of Regulations

Table 64431-A
Maximum Contaminant Levels
Inorganic Chemicals

Chemical	*Maximum Contaminant Level, mg/L*
Aluminum	1.
Antimony	0.006
Arsenic	0.010
Asbestos	7 MFL*
Barium	1.
Beryllium	0.004
Cadmium	0.005
Chromium	0.05
Cyanide	0.15
Fluoride	2.0
Hexavalent chromium	0.010
Mercury	0.002
Nickel	0.1
Nitrate (as nitrogen)	10.
Nitrate+Nitrite (sum as nitrogen)	10.
Nitrite (as nitrogen)	1.
Perchlorate	0.006
Selenium	0.05
Thallium	0.002

* MFL=million fibers per liter; MCL for fibers exceeding 10 µm in length.

Table 64442
Radionuclide Maximum Contaminant Levels (MCLs)
and Detection Levels for Purposes of Reporting (DLRs)

Radionuclide	*MCL*	*DLR*
Radium-226	5 pCi/L (combined radium-226 & -228)	1 pCi/L
Radium–228		1 pCi/L
Gross Alpha particle activity (excluding radon and uranium)	15 pCi/L	3 pCi/L
Uranium	20 pCi/L	1 pCi/L

Table 64443
Radionuclide Maximum Contaminant Levels (MCLs)
and Detection Levels for Purposes of Reporting (DLRs)

Radionuclide	*MCL*	*DLR*
Beta/photon emitters	4 millirem/year annual dose equivalent to the total body or any internal organ	Gross Beta particle activity: 4 pCi/L
Strontium-90	8 pCi/L (= 4 millirem/yr dose to bone marrow)	2 pCi/L
Tritium	20,000 pCi/L (= 4 millirem/yr dose to total body)	1,000 pCi/L

Table 64444-A
Maximum Contaminant Levels
Organic Chemicals

Chemical	*Maximum Contaminant Level, mg/L*
(a) Volatile Organic Chemicals (VOCs)	
Benzene	0.001
Carbon Tetrachloride	0.0005
1,2-Dichlorobenzene	0.6
1,4-Dichlorobenzene	0.005
1,1-Dichloroethane	0.005
1,2-Dichloroethane	0.0005
1,1-Dichloroethylene	0.006
cis-1,2-Dichloroethylene	0.006
trans-1,2-Dichloroethylene	0.01
Dichloromethane	0.005
1,2-Dichloropropane	0.005
1,3-Dichloropropene	0.0005
Ethylbenzene	0.3
Methyl-*tert*-butyl ether	0.013
Monochlorobenzene	0.07
Styrene	0.1
1,1,2,2-Tetrachloroethane	0.001
Tetrachloroethylene	0.005
Toluene	0.15
1,2,4-Trichlorobenzene	0.005
1,1,1-Trichloroethane	0.200
1,1,2-Trichloroethane	0.005
Trichloroethylene	0.005
Trichlorofluoromethane	0.15
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.2
Vinyl Chloride	0.0005
Xylenes	1.750*

Table 64444-A (continued)
Maximum Contaminant Levels
Organic Chemicals

Chemical	*Maximum Contaminant Level, mg/L*
(b) Non-Volatile Synthetic Organic Chemicals (SOCs)	
Alachlor	0.002
Atrazine	0.001
Bentazon	0.018
Benzo(a)pyrene	0.0002
Carbofuran	0.018
Chlordane	0.0001
2,4-D	0.07
Dalapon	0.2
Dibromochloropropane	0.0002
Di(2-ethylhexyl)adipate	0.4
Di(2-ethylhexyl)phthalate	0.004
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Ethylene Dibromide	0.00005
Glyphosate	0.7
Heptachlor	0.00001
Heptachlor Epoxide	0.00001
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Lindane	0.0002
Methoxychlor	0.03
Molinate	0.02
Oxamyl	0.05
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated Biphenyls	0.0005
Simazine	0.004
Thiobencarb	0.07
Toxaphene	0.003
2,3,7,8-TCDD (Dioxin)	3×10^{-8}
2,4,5-TP (Silvex)	0.05

*MCL is for either a single isomer or the sum of the isomers.

Table 64449-A
Secondary Maximum Contaminant Levels
"Consumer Acceptance Contaminant Levels"

Constituents	*Maximum Contaminant Levels/Units*
Aluminum	0.2 mg/L
Color	15 Units
Copper	1.0 mg/L
Foaming Agents (MBAS)	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Methyl-*tert*-butyl ether (MTBE)	0.005 mg/L
Odor—Threshold	3 Units
Silver	0.1 mg/L
Thiobencarb	0.001 mg/L
Turbidity	5 Units
Zinc	5.0 mg/L

Table 64449-B
Secondary Maximum Contaminant Levels
"Consumer Acceptance Contaminant Level Ranges"

	Maximum Contaminant Level Ranges		
Constituent, Units	*Recommended*	*Upper*	*Short Term*
Total Dissolved Solids, mg/L or	500	1,000	1,500
Specific Conductance, μS/cm	900	1,600	2,200
Chloride, mg/L	250	500	600
Sulfate, mg/L	250	500	600

Table 64533-A
Maximum Contaminant Levels and Detection Limits for Purposes of Reporting Disinfection Byproducts

Disinfection Byproduct	Maximum Contaminant Level (mg/L)	Detection Limit for Purposes of Reporting (mg/L)
Total trihalomethanes (TTHM)	0.080	
Bromodichloromethane		0.0010
Bromoform		0.0010
Chloroform		0.0010
Dibromochloromethane		0.0010
Haloacetic acids (five) (HAA5)	0.060	
Monochloroacetic Acid		0.0020
Dichloroacetic Acid		0.0010
Trichloroacetic Acid		0.0010
Monobromoacetic Acid		0.0010
Dibromoacetic Acid		0.0010
Bromate	0.010	0.0050 0.0010[1]
Chlorite	1.0	0.020

[1] For analysis performed using EPA Method 317.0 Revision 2.0, 321.8, or 326.0

APPENDIX B – Parameters to be Sampled as Part of the SRWA Source Water Monitoring Program

The following is the list of constituents to be monitored as part of the SRWA source water monitoring program. The monitoring period will be one full year (12 months), with the exception of the required LT2ESWTR parameters (i.e., *Cryptosporidium, E. coli*, turbidity), *Giardia*, total coliform, and TOC which will be sampled monthly for two full years (24 months). Because *Giardia* and total coliform are not required parameters for LT2ESWTR monitoring compliance, the sampling frequency may be reduced during the second year.

The yellow highlighted parameters and/or collection frequencies are above and beyond what was included in the source water sampling plan approved by DDW.

Table B-1. Detailed List of Monitored Constituents

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
General Water Characteristics (Physical and Chemical)						
Alkalinity, total	--	SM 2320B	mg/L	--		m
Ammonia	--	EPA 350.1	mg/L	--		m
Bromide	--	EPA 300.0	mg/L	--		m
Calcium	--	EPA 200.7	mg/L	--		q
Chloride	sMCL	EPA 300.0	mg/L	250		q
Color	sMCL	SM 2120B	units	15		q
Dissolved Oxygen (Field Measurement)	--	--	mg/L	--		m
Foaming Agents (MBAS)	sMCL	SM 5540C	mg/L	0.5		q
Iron (total and dissolved)	sMCL	EPA 200.8	mg/L	0.3		m
Magnesium	--	EPA 200.7	mg/L	--		q
Manganese (total and dissolved)	sMCL/NL	EPA 200.8	mg/L	0.05/0.5		m
Nitrate (as N)	pMCL	EPA 300.0	mg/L	10		m
Nitrate + Nitrite (as N)	pMCL	addition	mg-N/L	10	--	m

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
Nitrite (as N)	pMCL	EPA 300.0	mg-N/L	1	0.4	m
Odor-Threshold	sMCL	SM 6040E	units	3		q
Organic Carbon, Total (TOC)	--	SM5310C	mg/L	TT	0.3	m (24 months)
Organic Carbon, Dissolved (DOC)		SM5310C	mg/L	--		m
pH	--	SM 4500-H+ B	--	--		m
pH (Field Measurement)						m
Phosphorus (total as P)	--	SM 4500-PE/ EPA 365.1	mg/L	--		q
Potassium	--	EPA 200.7	mg/L	--		q
Sodium	--	EPA 200.7	mg/L	--		q
Specific Conductance (field measurement)	sMCL	SM 2510B	µS/cm	900		m
Sulfate	sMCL	EPA 300.0	mg/L	250		q
Temperature	--	--	°C	--		m
Total Dissolved Solids (TDS)	sMCL	SM2540C	mg/L	500		q
Total Suspended Solids (TSS)	--	SM2510D	mg/L	--		q
Turbidity	pMCL/sMCL	EPA 180.1	NTU	TT/5		2x/m (24 months)
Turbidity (field measurement)	pMCL/sMCL	EPA 180.1	NTU	TT/5		m
UV-254	--	SM 5910	cm^{-1}	--		m
Inorganic Contaminants with a primary (p) or secondary (s) MCL (not included in general water characteristics)						
Aluminum	pMCL/sMCL	EPA 200.8	mg/L	1/0.2	0.05	q
Antimony	pMCL	EPA 200.8	mg/L	0.006	0.006	q
Arsenic	pMCL	EPA 200.8	mg/L	0.010	0.002	q
Asbestos	pMCL	EPA 100.2	MFL*	7	0.2	q
Barium	pMCL	EPA 200.8	mg/L	1	0.1	q

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
Beryllium	pMCL	EPA 200.8	mg/L	0.004	0.001	q
Cadmium	pMCL	EPA 200.8	mg/L	0.005	0.001	q
Chromium (Total)	pMCL	EPA 200.8	mg/L	0.05	0.01	q
Chromium-6 (Hexavalent)	pMCL	EPA 218.6	mg/L	0.010	0.001	q
Copper	pMCL/sMCL	EPA 200.8	mg/L	1.3/1.0	0.05	q
Cyanide	pMCL	SM4500CN-F	mg/L	0.15	0.1	q
Fluoride	pMCL	SM4500F-C	mg/L	2.0	0.1	q
Lead	pMCL	EPA 200.8	mg/L	0.015	0.005	q
Mercury (inorganic)	pMCL	EPA 245.1	mg/L	0.002	0.001	q
Nickel	pMCL	EPA 200.8	mg/L	0.1	0.01	q
Perchlorate	pMCL	EPA 314.0	mg/L	0.006	0.004	q
Selenium	pMCL	EPA 200.8	mg/L	0.05	0.005	q
Silver	sMCL	EPA 200.8	mg/L	0.1	0.01	q
Thallium	pMCL	EPA 200.8	mg/L	0.002	0.001	q
Zinc	sMCL	EPA 200.8	mg/L	5	0.05	q
* MFL = million fibers per liter; MCL for fibers exceeding 10 µm in length						
Organic Contaminants with a primary or secondary MCL (excludes DBPs)						
1,1,1-Trichloroethane (1,1,1-TCA)	pMCL	EPA 524.2	mg/L	0.200	0.0005	q
1,1,2,2-Tetrachloroethane	pMCL	EPA 524.2	mg/L	0.001	0.0005	q
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	pMCL	EPA 524.2	mg/L	1.2	0.01	q
1,1,2-Trichloroethane (1,1,2-TCA)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,1-Dichloroethane (1,1-DCA)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,1-Dichloroethylene (1,1-DCE)	pMCL	EPA 524.2	mg/L	0.006	0.0005	q
1,2,4-Trichlorobenzene	pMCL	EPA 524.2	mg/L	0.005	0.0005	q

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
1,2-Dichlorobenzene	pMCL	EPA 524.2	mg/L	0.6	0.0005	q
1,2-Dichloroethane (1,2-DCA)	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
1,2-Dichloropropane	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,3-Dichloropropene [1]	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
1,4-Dichlorobenzene (p-DCB)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
2,3,7,8-TCDD (Dioxin)	pMCL	EPA 1613	mg/L	3.E-08	5. E-09	q
2,4,5-TP (Silvex)	pMCL	EPA 515.4	mg/L	0.05	0.001	q
2,4-Dichlorophenoxyacetic acid (2,4-D) [1]	pMCL	EPA 515.4	mg/L	0.07	0.01	q
Alachlor	pMCL	EPA 505	mg/L	0.002	0.001	q
Atrazine	pMCL	EPA 525.2	mg/L	0.001	0.0005	q
Bentazon	pMCL	EPA 515.4	mg/L	0.018	0.002	q
Benzene	pMCL	EPA 524.2	mg/L	0.001	0.0005	q
Benzo(a)pyrene	pMCL	EPA 525.2	mg/L	0.0002	0.0001	q
Carbofuran	pMCL	EPA 531.2	mg/L	0.018	0.005	q
Carbon Tetrachloride	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
Chlordane	pMCL	EPA 505	mg/L	0.0001	0.0001	q
cis-1,2-Dichloroethylene	pMCL	EPA 524.2	mg/L	0.006	0.0005	q
Dalapon	pMCL	EPA 515.4	mg/L	0.2	0.01	q
Di(2-ethylhexyl)adipate	pMCL	EPA 525.2	mg/L	0.4	0.005	q
Di(2-ethylhexyl)phthalate (same as Bis (2-ethylhexyl)phthalate [2])	pMCL	EPA 525.2	mg/L	0.004	0.003	q
Dibromochloropropane (DBCP)	pMCL	EPA 551.1	mg/L	0.0002	0.00001	q
Dichloromethane (Methylene chloride)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
Dinoseb	pMCL	EPA 515.4	mg/L	0.007	0.002	q
Diquat	pMCL	EPA 549.2	mg/L	0.02	0.004	q

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
Endothall	pMCL	EPA548.1	mg/L	0.1	0.045	q
Endrin	pMCL	EPA 508	mg/L	0.002	0.0001	q
Ethylbenzene	pMCL	EPA 524.2	mg/L	0.3	0.0005	q
Ethylene Dibromide (EDB)	pMCL	EPA 551.1	mg/L	0.00005	0.00002	q
Glyphosate [1]	pMCL	EPA 547	mg/L	0.7	0.025	q
Heptachlor	pMCL	EPA 505	mg/L	0.00001	0.00001	q
Heptachlor Epoxide	pMCL	EPA 505	mg/L	0.00001	0.00001	q
Hexachlorobenzene	pMCL	EPA 505	mg/L	0.001	0.0005	q
Hexachlorocyclopentadiene	pMCL	EPA 505	mg/L	0.05	0.001	q
Lindane	pMCL	EPA 505	mg/L	0.0002	0.0002	q
Methoxychlor	pMCL	EPA 505	mg/L	0.03	0.01	q
Methyl tert butyl ether (MTBE)	pMCL/sMCL	EPA 524.2	mg/L	0.013/0.005	0.003	q
Molinate	pMCL	EPA 525.2	mg/L	0.02	0.002	q
Monochlorobenzene	pMCL	EPA 524.2	mg/L	0.07	0.0005	q
Oxamyl	pMCL	EPA 531.2	mg/L	0.05	0.02	q
Pentachlorophenol	pMCL	EPA 515.4	mg/L	0.001	0.0002	q
Picloram	pMCL	EPA 515.4	mg/L	0.5	0.001	q
Polychlorinated Biphenyls (PCBs)	pMCL	EPA 505	mg/L	0.0005	0.0005	q
Simazine [2]	pMCL	EPA 525.2	mg/L	0.004	0.001	q
Styrene	pMCL	EPA 524.2	mg/L	0.1	0.0005	q
Tetrachloroethylene (PCE)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
Thiobencarb	pMCL/sMCL	EPA 525.2	mg/L	0.07/0.001	0.001	q
Toluene	pMCL	EPA 524.2	mg/L	0.15	0.0005	q
Total Xylenes	pMCL	EPA 524.2	mg/L	1.750	0.0005	q
Toxaphene	pMCL	EPA 505	mg/L	0.003	0.001	q

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
trans-1,2-Dichloroethylene	pMCL	EPA 524.2	mg/L	0.01	0.0005	q
Trichloroethylene (TCE)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
Trichlorofluoromethane (Freon 11)	pMCL	EPA 524.2	mg/L	0.15	0.005	q
Vinyl Chloride	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
Disinfection By-Products						
Haloacetic acids (HAA5)	pMCL	SM 6251B	mg/L	0.060	--	q
Total Trihalomethanes (TTHMs)	pMCL	EPA 551.1	mg/L	0.080	--	q
Bromate	pMCL	EPA 317.0	mg/L	0.010	0.0010	q
Chlorite	pMCL	EPA 300.0	mg/L	1.0	0.020	q
Radionuclides with an MCL						
Gross Alpha Particle (excluding radon and uranium)	pMCL	EPA 900	pCi/L	15	3	q
Gross Beta Particle	pMCL	EPA 900	mrem/yr	4	4	q
Radium-228 and -226 (combined)	pMCL	GA Method	pCi/L	5	1 for each	q
Strontium-90	pMCL	EPA 905	pCi/L	8	2	q
Tritium	pMCL	EPA 906	pCi/L	20,000	1,000	q
Uranium	pMCL	EPA 200.8	pCi/L	20	1	q
Microbiological						
Cryptosporidium	pMCL	EPA 1623	oocysts/L	TT	--	m (24 months)
E. coli	pMCL	SM 9223F	MPN/100mL	TT	--	2x/m (24 months)
Giardia	pMCL	EPA 1623	cysts/L	TT	--	m (24 months)

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
Total Coliform	pMCL	SM 9223B	MPN/100mL	TT	--	2x/m (24 months)
Applied in Watershed - Unregulated, High-Use Pesticides (>5,000 lbs/yr)						
Chloropicrin	aNL	551.1	mg/L	0.05	--	q
Chlorothalonil	HA (1-day)	525.2	mg/L	0.2	--	q
Methyl Bromide	CCL3, CCL4	524.2	--	--	--	q
Oxyfluorfen	CCL3, CCL4	525.2	--	--	--	q
Paraquat Dichloride	HA (1-day)	549.2	mg/L	0.1	--	q
Pendimethalin	none	525.2	mg/L			q
Additional Unregulated Pesticides Applied in the Watershed, with a Health Advisory Level or Considered for Future Regulation						
Acephate	CCL3, CCL4	LCMS-MS		--	--	q
Carbaryl	aNL	531.2	mg/L	0.7	--	q
Dimethoate	aNL	525.2	mg/L	0.001	--	q
Diuron	HA (1-day); CCL4	EPA 532	mg/L	1	--	q
Hexazinone	HA (1-day)	EPA 525.2	mg/L	3	--	q
Methomyl	HA (1-day)	531.2	mg/L	0.3	--	q
Metolachlor [2]	UCMR2; HA (1-day)	525.2	mg/L	2	--	q
Permethrin	CCL3, CCL4	525.2		--	--	q
Tebuconazole	CCL3, CCL4	LCMS-MS		--	--	q
Thiamethoxam	UCMR3	LCMS-MS		--	--	q
Thiophanate-Methyl	CCL4	LCMS-MS		--	--	q
Ziram	CCL4	630.1		--	--	q
Additional SOCs Reported in Historical Data						
Diazinon	aNL; HA	EPA 525.2	mg/L	0.0012	--	q

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]
Tertiary butyl alcohol (TBA)	NL	EPA 524.2	mg/L	0.012	--	q
Chlorpyrifos (Dursban)	UCMR4; HA	525.2	mg/L	0.03	--	q
EPTC	UCMR1	525.2		--	--	q
Malathion	aNL; HA	525.2	mg/L	0.16	--	q
Trifluralin	HA (1-day)	525.2	mg/L	0.08	--	q
Select Additional Unregulated Constituents of Interest						
1,2,3-Trichloropropane (1,2,3-TCP)	Forthcoming pMCL, NL	EPA 524.2	mg/L	5.00E-06	5.00E-06	q
Additional Unregulated Constituents of Interest Related to Dairy, Poultry and Ranch Operations						
17-β-estradiol	UCMR3, List 2	EPA 539	ng/L			q
17-α-ethynylestradiol	UCMR3, List 2	EPA 539	ng/L			q
Estriol	UCMR3, List 2	EPA 539	ng/L			q
Equilin	UCMR3, List 2	EPA 539	ng/L			q
Erythromycin	CCL3, CCL4	LC-MS-MS	ng/L			q
Estrone	UCMR3, List 2	EPA 539	ng/L			q
Testosterone	UCMR3, List 2	EPA 539	ng/L			q
4-androstene-3,17-dione	UCMR3, List 2	EPA 539	ng/L			q
Select Additional Unregulated Constituents of Interest Related to Algae Occurrence						
Algae Identification	--	Flow Cam	ng/L			q
Algae Enumeration	--	Flow Cam	ng/L			q
Chlorophyll A	--		ng/L			q
Microcystins Screen	UCMR4	ELISA	ng/L			2x/y
Cyanotoxins (Microcystins, Nodularin)	UCMR4	EPA 544	ng/L			2x/y
Cyanotoxins (Anatoxin, Cylindrospermopsin)	UCMR4	EPA 545	ng/L			2x/y

Parameter[4]	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3,4]

Footnotes:

[1] Also a high-use pesticide in this watershed.

[2] Also measured during prior water sampling.

[3] m=monthly; q-quarterly, 2x/m=twice per month; 2x/y=twice per year

[4] Highlighted constituents represent additional monitoring, either parameter of sampling frequency, beyond what was included in the source water sampling plan submitted to DDW. DDW accepted the proposed sampling plan in an email from Tahir Mansoor to Michael Brinton, dated July 25, 2016.

TT = Treatment Technique
pMCL = Primary Maximum Contaminant Level
sMCL = Secondary Maximum Contaminant Level
NL = DDW Notification Level
aNL = DDW Archived Notification Level
UCMR = Unregulated Contaminant Monitoring Rule
CCL = EPA's Contaminant Candidate List
HA = EPA Health Advisory Level

SRWA
Stanislaus Regional Water Authority

Item 7D
Board Synopsis
September 22, 2016

From: West Yost Program Management Team

Prepared by: Andy Smith, West Yost Associates

1. **ACTION RECOMMENDED:**

Motion: Accepting the Technical Memorandum dated September 6, 2016 – recommendation to further evaluate the candidate treatment trains presented in the Available Treatment Process Alternatives Technical Memorandum 1, Part 1.

2. **DISCUSSION OF ISSUE:**

As part of the Quick Start Plan, the TAC and Project Management (PM) Team have begun the process of identifying and evaluating available water treatment processes for the SRWA Surface Water Supply Project. The Available Treatment Process Alternatives Technical Memorandum (TM) 1, Part 1, which was finalized on September 6, 2016, includes the initial identification and comparison of potential treatment alternatives available to SRWA, and is intended to help the TAC screen options and narrow the field of candidate processes. The TAC and PM Team intend to prepare an additional TM (TM 1, Part 2) in the coming months, following completion of optional bench-scale testing necessary to fill information gaps identified in TM 1, Part 1. In turn, another future TM will be prepared that incorporates feasibility-level cost estimates for the preferred treatment alternatives.

A summary of the major discussion topics, as well as an outline of findings, is provided below. The complete TM is also attached.

Drivers for Treatment Process Evaluation

Several drivers are expected to shape the TAC's ongoing evaluation of treatment process alternatives, including potential contamination sources and source water quality (presented in the Tuolumne River Historical Water Quality Assessment TM), conformance to treatment performance goals (presented in the Treatment Performance Goals TM) and input from the Division of Drinking Water (DDW).

Treatment Process Alternatives

All available treatment processes may be subdivided into three general treatment steps:

- *Pretreatment* for removal of grit, sand and silt. Given that the Tuolumne River generally has very low turbidity, and that the existing infiltration gallery is expected to provide some removal of particulate matter, separate pretreatment is not anticipated for this Project.

- *Clarification and Filtration* for removal of particulate matter, organic carbon, and pathogens. A variety of clarification and filtration options may be available to this Project, including direct filtration (which skips an intermediate sedimentation step), conventional filtration (which includes sedimentation and generally utilizes granular media filters) and membrane filtration.

- *Disinfection* for inactivation of pathogens and establishment of a disinfectant residual in the distribution system(s). Feasible disinfection alternatives include the use of free chlorine, ozone or ultraviolet radiation for primary disinfection (i.e., inactivation of pathogens) and free chlorine or chloramines for secondary disinfection (i.e., for establishment of a disinfectant residual).

Summary of Treatment Alternatives
Following a detailed presentation of the applicability, advantages and disadvantages of different methods for achieving the treatment steps above, a total of five (5) candidate treatment trains have been identified for further evaluation.

- *Option A*: Direct filtration, granular media filters and primary disinfection with free chlorine, ultraviolet radiation, or both. (No ozone).
- *Option B*: Direct filtration, membrane filters and primary disinfection with free chlorine, ultraviolet radiation, or both. (No ozone).
- *Option C*: Conventional treatment with granular media filters and primary disinfection with free chlorine, ultraviolet radiation, or both. (No ozone).
- *Option D*: Direct filtration with ozone and biologically active granular media filters.
- *Option E*: Conventional treatment with ozone and biologically active granular media filters.

Of the five candidate trains above, Option E would provide the most robust treatment.

Information Gaps
Certain critical information will be necessary to further evaluate the candidate trains listed above. Some of this information will be obtained through the course of planned raw water sampling, and some could be obtained through optional bench-scale testing activities:

- Information to be obtained through planned raw water quality sampling:
  - Total organic carbon (TOC) concentrations
  - Pesticide concentrations
  - Algae-related taste and odor levels and/or toxins

- Information obtainable through optional bench-scale testing:
  - Infiltration gallery particulate matter removal performance

- Ability to remove TOC through "enhanced coagulation" (available to Options C and E above)
- Optimum dose and location for ozone addition

Narrowing of Viable Alternatives
To further refine the field of five candidate treatment trains summarized above, the TAC and PM team have considered two primary questions:

1) *Should the Project utilize ozone and biologically active filters, or avoid ozone and biologically active filters?* Ozone provides effective treatment for TOC, pesticides and synthetic organic compounds, and compounds which can cause undesirable tastes and odors. Ozone is generally followed by biologically active filters, which aid in the breakdown of compounds treated by ozone. As such, the combination of ozone and biologically active filters provides considerable enhanced treatment capabilities and robustness. However, including ozone in the treatment train is expected to add 8-10% to the capital cost of the facility.
2) *Should the Project utilize direct filtration or conventional treatment?* Direct filtration eliminates a sedimentation step and thereby could eliminate a treatment structure, which would reduce capital costs of the overall treatment plant. However, the ultimate feasibility of direct filtration will strongly depend on whether or not the turbidity of the influent water (after passing through the infiltration gallery) is low enough, and whether or not enough TOC can be removed without a sedimentation step to comply with disinfection byproduct limits.

3. FISCAL IMPACT / BUDGET AMENDMENT:

The five candidate treatment trains identified in the TM provide the range of treatment options which can adequately meet the water treatment goals and objectives adopted by the SRWA Board. More robust treatment trains will probably increase project costs, and less robust treatment trains might not meet the SRWA's treatment goals and objectives.

However, the identified optional bench-scale testing to identify what the optimum ozone dosages should be for our source water, and the optional bench-scale testing to assess the ability of a direct filtration plant to removal adequate amounts of TOC would be extremely valuable to conduct now, as part of other on-going raw water sampling and analysis. This optional work will have additional costs, and these additional costs will be developed and brought forward for Board discussion and decision at a future Board meeting.

4. INTERIM GENERAL MANAGER'S COMMENTS:

Supports moving forward with the continued evaluation of treatment trains utilizing ozone and biologically active filters (Options D and E), as well as the continued evaluation of the feasibility of direct filtration (Option D). Discussion and recommendations regarding optional bench-scale testing are to be provided under a separate staff report in the future.

5. **ENVIRONMENTAL DETERMINATION:** N/A

6. **ALTERNATIVES:**

A. See previous discussion under Fiscal Impact/Budget Amendment.

TECHNICAL MEMORANDUM

Stanislaus Regional Water Authority Water Supply Project Treatment Process Alternatives

Draft Date: August 12, 2016
Final Date: **September 6, 2016**

To: Stanislaus Regional Water Authority (SRWA)

Authors: Elaine W. Howe, P.E. (Trussell Technologies)
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Subject: Treatment Process Alternatives, TM 1, Part 1

1 - INTRODUCTION

The Stanislaus Regional Water Authority (SRWA) is planning to construct a new surface water treatment plant (WTP) to provide a new, supplemental drinking water supply to the cities of Ceres and Turlock (Cities). As part of the process of identifying the preferred treatment train for SRWA's new WTP, two workshops were scheduled and two Technical Memoranda (TM) were requested to discuss viable treatment options. The first workshop was held June 30, 2016 and included a robust discussion of treatment technologies and processes. The second workshop will be held after the list of candidate treatment processes has been narrowed to one or two preferred trains and feasibility level cost estimates have been developed.

The original intent of TM 1 was to provide descriptions and comparisons of potential treatment train alternatives—incorporating results from the pilot infiltration gallery testing, disinfection byproduct (DBP) modeling and other (optional) bench scale tests—to help screen treatment alternatives and narrow the field of candidate processes. After initial review of historical water quality data, identification of the SRWA's Technical Advisory Committee (TAC) performance goals for the WTP, and initial discussions with the Division of Drinking Water (DDW), it seemed prudent to prepare this TM 1 in two parts. TM 1, Part 1 (this document) will provide a description of the candidate treatment processes, a summary of the June 30, 2016 workshop, and will identify information gaps that can and/or should be addressed prior to completing the evaluation of candidate treatment processes. TM 1, Part 1 is organized as follows:

- Introduction (this section)
- Driver for Treatment Process Evaluation
- Treatment Process Alternatives
- Summary of Treatment Alternatives
- Information Gaps
- Decision Points Necessary to Refine Field of Available Alternatives
- Recommendations and Next Steps

TM 1, Part 2 will be an update of TM 1, Part 1 and will include results from bench-scale and/or pilot-scale tests and all additional information gathered to fill the gaps and allow refinement of the list of candidate alternatives. Depending on guidance from the TAC, it may be possible to narrow the field of alternatives prior to filling all the information gaps. Some of the additional information needs may be more for the purpose of defining design criteria and estimating operation and maintenance (O&M) costs than for process train selection. The second TM will add feasibility-level estimates of capital and O&M costs for the preferred treatment train(s).

2 - DRIVERS FOR TREATMENT PROCESS EVALUATION

This section provides an overview of the drivers expected to shape the TAC's evaluation of treatment process alternatives. The following subtopics are discussed below:

- Potential Contamination Sources
- Source Water Quality
- Treatment Performance Goals
- DDW Input

2.1 Potential Contamination Sources

Several potential sources of contamination were identified in the Turlock Irrigation District's (TID's) Watershed Sanitary Survey (WSS) of the Lower Tuolumne River and Turlock Lake (Brown and Caldwell, 2008), and online visual searches using Google Earth (US Dept. of State Geographer © 2016 Google) between La Grange Dam and the infiltration gallery. The following are the main potential contamination sources, with locations indicated in Figure 1:

- City of Waterford Wastewater Treatment Plant (WWTP). This is the only municipal WWTP in this reach of the River that could impact water quality at the infiltration gallery site; the remainder of the study area uses septic systems for wastewater disposal. The effluent from the storage ponds is pumped across the Tuolumne River (South side), to four drying beds/percolation basins. As of 2006, the facility met existing requirements of the Central Valley Regional Water Quality Control Board, but upgrades were needed to meet secondary treatment standards and future discharge standards (City of Waterford, 2006).

- Dairy, Poultry and Ranching Operations[1]. There are a number of dairy, poultry, and ranching operations located near the bank of the River. Potential contaminants from these operations include microbial pathogens (e.g., coliforms, *E. coli*, etc.), nitrogen compounds (e.g., ammonia, nitrate) that may potentially promote algae growth in stagnant reaches, and antibiotics and hormones that may be present at the animal operations.

- Geer Road Landfill. The Geer Road Landfill, which is closed now, is located directly across the river from the site of the infiltration gallery. As discussed in the 2008 TID WSS, although there are no active solid waste or hazardous waste disposal facilities within the study area, this closed landfill continues to be regulated by RWQCB waste discharge requirements during its closure (Brown and Caldwell, 2008). Results from the Second Semiannual and Annual 2015 Detection, Evaluation and Corrective Action Monitoring Report do not indicate degradation of the Tuolumne River from the landfill site (Tetra Tech BAS, January 2016).

- Recreational Areas: There are several recreational areas nearby and in the upper reaches of the Lower Tuolumne watershed, including La Grange Off-Highway Vehicle Use, Basso Bridge River Access, Turlock Lake State Recreational Area, and Fox Grove County Park.

- Pesticide and Herbicide Application to Agricultural Areas[1]: Given the large percentage of the watershed dedicated to agriculture, stormwater and irrigation runoff from these areas is a known source of contamination to the River. The Lower Tuolumne River, downstream of Don Pedro Reservoir, is listed as an impaired water body under USEPA Clean Water Act Section 303(d) (California State Water Resources Control Board, 2010). This designation is discussed in more detail in Section 2.2.

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[1] According to the United States Department of Agriculture (USDA, 2012), Stanislaus County ranks 7th among California's 58 counties in total value of agricultural products sold, 4th in value of livestock, poultry, and their products, and 3rd in value of sales for both poultry and eggs, as well as milk from cows (4th overall in the United States). In addition to livestock, the top three crops, in terms of land area, grown locally include almonds (3rd in the state and U.S.), forage land (hay and haylage, grass silage, and greenchop; 10th in the state and 84th in the U.S.), and corn for silage (3rd in the state and 4th in the U.S.). In terms of land use, approximately 50% of the county's farmland is pastureland and 44% is cropland.

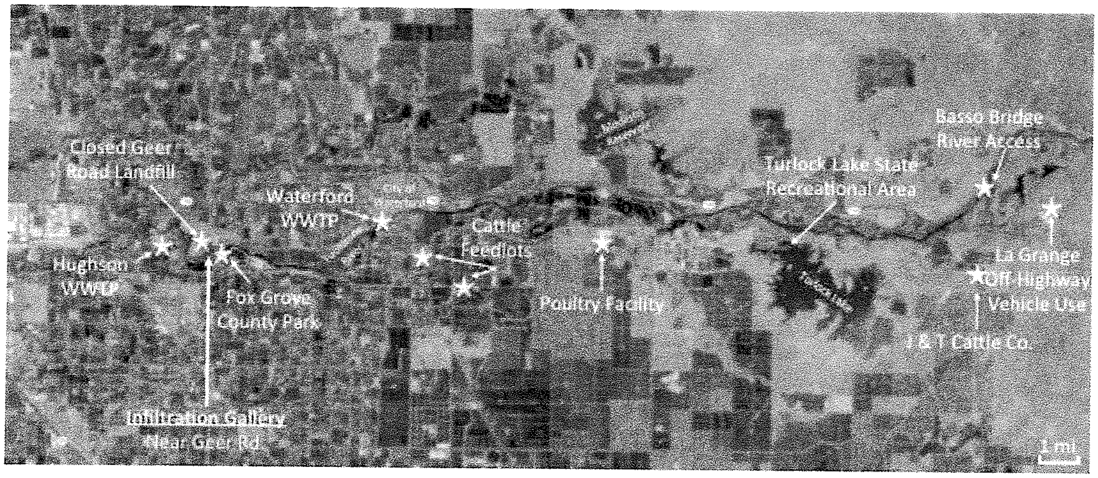

Figure 1. Potential Sources of Contamination in Project Vicinity

2.2 Source Water Quality

As part of the source water characterization process, historical water quality data collected on the Tuolumne River at locations between Don Pedro Reservoir and the confluence of Dry Creek at Modesto were reviewed. The sampling locations and monitoring agencies for the historical data have been presented elsewhere, in the Source Water Quality Assessment TM (Trussell Technologies, September 2016) and the Draft Source Water Characterization Sampling Plan for the SRWA Surface Water Supply Project (Trussell Technologies, July 2016) (Sampling Plan), and are not repeated here. Key points about water quality parameters that are drivers for process train selection are summarized below.

Turbidity. While limited to the period between May 2006 and April 2008, the historical turbidity data collected at the infiltration gallery site, are low—consistently less than 10 NTU. A plot of these turbidity data from the infiltration gallery location along with data from two upstream locations are shown in Figure 2. There is no apparent seasonal fluctuation and it is difficult to tell if or how much the turbidity increases in response to storm events or releases from Don Pedro Reservoir, but the amount of data is limited. Additionally, filtration through the rock and gravel media above the infiltration gallery is expected to reduce storm related turbidity spikes, should they occur in the river. SRWA may decide to test a pilot filter column containing media representative of the cover over the infiltration gallery to evaluate changes in turbidity under ambient and simulated high turbidity conditions. Refer to Section 5 of this TM for further discussion of optional pilot- and bench-scale tests.

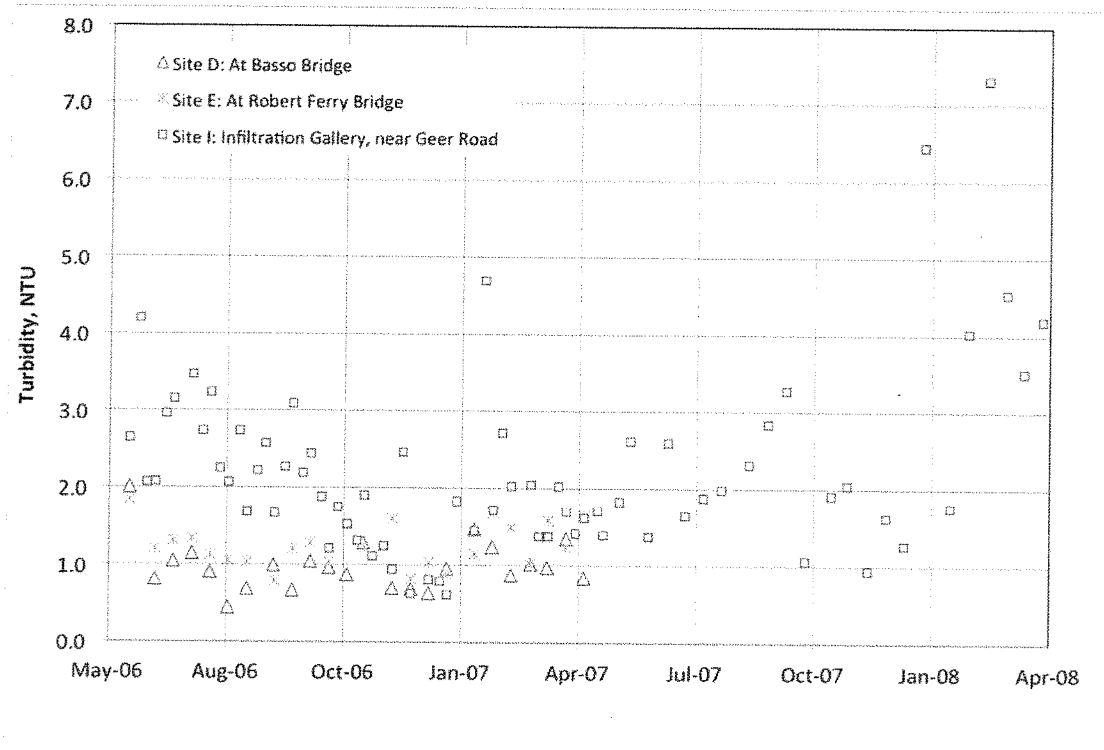

Figure 2. Turbidity of the Tuolumne River Sites D (Basso Bridge), E (Robert Ferry Bridge), and I (Infiltration Gallery) Based on Data from TID's 2008 Watershed Sanitary Survey.

Total Organic Carbon (TOC). Based on historical data, the average TOC concentration at the infiltration gallery is somewhat higher than at upstream and downstream locations. The average concentration at the infiltration gallery was 3.3 mg/L (ranging from 1.4 mg/L – 6.5 mg/L) versus 2.9 mg/L at Robert Ferry Bridge approximately 14 river miles upstream, and 1.7 mg/L at Mitchell Road downstream near Modesto. The concentrations reported at the infiltration gallery location are high enough that DBP formation will be a concern with free chlorine unless TOC reduction is achieved during treatment. According to the 2008 TID pilot report, total trihalomethane (TTHM) formation in samples of raw water (using a 3 mg/L chlorine dose) was close to 100 micrograms per liter (µg/L), and well above the regulatory limit of 80 µg/L.

TOC concentrations reported at the infiltration gallery location seem uncharacteristically high and variable, as shown in Figures 3 and 4. In order to obtain a better understanding of the TOC levels at this location, and potentially to characterize seasonal and storm related influences, TOC will be measured monthly as part of the source water monitoring program, expected to start during the fall of 2016.

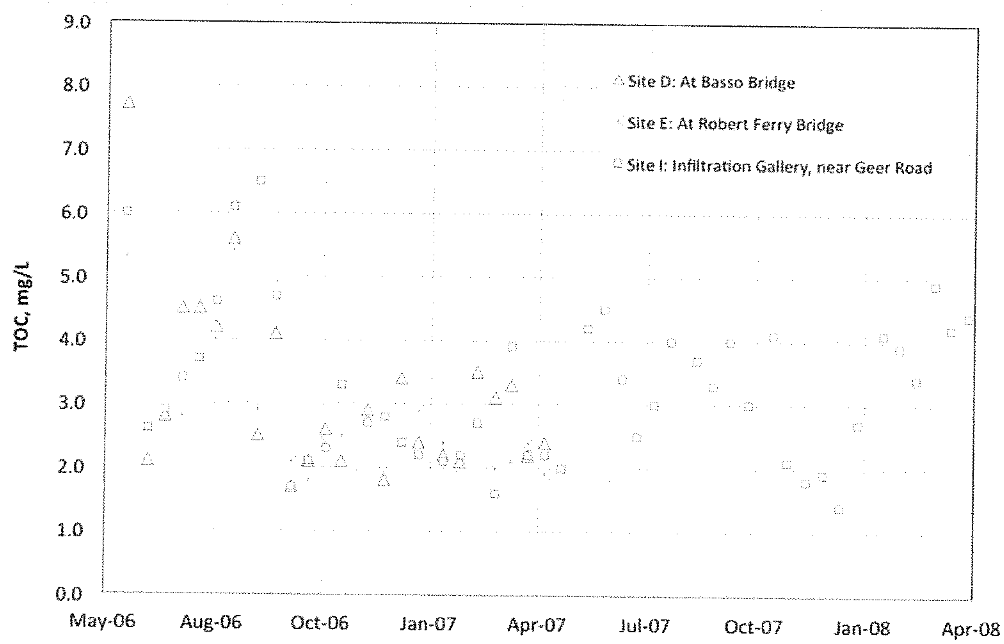

Figure 3. TOC Concentrations of the Tuolumne River at Sites Between La Grange Dam and the Infiltration Gallery Location

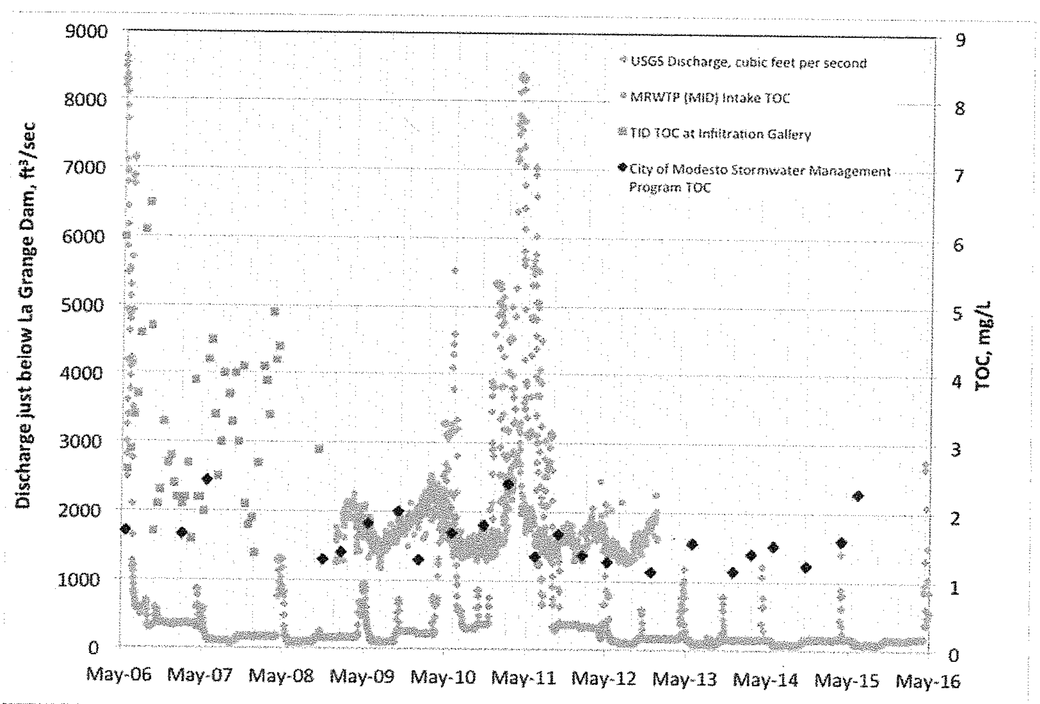

Figure 4. TOC of Modesto Reservoir, the Tuolumne River at the Infiltration Gallery Location, and Downstream of Modesto near Mitchell Road as a Function of River Flows

Ammonia, Nitrite, and Nitrate. The nitrate levels measured in the study area reflect the presence of upstream cattle and poultry facilities, and possibly the City of Waterford's WWTP percolation ponds. Ammonia (NH_3) and nitrite (NO_2) concentrations at the infiltration gallery location were below detection, but nitrate (NO_3) concentrations were measured between 1.3 mg/L and 3.8 mg/L as NO_3 (Figure 9). Nitrate concentrations at the upstream Basso Bridge and Roberts Ferry Bridge sites were below the detection level. These nitrate concentrations measured at the infiltration gallery location are not a regulatory or health concern and nowhere near the primary maximum contaminant level (pMCL) of 45 mg/L as NO_3. They are, however, indicative of the potential for biological and algae growth in stagnant areas of the river, along with the potential for taste and odor occurrences often associated with algal blooms. During a June 29, 2016 meeting with SRWA, DDW noted recent increased impacts to water quality due to algae in locations where algae have not been previously observed. Additionally, MID offered that ozone was included in their WTP treatment train to provide treatment for tastes and odors (T&O).

Pesticides and Other Synthetic Organic Chemicals (SOCs). The Lower Tuolumne River Watershed (downstream of Don Pedro Reservoir) is a large agricultural area with several pesticides applied to crops throughout the year (as spray or fumigants) and is listed as an impaired water body under USEPA Clean Water Act Section 303(d) (California State Water Resources Control Board, 2010). This designation is largely due to the presence of several pesticides, including chlopyrifos, diazinon, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane - including lindane, endosulfan, and toxaphene), as well as pollution from mercury, warm water, and an unknown toxicity. As of 2014, total maximum daily loads (TMDLs) were established by the California Regional Water Quality Control Board Central Valley Region to limit diazinon and chlorpyrifos in the San Joaquin River and Sacramento River basins.

There are only limited historical data for pesticides in the Tuolumne River, with the most recent being collected between 2005 and 2008. The pesticides measured in the river between 1995 and 2008 are shown in Table 1. The pesticides with an enforceable regulatory limit are shown in blue font, and those measured above the limit are shown in red font. In addition, the California Department of Pesticide Regulation's (CDPR's) Pesticides Use Reporting (PUR) database indicates there were 19 pesticides applied in the Lower Tuolumne River Watershed at a high application rate—greater than 5,000 lbs/year or greater than 10,000 acres per year. So, it is a distinct possibility that the source water for the SRWA's WTP will contain low levels of pesticides or other organic contaminants.

There are also several cattle feedlots and poultry operations along the river in the Lower Tuolumne River Watershed, where hormones and/or antibiotics may be used and may be potential contaminants [this is an assumption and not based on monitoring data].

Table 1. Historical Dataset of Pesticides Measured in the Tuolumne River

Location	Year	Pesticides Detected	Con-centration (µg/L)	Regulatory List	MCL/NL (µg/L)
Between La Grange Dam and Modesto	1995	Diazinon Napropamide Simazine Chlorpyrifos (Dursban) Chlorthal-dimethyl Trifluralin	0.003 – 0.04 0.024 0.069 – 0.22 0.007 – 0.021 0.003 – 0.013 0.007	- NL - None - Primary MCL - UCMR4 - EPA HA - EPA HA	1.2 -- 4 -- -- --
Waterford LM Spill; Regional Board Irrigation Lands Monitoring site code: 535MIDWFS	2005 - 2008	Diuron Glyphosate Isoxaben Norflurazon Oryzalin Prodiamine	1.2 – 860 8.1 – 20 5.5 – 9.7 0.084 – 1.4 24 – 170 0.47 – 1.3	- EPA HA; CCL3 - Primary MCL - None - None - None - None	-- 700 -- -- -- --
Between La Grange Dam and Modesto	?	Chlorpyrifos (Dursban) Chlorthal-dimethyl Diazinon Malathion Metolachlor Napropamide Simazine	0.04 – 0.032 0.002 – 0.012 0.003 – 2.9 0.031 – 0.16 0.003 – 0.02 0.017 – 0.059 0.038 – 2.2	- UCMR4 - EPA HA - NL - aNL - UCMR2 - None - Primary MCL	-- -- 1.2 160 -- -- 4
Fox Grove County Park	2007-2008	2,4-Dichlorophenylacetic acid 3,4-Dinitrotoluene Bis(2-Ethylhexyl) Phthalate EPN (ENT) N-Nitrosopyrrolidine Tert-Butyl alcohol (TBA)	0.634 – 3.6 12.2 – 24.2 3.7 1.26 – 3.01 0.009 150	- None - None - Primary MCL - None - None - NL	-- -- 4 -- -- 12

<u>Total Coliform and *E. coli*.</u> The median total coliform concentration at the infiltration gallery location (between May 2006 and October 2008) was 130 MPN/100mL, based on 73 data points. Higher total coliform concentrations were reported both upstream and downstream, but with substantially smaller datasets. The median concentration at Waterford Road (5.7 miles upstream) was 1,733 MPN/100mL, and the median concentration at Ceres River Bluff Park (7 miles downstream) was 2,076 MPN/100mL.

The median *E. coli* concentration at the infiltration gallery location was 12.7 MPN/100mL. Higher *E. coli* levels were measured upstream and downstream of the infiltration gallery location, but again with significantly fewer data points.

The required level of disinfection will be determined from source water monitoring for *Cryptosporidium* as required by the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), and source water total coliform and *E. coli* concentrations. DDW will use the total coliform and *E. coli* data to potentially require additional *Giardia* and virus treatment. Considering that multi-barrier treatment is required under the Surface Water Treatment Rule (SWTR), the selected treatment train will include both filtration and disinfection treatment. Regardless of the specific processes selected, the combination of filtration and disinfection is expected to provide sufficient credit for pathogen removal/ inactivation. Thus, pathogen concentrations in the source water likely will not be a driver for process train selection, but will become important when design criteria for the new WTP are discussed. The SWTR regulations are discussed further in a separate TM, which provides an assessment of the project source water quality (Trussell Technologies, September 2016).

Asian Clams. Asian clams (*Corbicula fluminea*) are considered an invasive mollusk and are widespread through parts of central and southern California (Figure 5). The clams are generally found at sediment surfaces or slightly buried in sediment. Unlike other invasive mollusks, notably Quagga and zebra mussels, Asian clams do not adhere to rock or other hard surfaces (e.g., pipe walls).

Modesto Reservoir has been found to contain Asian clams and MID has routinely encountered the clams within their WTP. In the membrane filtration portion of their WTP, MID has noted the potential for damage to the membranes due to broken clam shell fragments. In the conventional treatment portion of their WTP, MID has found that ozone effectively kills the clams; no shells have been found downstream of the ozone contactor.

It is unknown at this time whether Asian clams are present in the Tuolumne River downstream of the Don Pedro Dam, or whether they are only found in Modesto Reservoir. If the clams are in the Tuolumne River, it is unknown whether the infiltration gallery intake for the WTP will be able to remove small enough sized particles to remove Asian clam larvae[2]; this question should be answered if the TAC elects to conduct a pilot filter column test. Refer to Section 5 of this TM for further discussion of optional pilot- and bench-scale tests.

Regardless, given MID's experience, the design for SRWA's WTP should consider provisions to remove clam shells from the infiltration gallery piping, raw water pump station wet well and WTP treatment basins. If membrane filtration is a selected candidate treatment alternative, adequate protection should be provided to keep the clams and shells from the membrane system.

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[2] Asian clam larvae range in size from 0.25 mm to about 1.5 mm. (New York Invasive Species Information, http://www.nyis.info/?action=invasive_detail&id=52). The aperture of the existing infiltration gallery screens is 0.060 inches, or 1.524 mm.

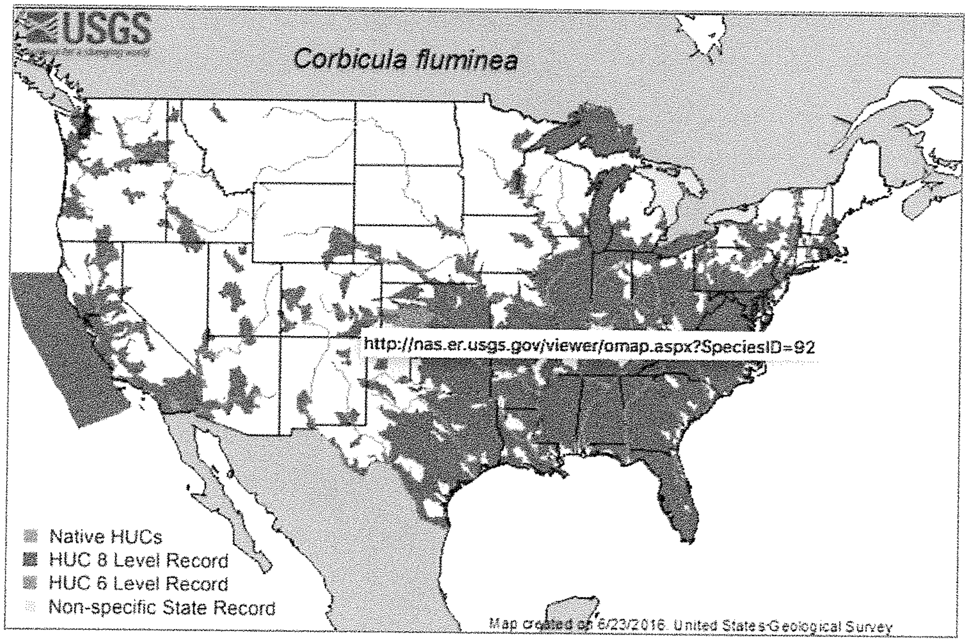


Figure 5. Occurrence of Asian Clams in the United States (USGS, http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=92)

2.3 Treatment Performance Goals

A summary of the treatment performance goals developed by the TAC for the new WTP are shown in Table 2. The discussion for this TM is focused on performance goals related to water quality, specific treatment goals, as well as narrowing the field of alternative treatment processes. The relevant performance goals from Table 2 will be integrated into the discussion of which alternative treatment processes are viable for further consideration and which should be ruled out early in the evaluation process. A more detailed listing of the treatment performance goals identified by the TAC is available in the Treatment Performance Goals TM (Trussell Technology, July 2016) prepared following the May 12, 2016 Workshop.

Table 2. Summary of SRWA Treatment Performance Goals for the New WTP

Treatment Performance Goals	TAC Importance Ranking[A]
Meet drinking water regulations with room for comfort	5
Minimize DBP formation	5
Use proven processes (Demonstration testing required for membranes)	5
Provide a reasonably robust process	5
Design for unmanned night operations	4
Consider processes that reduce aesthetic concerns (e.g., red water, tastes and odors)	5

Treatment Performance Goals	TAC Importance Ranking[A]
Treat pesticides, pharmaceuticals, and other synthetic organic chemicals (SOCs) if they appear in the raw water	3
Design for future unknown regulations	2
[A] Importance Factor: 5 = Most Important, 1 = Least Important	

2.4 DDW Input

On June 29, 2016, representatives of SRWA, West Yost Associates and Trussell Technologies met with DDW to (a) introduce the SRWA Surface Water Supply Project, (b) discuss preliminary information from a review of historical water quality and (c) present the proposed source water monitoring plan. During this meeting, DDW expressed viewpoints about preferred treatment processes. It should be noted that these viewpoints are not regulations, and the SRWA must be able to justify the "preferred" treatment train based on technical merit and cost considerations, among others, and not strictly on DDW input. As the permitting entity, however, DDW's input should be carefully considered. The following is a brief summary of key DDW input from the June 29, 2016 meeting with DDW:

- DDW discourages the use of direct filtration and stated a preference for conventional treatment.
- DDW may require higher levels of disinfection treatment for *Giardia* and viruses, depending on source water sampling results for total coliform and *E. coli*.
- If membrane filtration (MF) is a recommended treatment option, DDW recommends including pretreatment with sedimentation prior to MF.
- Disposal of the clean-in-place chemicals used for cleaning the MF membranes must be considered because DDW will not allow this waste stream to be returned to the influent for blending with the raw water.
- DDW expressed a preference for ozone for primary disinfection, due to its disinfection capabilities, reduced DBP formation (with free chlorine), and treatment for algae by-products and related T&O compounds.
- DDW discouraged the use of chloramines for secondary disinfection, due in part to the added complexity of incorporating chloramines to groundwater wells in the distribution system.
- DDW has noted recent increased negative impacts to water quality due to algae, in locations where algae has not been previously observed.
- Granular media filter re-rating to a higher rate (i.e., above the initial rate of 6 gallons per minute per square foot), based on performance demonstration, is an option for future increases in plant capacity.

3 - TREATMENT PROCESS ALTERNATIVES

This Section presents a logical progression of the various alternatives available for surface water treatment. It is the same progression presented during the June 30, 2016 Treatment Process Alternatives workshop. Each of the following subsections includes process descriptions, applicability information, advantages and disadvantages:

- Typical Treatment Steps in Surface Water Treatment
- Pretreatment
- Clarification and Filtration
- Disinfection

3.1 Typical Treatment Steps in Surface Water Treatment

A typical surface water treatment train includes the following steps:

1. **Pretreatment** for grit, sand and silt removal
2. **Clarification** using a coagulant (e.g., ferric chloride, aluminum sulfate, polyaluminum chloride) for removing particulate matter and organic carbon
3. **Filtration** for additional particulate matter and pathogen removal
4. **Primary disinfection** for pathogen inactivation (e.g., Giardia, viruses)
5. **Secondary disinfection** to maintain a disinfectant residual throughout the distribution system to prevent bacteria regrowth in distribution system piping

Examples of process options for each of the above treatment steps are shown in Figure 6, and discussed in greater detail below.

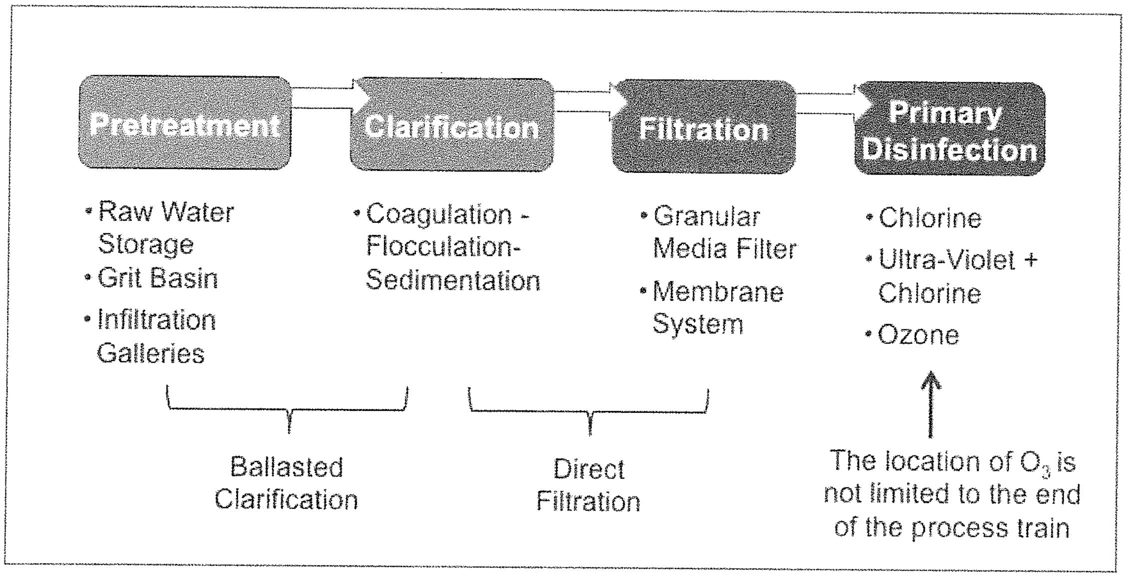


Figure 6. Typical treatment steps in surface water treatment (Note, direct filtration does not include sedimentation)

3.2 Pretreatment

The required degree of pretreatment for a given surface water depends on its average particulate concentration (measured as turbidity), the size of the suspended particles and the variability of particulate concentrations. Some waters, particularly rivers, are "flashy" and exhibit pronounced storm- and runoff-related high turbidity levels that can increase chemical demands and overload the clarification basins, potentially reducing performance of the sedimentation basin, reducing filter run times, and ultimately resulting in ineffective treatment. Even more important, such rivers often carry large particles, sands and silts that settle out in flocculation basins, where their removal is difficult to manage. In general, sediment greater than 0.1 mm in diameter should be removed to prevent abrasion-related damage to equipment, such as pumps and mixers, and accumulation of sediment in basins. Water treatment facilities with large raw water reservoirs or basins often experience sediment removal in conjunction with water storage, via settling of solids. Other available options for sediment removal include conventional grit basins, and grit basins with the addition of enhanced sedimentation devices such as lamella plates.

The intake for the SRWA's WTP is a partially constructed infiltration gallery, with piping already in-place below the riverbed. This piping is comprised of sixteen (16), 45-foot long sections of 24-inch slotted pipe, covered by four to five feet of pea gravel, washed rock and river cobble. The slotted pipe apertures are 0.060 inches. The wet well and raw water pump station for the infiltration gallery have not yet been constructed.

The infiltration gallery is expected to reduce the particulate load of the raw water pumped to the WTP. Available historical raw water turbidity data is insufficient to assess storm related turbidity spikes on the Tuolumne River. From the available historical data, the turbidity of the river is generally low (i.e., less than 10 NTU). Pilot-scale filter columns containing media representative of the gravel and media covering the infiltration gallery piping may be tested to simulate performance of the infiltration gallery for particulate removal under both ambient low-turbidity and simulated high-turbidity conditions.

Considering that the available historical raw water turbidity is low and that additional particulate removal is expected through the infiltration gallery, it is not expected that a separate sedimentation basin or additional pretreatment would be required for the SRWA WTP. Collection of bi-weekly raw water turbidity data over a two year period has been recommended (SRWA Water Quality Sampling Plan, July 2016) and should provide additional understanding of seasonal changes in particulates. Unless the source water is found to be "flashy", pretreatment is not needed. This scenario is illustrated in Figure 7.

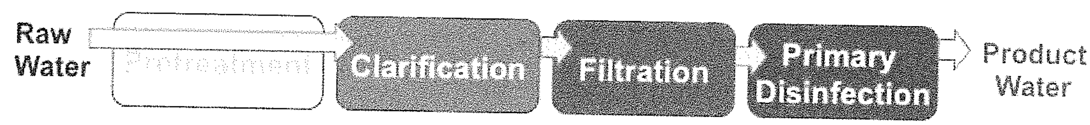


Figure 7. Typical surface water treatment with low source water turbidity

3.3 Clarification and Filtration

After deciding that pretreatment is not required, the next step in the treatment process selection is determining the appropriate clarification and filtration processes. In order to distinguish between the options—direct filtration or conventional clarification with filtration—the relevant questions are, "What degree of clarification is needed for this water?" "Can direction filtration be used?" "Will coagulation be required for TOC removal for controlling disinfection by-product formation?" The various options associated with these two clarification and filtration types are discussed further in this subsection, according to the following subtopics:

- Direct Filtration Options
- Conventional Clarification and Filtration Options

3.3.1 Direct Filtration Options

Direct filtration involves the use of a coagulant, followed by rapid mix and flocculation, ahead of filtration, and effectively skips the sedimentation step. It is sometimes designed with no flocculation as well, in which case it is usually called in-line or contact filtration. A low coagulant dose is used to de-stabilize particles and allow removal through depth filtration. For the purpose of this discussion, direct filtration includes both granular media filtration and membrane filtration. As defined by the SWTR, though, direct filtration includes the use of a granular media filter, while membrane filtration is considered an "alternative filtration technology."

In very general terms, direct filtration is an appropriate technology if the influent turbidity is consistently less than 10 NTU; contact filtration is not often practiced in California. Occasional turbidity spikes up to 20 NTU can be tolerated as long as they are infrequent and do not last long; longer duration spikes may substantially reduce filter runs and turbidity breakthrough may occur. For persistent turbidity spikes above 20 NTU, the WTP would likely have to shut down until the raw water turbidity subsides. Special media can be designed to handle higher turbidities, but, normally, extensive pilot studies are required to optimize media design and assure good performance.

In general, direct filtration precludes the use of enhanced coagulation for the removal of DBP precursor material (i.e., TOC), due the relatively low coagulant doses that direct filtration can accommodate (typically 1-5 mg/L). By contrast, conventional treatment trains can employ higher coagulant doses, often 15-30 mg/L.

If direct filtration is favored and TOC levels are above 1.5 mg/L, DBP formation with free chlorine may be a regulatory concern. If raw water TOC concentrations are routinely above 1.5 mg/L, either (a) chloramines should be used for secondary disinfection to minimize DBP formation in the distribution system, or (b) conventional treatment (i.e., with sedimentation) should be used instead of direct filtration to accommodate a higher coagulant dose and possibly lower pH (i.e., enhanced coagulation) for greater TOC removal.

Direct filtration alone will not address pesticide/SOC removal. The combination of ozone and biologically active carbon (BAC) filtration need to be included with direct filtration to address pesticides and SOCs.

Other considerations for direct filtration are:

- DDW discourages the use of direct filtration
- For direct filtration with GMF, at least 6 months of pilot testing is recommended for proper selection of media size, design of the filter bed, and selection of design filtration rate.
- For direct filtration with membranes, at least 4 to 6 months of demonstration testing, covering multiple seasons is also recommended for proper selection of the design flux and to confirm the acceptable low rate of fouling.

The following subsections discuss the pairing of the direction filtration process with granular media and membrane filtration processes.

3.3.1.1 Direct Filtration with Granular Media Filtration (GMF)

Based on historical data, the turbidity of the Tuolumne River in the reach near the infiltration gallery is less than 10 NTU and low enough for a direct filtration option. As stated, though, there is not enough data to assess storm related turbidity levels or the duration of storm related turbidity spikes, if they occur. Also, water quality improvements afforded by the infiltration gallery is unknown at this time. Pilot filter column tests may be performed to evaluate turbidity removal through the infiltration gallery.

A simplified depiction of a direct filtration treatment train with a granular media filter is shown in Figure 8. In the coagulation step, a low dose of coagulant is added in a high-speed mixing environment for particle de-stabilization. The flocculation step follows, with slow mixing speeds that promote floc formation. The flocculation time for a direct filtration plant is shorter than the flocculation time in a conventional treatment plant—10 to 20 minutes vs. 20 to 30 minutes, respectively (Crittenden, et al., 2012). Sedimentation is not needed with direct filtration treatment.

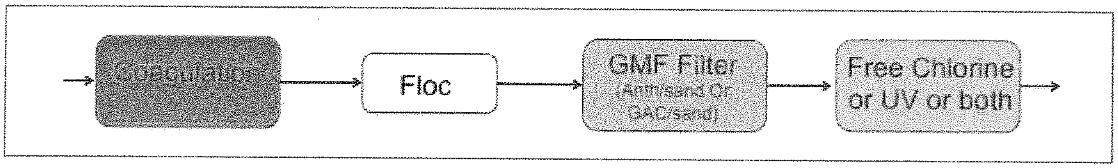


Figure 8. Direct Filtration using a Granular Media Filter

Both anthracite/sand and GAC/sand are appropriate and effective filter media but GAC is marginally more expensive that anthracite. A GAC/sand filter is operated the same as an anthracite/sand filter; the filter is backwashed every 48 to 72 hours, as needed, based on headloss buildup or turbidity breakthrough. The GAC in a GAC/sand filter is not included for purposes of SOC or TOC adsorption, although adsorption can be expected to occur during the first 6 months to a year of operation. Once the GAC's adsorption capacity is exhausted, the media is not regenerated as would occur in a strict GAC adsorption column. GAC/sand is often the filter media of choice when ozone is included in the process train because of the enhanced biological activity and contaminant removal it provides compared with anthracite. When ozone is included in the process train, the ozone breaks down organic molecules (e.g., TOC and SOCs) into smaller fragments that are more easily degraded by microbes on the media. Biological activity can be present in both anthracite/sand and GAC/sand filters, even without ozone, but removal of organics is substantially greater when ozone first breaks down the organic material making it more biodegradable. If chlorine is added ahead of an anthracite/sand filter, the chlorine is able to pass through the filter and will hinder biological growth and activity. With a GAC/sand filter, chlorine is removed by the GAC in the first few inches of the filter bed.

In terms of very general costs, a direct filtration treatment train with granular media is roughly 10% to 15% lower in capital cost than a conventional treatment train with granular media filtration.

3.3.1.2 Direct Filtration with Membrane Filtration

For direct filtration with membranes—either microfiltration or ultrafiltration membranes—the coagulation step may or may not be needed for effective filtration, but is often included. Flocculation, however, is not required for membrane filtration. A schematic of a membrane filtration process train is shown in Figure 9. Often a low dose of coagulant (i.e., 1 to 5 mg/L) is added to help reduce membrane fouling, increase the time between membrane cleanings, and possibly allow operation at a higher flux. If the TAC pursues membrane filtration, it is recommended that demonstration testing be performed (4 to 6 months) to investigate the effect of coagulant on membrane performance, as well as the optimum coagulant type and dose.

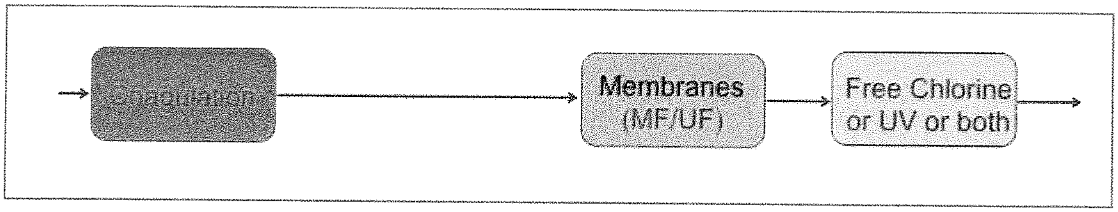


Figure 9. Direct filtration with membrane filtration

Operation of a membrane filtration system includes automatic reverse filtration/air scrubbing to remove accumulated particulate material from the membranes, a daily chemically enhanced backwash (CEB) to disinfect the membranes and restore permeability, and less frequent, but periodic, clean-in-place (CIP) chemical cleaning sequences. CIP sequences typically use citric acid. DDW has stated that CIP waste chemicals cannot be returned to the plant influent for blending with raw water, and must be either pumped to a sanitary sewer system for treatment at a nearby wastewater treatment plant (WWTP) or hauled off-site for proper treatment and disposal. Because of the remote location of the SRWA WTP, the CIP waste would have to be hauled off-site for disposal. It should be noted that some WWTPs do not accept citric acid waste because it chelates the iron in ferric chloride, which can interfere with the WWTP's performance.

Membrane filtration systems are exempt from the Enhanced Coagulation TOC removal requirements of the Disinfectants/Disinfection By-Products Rule (D/DBP), but the finished water must still meet the TTHM and haloacetic acids (HAA5) pMCLs in the distribution system. The pMCL for TTHMs is 80 μg/L and for HAA5 the pMCL is 60 μg/L. As mentioned previously, membrane filtration provides little or no TOC removal because only a very low coagulant dose, if any, is used. Given the uncertain TOC concentrations at the intake location and the fact that only a small fraction of the DBP precursor material will be removed through membrane filtration, it is likely that chloramines will have to be considered for secondary disinfection. Actual DBP formation in the source water in relation to TOC concentration can be estimated through bench-scale tests. Refer to Section 5 of this TM for further discussion of optional pilot- and bench-scale tests.

One advantage of membrane filtration is that it is considered an "absolute barrier" to *Giardia* and *Cryptosporidium*. The SWTR and subsequent Interim Enhanced Surface Water Treatment Rule (IESWTR) and LT2ESWTR require a specific amount of pathogen treatment be achieved through multi-barrier treatment (i.e., removal via filtration and inactivation via disinfection) when treating a surface water. Generally, DDW will credit membrane filtration with 4-log *Giardia* and 4-log *Cryptosporidium* removal. The membrane manufacturer must conduct a "challenge test" using the specific membrane to be installed and DDW must approve the submitted challenge test report. This is a product-specific challenge test and not a water-specific test. Greater *Giardia* and *Cryptosporidium* removal credit is awarded for membrane filtration than for direct filtration with GMF, as summarized in Table 3 below; the additional required treatment credit, for multi-barrier treatment, is achieved through disinfection. Virus removal credit is awarded for direct filtration with GMF, but typically not for membrane filtration. For comparison, the credit achieved for conventional treatment with GMF—complying with filter effluent turbidity requirements—Is also shown in Table 3.

Table 3. Pathogen Removal Credit for Direct Filtration with a Granular Media Filter Compared to Membrane Filtration

Pathogen	Required Treatment	Direct Filtration with GMF	Direct Filtration with MF	Conventional Treatment with GMF
Cryptosporidium[(a)]	2-log	2-log	4-log	2-log
Giardia[b]	3-log	2-log	4-log	2.5-log
Viruses[b]	4-log	1-log	--	2-log

Footnotes:

a. Assumes Bin 1 classification
b. Regulations require multi-barrier treatment. The remaining required credit is achieved through disinfection

Membrane filtration does not provide treatment for pesticides, other SOCs, or algae-related tastes and odors. Therefore, if the TAC elects to pursue membrane filtration, they will have to make the following concessions with regard to regulated pesticides and SOCs:

- Not treat for regulated pesticides/SOCs and assume they will remain below their respective MCLs in the source water. Note that the historical pesticide/SOC data reported two contaminants above a DDW Notification Level but none above a primary MCL.
- Include the addition of powdered activated carbon (PAC) or the use of GAC adsorption in the treatment train. Activated carbon treatment would be required continuously because it is not possible to know if/when pesticides are above their respective MCL in the source water. Note that with GAC adsorption the GAC is regenerated once the carbon has exhausted its adsorption capacity; this is not the same as using GAC as a filter media in a GAC/sand (or BAC) filter where the filter is repeatedly backwashed and the media is never regenerated.
- Add a process such as ozone/BAC to the treatment train to breakdown (ozone) and biodegrade (BAC) the organic molecules. Note that addition of an ozone/BAC process to a treatment train with membrane filtration would necessarily result in redundant filtration processes.

When the TAC considers the viability of membrane filtration, the following should be kept in mind:

1. DDW is not a proponent of membrane filtration and permitting the WTP may be challenging
2. There have been two negative local experiences with membranes (i.e., MID and SSJID) and only one positive experience (i.e., Lodi)
3. The WTP design must include adequate protection for the membranes from the potential threat of Asian clams

3.3.2 Conventional Clarification and Filtration Treatment Options

A conventional treatment train for surface water treatment includes coagulation, flocculation, sedimentation, granular media filtration, and both primary and secondary disinfection. A conventional treatment train is generally 10% to 15% more expensive than a direct filtration treatment train.

A schematic of a conventional treatment train is shown in Figure 10. This subsection focuses on the clarification (i.e., coagulation, flocculation and sedimentation) and filtration components of conventional treatment; disinfection is addressed separately in Section 3.4.

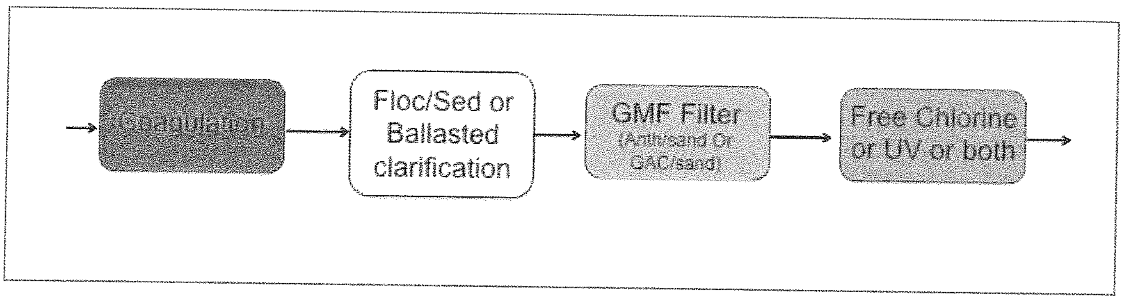


Figure 10. Conventional Treatment Train for Treatment of a Surface Water

Coagulation and Flocculation

In conventional treatment, a coagulant (e.g., ferric chloride or aluminum sulfate) is added to facilitate settling and removal of particulate material. In order to control DBP formation, the coagulant dose is generally high enough to also provide removal of TOC—typically 20 mg/L to 30 mg/L. In addition, the pH can be adjusted as needed to provide "enhanced coagulation" for DBP control, as coagulant performance is partially a function of pH.

Depending on the source water TOC concentration and alkalinity, the Enhanced Coagulation part of the D/DBP Rule requires a specific percentage TOC removal, or demonstration that the required removal cannot be reasonably achieved (Table 4). Enhanced coagulation is not required if the source water TOC is less than 2 mg/L. As stated previously, direct filtration is exempt from the Enhanced Coagulation requirements but the DBP MCLs must still be met.

Because conventional treatment is amenable to enhanced coagulation, TOC removal may be sufficient for DBP control, thereby allowing the use of free chlorine for secondary disinfection. Bench-scale jar tests can be done to evaluate a) TOC removal over a range of pHs, coagulant types and doses, and

b) the subsequent DBP formation in the settled water with both free chlorine and chloramines.

Due to the uncertainty about the Tuolumne River TOC concentrations at the infiltration gallery location (as discussed in Section 2.2), the upcoming source water monitoring program will be relied upon to clarify the expected range of TOC concentrations, and subsequent TOC removal requirements, for this source water.

The detention time for conventional coagulation/flocculation is 20 to 30 minutes (Crittenden, et al., 2012).

Table 4. TOC Removal Required Under the Stage 1 D/DBPR

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0-60	>60-120	>120
>2.0 – 4.0	35%	25%	15%
>4.0 – 8.0	45%	35%	25%
>8.0	50%	40%	30%

Sedimentation

There are several options for sedimentation. Conventional sedimentation uses large, rectangular, horizontal-flow basins and the detention time ranges from 1.5 to 4 hours (Crittenden, et al., 2012). As an alternative, high-rate sedimentation with lamella plate or tube settlers can be used. The detention time ranges from 6 to 10 minutes with tube settlers and 15 to 25 minutes with plate settlers (Crittenden, et al., 2012).

Another option which combines coagulation/flocculation/sedimentation into one unit process is sand ballasted clarification (SBC). With SBC, sand is added to provide nucleation sites for floc formation and growth. A high density sand is used and because of its density the sand/floc settles very rapidly. Plate settlers are generally incorporated into the SBC basins for high-rate clarification.

SBC is a very robust treatment process and generally is used when treating a surface water with highly variable raw water turbidity and TOC conditions. SBC also has a substantially smaller footprint than conventional coagulation/ flocculation/ sedimentation, but because of the proprietary nature of SBC systems, the capital cost may be more. However, under recent Design-Build or Design-Build-Operate procurement approaches, SBC has been shown to be a cost-competitive process.

Filtration

Both anthracite over sand and GAC over sand are appropriate filter media in a conventional treatment train. GAC is recommended for treatment trains which include ozone upstream of the filters, as GAC provides a more suitable adsorption / substrate environment for the microbial communities necessary to biodegrade the organic molecules broken apart during ozone treatment.

As discussed for direct filtration (Section 3.3.1.1), GAC is marginally more expensive than anthracite. Without the addition of ozone in the process train to break down the larger organic molecules making them amenable to biodegradation, there is not much benefit in using GAC rather than anthracite as a filter media. The adsorption capacity of the GAC for SOCs and TOC is rather quickly exhausted (typically within a few months), and without ozone there will not be significant biological degradation of organic material on the GAC filter media. So, without ozone/BAC, a conventional treatment train does not effectively address agricultural-related pesticides/SOCs or algae related T&O.

3.4 Disinfection

As required by drinking water regulations, surface water treatment must include both primary and secondary disinfection. Primary disinfection is included to meet the pathogen inactivation requirements of the SWTR (i.e., multi-barrier requirements), whereas secondary disinfection is required for the purpose of maintaining a detectible disinfection residual throughout the distribution system (i.e., required by the Disinfection/Disinfection By-Product Rule). The options for each are the following:

Primary Disinfection

- Free chlorine
- Ozone
- Ultraviolet radiation (UV)
- Chloramines

Secondary Disinfection

- Free chlorine
- Chloramines

Typically, only free chlorine or ozone are used for primary disinfection. Chloramines are not as effective for disinfection as free chlorine and therefore require a very long contact time to deliver equivalent treatment. UV provides good disinfection for *Cryptosporidium* and *Giardia*, but requires a high dose for virus inactivation. UV is an expensive option unless additional *Cryptosporidium* treatment credit is needed in the treatment train.

For secondary disinfection, each chemical has pros and cons. Free chlorine compared with chloramines is a stronger disinfectant and oxidant, and thus reacts with TOC to form higher concentrations of DBPs; it decays faster in the distribution system; and it is more easily detected by taste and smell. Chloramines are more stable than free chlorine, so they decay slower in the distribution system and form lower DBP concentrations when reacting with TOC; they require careful control of the chlorine to ammonia ratio; they can lead to nitrification issues; and chloramines require both ammonia feed and chlorine addition at well-heads for continued groundwater use.

The choice of final (i.e., secondary) disinfectant will be largely determined by TOC removal through the WTP, the TOC concentration of the finished water, and subsequent DBP formation potential. Due to uncertainty in TOC levels of the source water, all treatment alternatives should include the capability for chloramine addition. The source water monitoring program and bench testing will allow economical evaluation of DBP precursor removal through clarification and subsequent DBP formation with both free chlorine and chloramines.

3.4.1 Incorporating Ozone into the Process Train

Although incorporating ozone in a treatment train typically adds 8% to 10% to the capital cost of the facility, an ozone train provides more than just disinfection. Due to ozone's ability to break down larger organic molecules, it adds robustness to the process by addressing the following treatment needs:

- Treatment for low concentration pesticides, SOCs, and contaminants of emerging concern (CECs) (e.g., hormones, antibiotics, etc.)
- Treatment for algae related T&O, and algal cyanotoxins if present
- Enhanced filtration performance with granular media filters, such as longer filter funs and lower filter effluent turbidity

When ozone is added to the treatment train it is recommended that biologically active carbon (BAC) filtration—using GAC/sand filter media—be included after ozonation to reduce the assimilable organic carbon (AOC) concentration, making the water more stable before it is introduced into the distribution system. Higher AOC concentrations can lead to bacterial regrowth in the distribution system and potential difficulty maintaining a disinfectant residual throughout the system.

Although anthracite/sand filter media could be used in place of GAC/sand media, GAC is preferable because the GAC provides adsorption sites for organic material which promotes biological degradation of organic carbon. As the microbes degrade the organic carbon, additional sites are made available for further adsorption, effectively regenerating the GAC. Thus, GAC promotes better degradation of toxic compounds through adsorption and adaptation. By virtue of the biodegradation of the organic material, the combination of ozone and BAC filtration provides additional TOC removal capability—perhaps as much as 35% (Crittenden, et al., 2012)—resulting in lower DBP levels when free chlorine is used as a secondary disinfectant.

The following example illustrates the effect of adding ozone to a treatment train, in this case a membrane filtration process piloted by TID in 2008:

- The TID pilot study (Brown and Caldwell, 2008) found that even considering the very low raw water TOC concentrations being pilot tested (raw water TOC averaged 1.75 mg/L during the study) and membrane filtration, TTHM and HAA levels with 3 mg/L free chlorine disinfection and a 5-day sample holding time were close to or just above the regulatory limits. [Note: Membrane filtration can be considered a worst case filtration scenario for DBPs, since it does not provide biological activity for degradation of organics].

- With pre-ozonation ahead of membrane filtration, TTHMs were reduced 35% and HAAs were reduced 50%; resulting effluent TTHMs were below 50 µg/L and HAAs were below 30 µg/L.
- When alum coagulation was added after pre-ozonation, DBP levels were further reduced to TTHMs below 30 µg/L and HAAs below 10 µg/L. [It should again be noted that the source water TOC for the 2008 pilot study was substantially lower that the TOC measured during the same time period at the infiltration gallery location].

Ozone can be incorporated into both direct filtration and conventional treatment trains. The pros and cons of each of these options are discussed in the subsections below.

3.4.1.1 Adding Ozone to Direct Filtration

Ozone can be added to both the GMF and membrane direct filtration trains, as shown in Figure 11. The preferred choice for ozone addition in the **GMF train** is pre-ozonation, since adding ozone after floc formation can break apart the floc and potentially have a negative impact on particulate removal through the GAC/sand filter. In turn, pre-ozonation can enhance the performance of the GMF filter, resulting in longer filter runs and lower effluent turbidity. The ozone/BAC combination can also provide a moderate percentage (up to 35%) TOC removal.

The preferred choice for ozone addition in the **membrane filtration train** is after the membranes, particularly since pre-ozonation does not enhance membrane filtration. Ozone can be very damaging to the membrane and potting materials and as such it is critical to protect the membranes from exposure to ozone. Biofiltration is recommended following ozone for AOC removal. Including both membrane filtration and BAC filtration in the same treatment train is redundant. Therefore, the membrane filtration train with ozone is not justifiable.

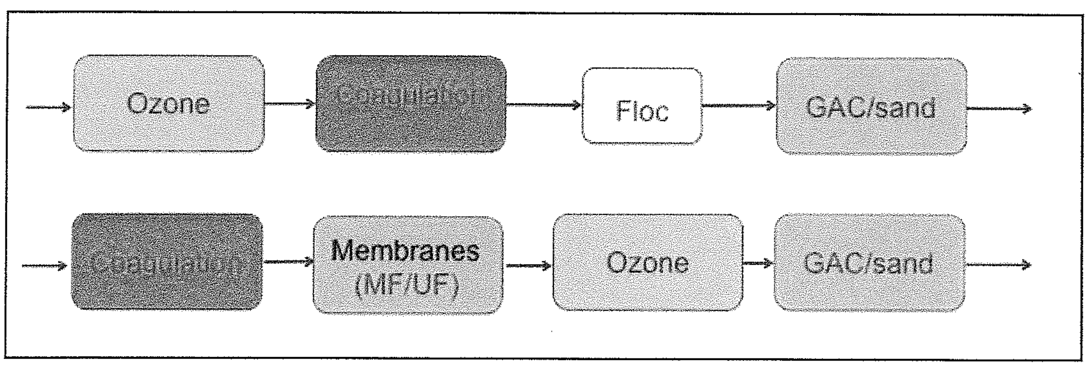


Figure 11. Options for Adding Ozone to Direct Filtration

3.4.1.2 Adding Ozone to Conventional Treatment

Ozone can easily be added to a conventional treatment train (Figure 12). Two locations should be considered for ozone, and each offers different advantages. Pre-ozone ahead of coagulation improves the coagulation process and reduces the coagulant dose. MID's conventional treatment train includes pre-ozone and MID has reported reduced coagulant usage. Intermediate ozone (after sedimentation) has a lower ozone demand because the TOC concentration is lower as a result of clarification.

Both ozonation locations are effective for disinfection, pesticide/SOC removal, and T&O mitigation. If the TAC elects to continue evaluation of a treatment train that includes ozone, bench-scale ozone demand tests can be done to evaluate the difference in ozone demand—and therefore ozone dose and treatment cost—between pre-ozone and intermediate ozone. Bench-scale tests can also be done to evaluate any difference in DBP formation between these two ozone location options.

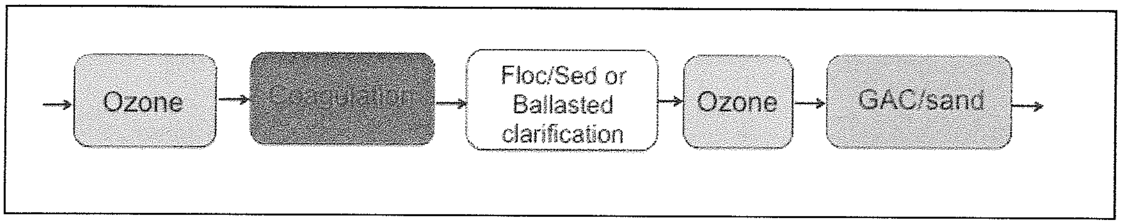


Figure 12. Addition of Ozone into the Conventional Treatment Process Train

4 - SUMMARY OF TREATMENT ALTERNATIVES

Considering the benefits offered by the addition of ozone—treatment for pesticides, SOCs and T&O compounds, while also providing disinfection—the candidate treatment trains are divided into two groups—those without ozone and those with ozone as shown in Figures 13 and 14 and listed below:

Treatment Trains without Ozone

- **Option A**: Direct filtration with granular media filters and primary disinfection with free chlorine, UV or both
- **Option B**: Direct filtration with membrane filters and primary disinfection with free chlorine, UV or both
- **Option C**: Conventional treatment with granular media filters and primary disinfection with free chlorine, UV or both

Treatment Trains with Ozone

- **Option D**: Direct filtration with pre-ozonation and biologically active granular media filters

Option E: Conventional treatment with pre- or intermediate ozonation and biologically active granular media filters

A brief summary of key considerations for these treatment alternatives is the following:

- TOC (i.e., DBP precursor material) at the infiltration gallery is high enough to cause concern over DBP formation with free chlorine, based on historical data. Chloramines form much lower DBP levels compared with free chlorine for secondary disinfection.
- Direct filtration without ozone (Options A and B) is unlikely to meet DBP requirements using free chlorine for secondary disinfection.
- Conventional treatment without ozone (Option C) may meet DBP requirements using free chlorine for secondary disinfection. More information about source water TOC is needed for consideration of this option, however.
- Treatment trains without ozone (Options A, B, C) will not address pesticides or T&O.
- Direct filtration with ozone (Option D) will address pesticides, and may meet DBP requirements using free chlorine. This train does not provide robust treatment for variable influent water quality, however.
- Conventional treatment with ozone (Option E) is the most robust train. It will provide treatment for pesticides/SOCs and T&O, and is expected to meet DBP requirements. Ozone\BAC will provide additional DBP protection by removing additional TOC beyond that removed through clarification.
- The choice of final (i.e., secondary) disinfectant will be determined by the amount of TOC removal provided by treatment. Due to uncertainty in TOC levels at the infiltration gallery, all treatment alternatives should include the capability for chloramine addition. Bench testing and additional source water monitoring will also inform this choice.

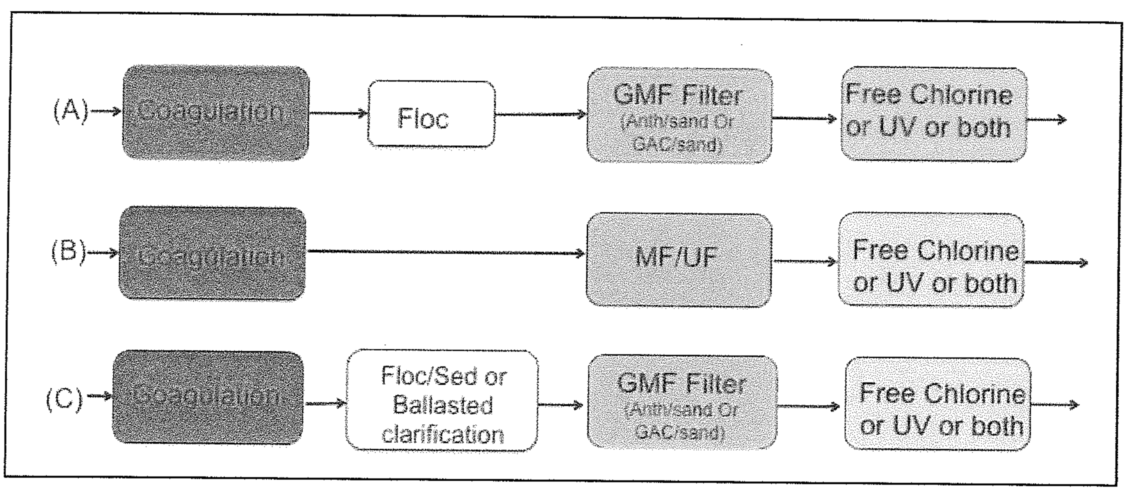


Figure 13. Candidate Treatment Trains without Ozone

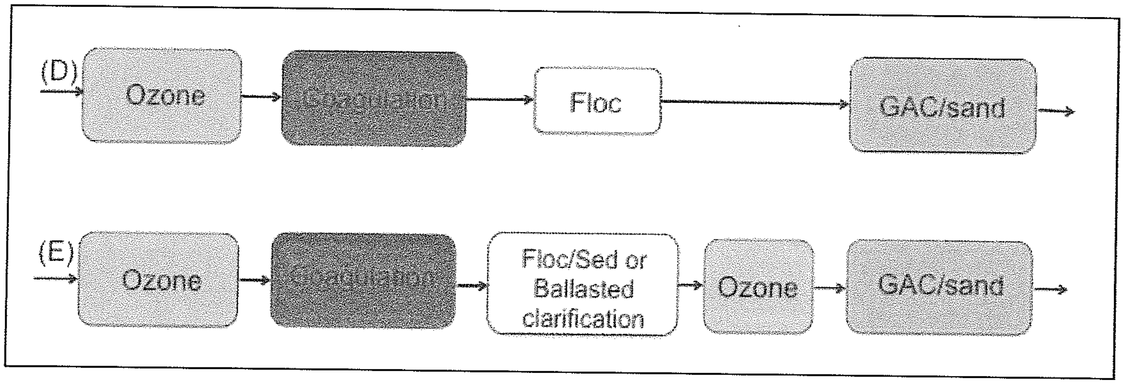


Figure 14. Candidate Treatment Trains with Ozone

A qualitative assessment of the above candidate treatment trains' ability to meet a selection of the TAC's most highly ranked treatment performance goals (i.e., goals with an importance ranking of five) is provided in Table 5. The intent of this summary table is to assist the TAC in selecting the candidate treatment alternative(s) that should be evaluated in greater detail and to justify the elimination of processes that do not provide appropriate treatment, based primarily on source water quality and treatment needs.

Table 5. Qualitative Ranking of Candidate Treatment Trains for Meeting Selected Treatment Performance Goals[1]

Treatment Train	Process Train Capabilities[2] for Addressing Selected SRWA Treatment Goals[1]				
	Meet Regulations with Safety Factor: **Regulated SOCs**	Meet Regulations with Safety Factor: **DBPs**	Reduce Aesthetic Concerns: **Tastes & Odors**	Robust Process for Variable Source Water **Turbidity**	Robust Process for Variable Source Water **TOC**
Option (A) Direct Filtration[3] with GMF, no Ozone	**1** – For anthracite/ sand, due to no adsorption **2** – For GAC/sand, due to limited adsorption; no ozone for SOC removal	**2** - Limited by low coagulant dose; no ozone for precursor removal; chloramines may be necessary	**1** – For anthracite/ sand, due to no adsorption; no ozone for T&O removal **2** – For GAC/sand, due to limited adsorption;; no ozone for T&O removal	**1** – Unknown influence of infiltration gallery; difficult to find operators with experience	**2** - Limited by low coagulant dose
Option (B) Direct Filtration[3] with MF, no Ozone	**1** – No ozone, no biological activity, no SOC removal	**2** - Limited by low coagulant dose; no ozone for precursor removal; chloramines may be necessary	**1** – No Treatment	1 – Unknown influence of infiltration gallery; difficult to find operators with experience	**2** - Limited by low coagulant dose
Option (C) Conventional Treatment with GMF, no Ozone	**2** – Possible adsorption onto floc; no ozone for SOC removal	**4** – Enhanced coagulation is an option; no ozone to reduce precursors	**3** – Powdered Activated Carbon can be added as needed; no ozone to remove T&O	**5** – SBC is potentially more robust for high turbidity levels	4 – Coagulant dose can be varied
Option (D) Direct Filtration[3] with Pre-Ozone and GMF	**4** – O_3/BAC provides treatment	**3** – Limited by low coagulant dose; O_3/BAC provides additional TOC removal	**4** – O_3/BAC provides treatment, but more information needed about ozone treatment for algal toxins	**1** – Unknown influence of infiltration gallery	**3** - Limited by coagulant dose but O_3/BAC provides additional TOC removal
Option (E) Conventional Treatment with Pre- or Intermediate Ozone and GMF	**5** – Some additional removal may be provided by adsorption onto floc	**5** - O_3/BAC provides additional TOC removal	**4** – O_3/BAC provides treatment, but more information needed about ozone treatment for algal toxins	**5** – SBC is potentially more robust for high turbidity levels	**4** – Coagulant dose can be varied; O_3/BAC provides additional TOC removal

Notes:

[1] Goals listed include those identified as most important (ranking score of 5) to the TAC.
[2] Capability rankings: 1 = No ability to meet goal; 5 = Fully capable of meeting goal.
[3] Pilot testing is required for direct filtration options.

5 - INFORMATION GAPS

Information gaps identified at the June 30 workshop and discussed in this TM, as well as the available measures to provide the missing information, are summarized in Table 6 below.

Another important topic that was not discussed during the June 30 workshop, but is quite important to the success of this project, is integration of the new surface water into the Ceres and Turlock distribution systems that have historically seen only groundwater. Introducing a new water into a distribution system can be challenging and has potential for colored water events and more corrosive conditions. Some utilities have made this transition with few, if any, negative consequences, while others have experienced significant water quality and public perception issues related to "red water", "black water", or elevated lead levels. This TM was focused on describing the pros and cons of each candidate treatment train for the purpose of reducing the list of viable treatment alternatives; corrosion control was not considered at this point in time.

A future task should focus on understanding (1) the current and historical quality of the Cities groundwater, (2) the pipeline materials used in the distribution systems, (3) the history of customer complaints, and (4) water flow direction and detention times in the systems. The future WTP must include a corrosion control strategy for minimizing corrosion related issues when this new treatment facility comes on-line. This corrosion control strategy should encompass (1) finished water quality for maintaining a stable water chemistry in the distribution system, (2) addition of a corrosion inhibitor to stabilize existing corrosion scale, (3) distribution system preparation measures such as unidirectional flushing (UDF) to remove loose iron scale and manganese deposits, and potentially (4) a pilot-scale pipe loop study evaluating the effectiveness of corrosion control options. Corrosion control treatment and integration of surface water into the Cities existing distribution systems will be addressed either later in Phase 1 of this project, once the preferred treatment train has been selected, or during Phase 2 of this project. The timing and scope of this corrosion control evaluation will be discussed between the TAC and West Yost at an upcoming project meeting.

Table 6. Information Gaps and Available Measures to Provide Missing Information

Category	Information Gap	Available Measures to Provide Missing Information	Anticipated Outcome(s) of Available Measures	Current Disposition of Available Measures
Infiltration Gallery Performance	Ability of the infiltration gallery to reduce turbidity in the raw water to the WTP, under variable turbidity conditions in the River. Ability of infiltration gallery to remove grit and silt that would accumulate in downstream treatment	Pilot filter column testing using raw and spiked river water samples	Determination of feasibility of direct filtration	Optional task, pending review and direction from TAC
	Ability of the infiltration gallery to remove particles the size of Asian clam larvae, to keep the clams from entering basins at the treatment plant		Determination of likelihood of potential future Asian clam colonization in raw water pump station wet well and WTP basins	
Tuolumne River TOC Concentrations	Historical TOC data collected at the intake location indicate higher TOC concentrations than measured at the Modesto Reservoir influent or downstream near the Hughson WWTP where the TID pilot study was conducted	Measurement of raw water TOC concentrations	Determination of feasibility of direct filtration and disinfection with free chlorine. Determination of TOC removal requirements	24 months of measurement included in Sampling Plan
Pesticide Contamination	There are limited historical data regarding pesticide concentrations in the River, but several high use pesticides in the watershed.	Measurement of regulated pesticides in raw water	Determination of need for ozone or PAC treatment (if ozone is not included)	Quarterly measurements included in Sampling Plan
Potential for Algae-related T&O and Toxins	MID's water treatment plant includes ozone for T&O treatment. Other than detectable nitrate concentrations, there is little data to indicate whether or not T&O are a potential aesthetic issue for the influent water	Sample collection and analysis for Chlorophyll-a , algae species identification and enumeration, and subsequent 2-Methylisoborneol (MIB), geosmin and/or algal toxin analyses, as needed	Determination of need for ozone or PAC treatment (if ozone is not included)	Not a part of DDW-approved Sampling Plan. Included with additional recommended monitoring.

Category	Information Gap	Available Measures to Provide Missing Information	Anticipated Outcome(s) of Available Measures	Current Disposition of Available Measures
Potential TOC Removal through Enhanced Coagulation	It is unknown if there will be enough TOC removal to use free chlorine. Evaluate required coagulant dose and resulting TOC removal and DBP formation.	Jar testing of raw water samples to evaluate various coagulant, dose and pH combinations for optimum TOC removal and minimal DBP formation	Identification of optimum coagulant, dose and pH Determination of typical TOC removal and corresponding DBP formation through enhanced coagulation. Greater understanding if chloramines will or will not be necessary.	Optional task, pending review and direction from TAC
Ozone Demand of Raw and Clarified Source Water	An understanding of the ozone demand associated with the source water and the clarified water (based on optimal coagulant dose determined), along with an understanding of corresponding ozone byproduct formation. Evaluation of the optimum location for ozonation in the treatment train.	Bench testing to identify optimum ozone dose for required disinfection and T&O control using raw and clarified (i.e., coagulated and clarified) river water samples	Determination of optimum location for ozonation in conventional treatment train Identification of optimum ozone dose	Optional task, pending review and direction from TAC

6 - NARROWING THE FIELD OF VIABLE TREATMENT TRAIN ALTERNATIVES

Extrapolating from the historical water quality data, while concurrently recognizing and acknowledging limitations of the historical data, the TAC can begin to rule out some of the candidate treatment trains. This section of the TM reflects discussions at the June 30, 2016 workshop and attempts to provide justification for eliminating some of the initial five alternative treatment trains on the basis of source water quality and treatment needs. The following discussion centers on two primary questions:

1. Ozone/BAC or No Ozone/BAC?
2. Direct Filtration or Conventional Treatment?

Further narrowing the list of viable alternatives to just one or two treatment trains may require a combination of additional source water quality data, bench-test and/or pilot-test results described in Table 6.

6.1 First Decision – Ozone/BAC or No Ozone/BAC?

Ozone should be seriously considered in the selected treatment train(s) because of the enhanced treatment it offers as well as the robustness it provides for potentially variable and unknown water quality. Because of the large agricultural area and high pesticide usage in the Lower Tuolumne River watershed, ozone in combination with BAC provides excellent treatment for low levels of regulated pesticides that are likely to contaminate the river. Several pesticides and other SOCs were reported in the historical water quality data for the Tuolumne River.

Ozone with BAC is also effective treatment for algae-related T&O (i.e., aesthetic) considerations and, although there is not a lot of direct evidence of algal blooms in this source at this time and good data on algal blooms are often hard to come by, there is evidence of the presence of the nutrients that encourage algal blooms in this source water. Finally, the off-flavors associated with algal blooms are one of the principle complaints associated with surface water sources. Ozone/BAC also will provide additional TOC removal beyond what is achieved with conventional clarification. If ozone is used in the treatment train, GAC/sand filtration—referred to as BAC—should also be included because of the microbial activity on the filter media. This biological activity allows additional removal of SOCs, taste and odor compounds and TOC broken down by ozone, as well as lower AOC concentrations in the finished water. High AOC concentrations can lead to bacterial regrowth in the distribution system and potential difficulty maintaining a disinfectant residual.

Drinking water regulations require the finished water from a WTP to be in compliance with all enforceable standards. Per the treatment performance goals set out by the TAC during the May 12, 2016 Treatment Performance Goals Workshop and summarized in the ensuing technical memorandum (Trussell Technologies, July 21, 2016), the TAC desires a robust treatment approach for regulated contaminants, contaminants on the regulatory horizon (e.g., those with an NL, an aNL, or on a UCMR list) and aesthetic considerations, while at the same time being financially responsible regarding treatment for unregulated contaminants. Having a robust treatment train was ranked 5 (most important) by the TAC, while treatment for unregulated pesticides and CECs was ranked 2 (low importance). As discussed previously (Source Water Quality Assessment TM, Trussell Technologies, July 2016), several pesticides were measured in past river samples, but only two—diazinon and tert-butyl alcohol—were measured at a concentration above their respective regulatory notification level. The watershed around the infiltration gallery is a large agricultural area with several pesticides applied at an application rate greater than 5,000 lbs/yr. Thus, there is potential for low levels of pesticides in the source water for the WTP.

From a financial point of view, including ozone and in the treatment train will add 8% to 10% to the capital cost of the facility. Assuming the TAC decides that ozone is warranted on the basis of source water quality and treatment needs, the next consideration is whether or not the source water is amenable to direct filtration. As discussed earlier in this TM, direct filtration with membranes is not warranted because "double filtration" with a GAC/sand GMF would be required, resulting in a redundant and more costly alternative. So, **if ozone is chosen**, the two remaining candidate treatment trains are those shown in Figure 15.

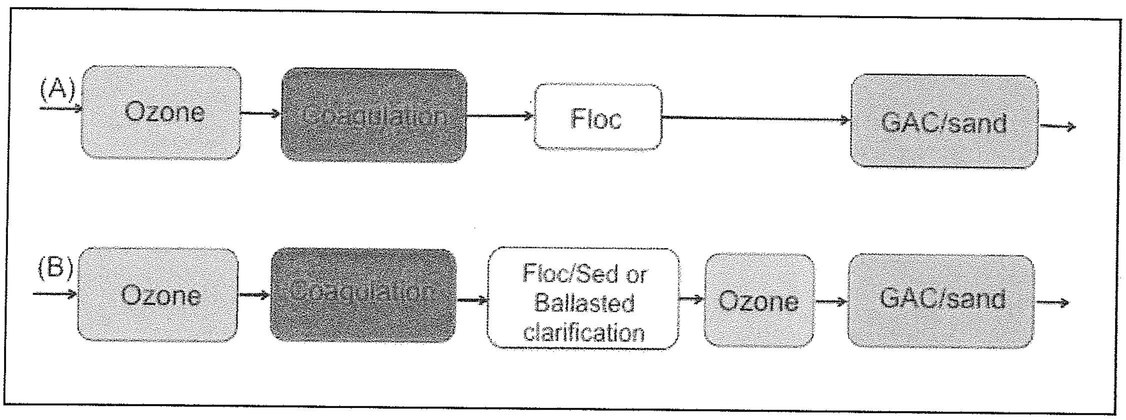


Figure 15. Feasible Treatment Trains if Ozone Treatment is Included

6.2 Second Decision – Direct Filtration or Conventional Treatment?

Notwithstanding the potential cost savings associated with direct filtration, deciding between direct filtration and conventional treatment comes down to the following treatment considerations:

- Will the turbidity of the influent water (after passing through the infiltration gallery) be consistently low enough to accommodate direct filtration?
- How much TOC removal will be required for DBP control with free chlorine for secondary disinfection?

- Can this be achieved with the low coagulant doses used with direct filtration?
- Should chloramines be considered for secondary disinfection rather than free chlorine?

Turbidity. The rule of thumb upper turbidity that direct filtration can accommodate is 10 NTU. Brief periods of elevated turbidity—up to roughly 20 NTU—can normally be tolerated without exceeding filter effluent turbidity limits. There are not enough raw water turbidity data to assess whether the turbidity will be consistently low—although the limited historical data are encouraging, indicating the turbidity of the raw water is consistently below 10 NTU. The historical data also do not allow assessment of the impact of storm events and associated high river flows on turbidity. In addition, improvement in influent turbidity provided by the infiltration gallery is unknown at this time. In general terms, conventional treatment is typically 10% to 15% higher in capital cost than direct filtration (with granular media filtration). If the TAC decides to continue investigating the viability of direct filtration, the following must be considered:

- Proper design of a direct filtration granular media filter (GMF) will require pilot testing (estimated 6 months) for proper media design.
- Pilot testing is required because the chemical requirements for particle destabilization are different with direct filtration, and experience has shown that the filter bed depth and filtration rate for proper depth filtration are different for each water with direct filtration.

TOC. A low coagulant dose must be used with direct filtration—less than 5 mg/L typically—so only a small amount of TOC removal will be achieved through coagulation. TOC is the precursor material for DBP (e.g., TTHMs and HAAs) formation during disinfection. The MCLs for TTHMs and HAAs are 80 µg/L and 60 µg/L, respectively. A rule of thumb for TTHM formation with free chlorine is 30 µg/L TTHMs for every 1 mg/L of TOC. Therefore, the estimated target TOC of the finished water from this WTP should be below 1.5 mg/L. Ozone/BAC will reduce TOC concentrations, by as much as 35% (Crittenden, et al., 2012). If the TAC decides to continue investigating the viability of direct filtration, they will need to consider the following:

- If the influent TOC is consistently low—say 2.0 mg/L or less—direct filtration with O_3/BAC may provide effective DBP precursor removal and allow the use of free chlorine for secondary disinfection in the distribution system. However, the historical data at the infiltration gallery location had an average concentration of 3.3 mg/L, with a maximum of 6.5 mg/L. *Therefore, given the uncertainty of the influent TOC concentrations, if direct filtration with O_3/BAC is selected, both Ceres and Turlock should be prepared to use chloramines for secondary disinfection in their distribution systems.* There may be public perception issues associated with switching to chloramines.

- DDW is not a proponent of direct filtration or chloramination. Pilot testing done for the filter design, though, should alleviate DDW's concerns if the TAC pursues direct filtration.
- Bench tests cannot be easily done to assess the TOC removal provided by O_3/BAC filtration, due to the time required to establish biological growth on a filter. Pilot scale testing with continuous feed of the source water is more appropriate for determining TOC removal from O_3/BAC filtration.

In summary, if the TAC decided to pursue direct filtration, the WTP will most likely need to employ chloramines for secondary disinfection, and the Cities will in turn have to switch to chloramines for disinfection in their distribution systems. Conventional treatment with ozone will be the more expensive option, but also the more robust system for variable influent water quality and will provide the greatest assurance of continuously meeting regulatory standards and the TAC's treatment goals.

7 - RECOMMENDED NEXT STEPS

This section outlines the recommended steps the TAC and program management team should take to begin narrowing the field of candidate treatment trains, fill information gaps and lay the groundwork for TM 1, Part 2 and the second treatment process alternatives workshop.

The TAC should review TM 1, Part 1 (this TM) and provide direction to the program management team on the following issues:

1. Is the TAC prepared to eliminate any of the five treatment train options described in Section 4 of this TM? If so, which options?

2. Does the TAC wish to move forward with available bench- or pilot-scale testing measures to filling information gaps? If so, which testing measures?

3. Based on the TAC's responses to the above questions, does the TAC wish to schedule the next process alternatives workshop before or after the results of any selected testing measures are available?

8 - REFERENCES

Brown and Caldwell (2008). *Turlock Irrigation District Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake.*

Brown and Caldwell (2008b). *Turlock Irrigation District Regional Surface Water Supply Pilot Study Report.*

California Department of Pesticide Regulation (2016), Pesticide Use Reporting (PUR) Database, 2014 data for Lower Tuolumne River watershed, Stanislaus

County, California Pesticide Information Portal (CalPIP) <http://calpip.cdpr.ca.gov/main.cfm>, accessed May 11, 2016.

Crittenden, J. C., R. R. Trussell, D. W. Hand, K. J. Howe and G. Tchobanoglous (2011, In Press). Water Treatment: Principles and Design, Third Edition, John Wiey & Sons, Inc.

Trussell Technologies (September, 2016). *Tuolumne River Water Quality Assessment for the Stanislaus Regional Water Authority Water Supply Project*, Technical Memorandum.

SRWA
Stanislaus Regional Water Authority

Item 7E
Board Synopsis
September 22, 2016

From: West Yost Program Management Team

Prepared by: Andy Smith, West Yost Associates

1. **ACTION RECOMMENDED:**

Motion: Accepting the recommendations to proceed with raw water sampling and analysis activities for source water characterization.

2. **DISCUSSION OF ISSUE:**

To obtain a Drinking Water Permit for SRWA's new surface water supply system, the Division of Drinking Water (DDW) requires the preparation of a source water quality analysis. This analysis requires that raw water samples from a location specific to the Project's intake location (i.e., the infiltration gallery) be collected and analyzed. Based on the TAC's and Project Management (PM) Team's review of available historical raw water quality information for the Tuolumne River, a Source Water Characterization Sampling Plan for the SRWA Surface Water Supply Project (Sampling Plan) was prepared to describe the sampling effort intended to satisfy DDW's requirements. This document was reviewed and approved by DDW in July 2016. In addition to the parameters defined in the Sampling Plan approved by DDW, the TAC and PM Team are recommending sampling and analysis of several parameters for which DDW does not require data, but which will provide valuable information concerning the types and performance of treatment processes required. These additional parameters include a variety of algal toxins (which can result in taste and odor concerns) as well as antibiotics and hormones (which may be present due to upstream agricultural activities), and are reflected in the finalized version of the Sampling Plan (attached).

The Sampling Plan requires the collection and analysis of a variety of samples over a period of 24 months. In addition to satisfying DDW's requirements for source water quality characterization, the results from the sampling and analysis activities will guide the development of design and performance criteria for the SRWA's future water treatment plant.

The type of field sampling and laboratory analysis activities required by the Sampling Plan are generally provided by specialized companies possessing the necessary equipment, staff and certifications to conduct the work. The TAC and PM Team have solicited, received and evaluated quotations from a total of five (5) firms which offer the necessary services, and are recommending the selection of two firms: **Fishbio** for the collection of raw water samples, and **Eurofins Analytical** for the laboratory analysis of the samples. Both firms would be contracted as subconsultants to West Yost Associates.

An expanded summary of the major components of the sampling and analysis activities, as well as a presentation of costs, is provided below.

Raw Water Sample Collection
As delineated in the finalized Sampling Plan, nearly 150 individual parameters must be sampled and analyzed at frequencies ranging from bi-weekly to quarterly. The majority of the parameters are to be sampled and analyzed quarterly over a 12-month period, while the remaining parameters will be sampled over a 24-month period at varying frequencies. The parameters can be broadly categorized as follows:

- General water quality characteristics (physical and chemical)
- Inorganic contaminants
- Organic contaminants
- Disinfection byproducts
- Radionuclides
- Microbiological contaminants
- Pesticides
- Additional synthetic organic chemicals

Samples will be collected directly from the Tuolumne River, in the area above the existing buried infiltration gallery. Sample containers will be labeled, packaged in ice coolers and either handed off to a courier or transported to a local express shipping facility for shipment to the analytical laboratory.

The sampling company being recommended by the TAC and PM Team, Fishbio, has extensive knowledge of the Tuolumne River, is local to the sampling location (located in Oakdale), was given a favorable reference by a past client contacted by the PM Team, and was substantially less expensive than the other sampling firm contacted by the PM Team. The requested budget for Fishbio to complete the sampling work as a subconsultant to West Yost Associates is $39,000.

Laboratory Analysis of Raw Water Samples
Samples collected during each of the sampling events will be analyzed in an appropriately certified laboratory according to the analytical methods identified in the Sampling Plan. Samples will be collected, shipped and analyzed within the specified holding times. The analytical laboratory will be responsible for preparing, labeling and shipping to the sample collection company all of the sample vessels and ice coolers necessary to complete each sampling event, along with chain-of-custody forms. The analytical laboratory will also be responsible for all courier and shipping fees necessary to transmit the physical samples collected by Fishbio to the appropriate laboratory location.

The analytical laboratory being recommended by the TAC and PM Team, Eurofins Analytical, is certified to analyze all of the required samples, has received favorable reviews by the PM Team based on an extensive work history, and was comparable in cost to each of two other laboratories contacted by the PM Team. The requested budget for Eurofins Analytical to complete the analytical work as a subconsultant to West Yost Associates is $66,000.

3. **FISCAL IMPACT / BUDGET AMENDMENT:**

The total requested budget amendment for the above sampling and analysis activities is $105,000. These costs were not included in West Yost's original scope of work/agreement because the actual analytical constituents and sampling frequencies required by DDW could not have been determined until subsequent discussions and a meeting with DDW, after the initiation of the QSP.

4. **INTERIM GENERAL MANAGER'S COMMENTS:**

Supports moving forward with the budget amendment and the award of subcontracts to Fishbio and Eurofins Analytical.

5. **ENVIRONMENTAL DETERMINATION:**

N/A

6. **ALTERNATIVES:**

A. In lieu of Fishbio and/or Eurofins Analytical, utilize one or more of the other companies which provided quotations for the sampling and laboratory analysis work.

ITEM 7E - Attach

WATER QUALITY SAMPLING PLAN

Stanislaus Regional Water Authority

Draft Date: June 22, 2016; July 14, 2016
Final Date: September 7, 2016

To: Stanislaus Regional Water Authority (SRWA)
Technical Advisory Committee

From: Trussell Technologies, Inc. and West Yost Associates

Authors: Elaine W. Howe, P.E. (Trussell Technologies)

Reviewers: Andy Smith, P.E. (West Yost Associates)
R. Rhodes Trussell, Ph.D., P.E.
Celine C. Trussell, P.E.

Subject: **Source Water Characterization Sampling Plan for the SRWA Surface Water Supply Project**

The Stanislaus Regional Water Authority (SRWA), a joint powers authority between the Cities of Turlock and Ceres (Cities), is embarking on a new water supply project to provide treated surface water to the Cities to supplement their existing groundwater supply. The source water for this new water treatment plant (WTP) is the Tuolumne River. The proposed intake is an existing Infiltration Gallery located four to five feet below the river bottom.

The following document is intended to provide background information on the project and describe the river water monitoring program needed for source water characterization and to fulfill the required Source Water Quality Analysis component of the domestic water supply permit application for the WTP. Source water monitoring is proposed in two phases: Phase 1 intensive monitoring to facilitate process train selection and treatment system design, and Phase 2 long-term reduced monitoring of any changes in water quality prior to construction and startup of the treatment plant. The sampling program described in this document is for the first phase of intensive monitoring. The long-term sampling plan will be prepared after review of the Phase 1 monitoring results.

1 - PROJECT LOCATION AND BACKGROUND

The source water for this project is the Tuolumne River. The Tuolumne River originates in the Sierra Nevada and flows west through the San Joaquin Valley before joining the San Joaquin River southwest of the San Joaquin River National Wildlife Refuge. The Infiltration Gallery is located in the Lower Tuolumne River watershed. This Lower Tuolumne River watershed begins in the foothills around La Grange Reservoir and ends at the Infiltration Gallery location (Figure 1)—about 25 miles upstream of the confluence with the San Joaquin River (Brown and Caldwell, 2008). At La Grange Dam, the water is diverted into Turlock Irrigation District's (TID's) and Modesto Irrigation District's (MID's) irrigation canals, and also released into the lower Tuolumne River, which is the water supply at the Infiltration Gallery. The location of this Infiltration Gallery is shown in Figure 2, relative to the Cities of Hughson and Waterford, with an enlargement of the site location shown in Figure 3.

The watersheds for Turlock Lake and the Lower Tuolumne River include steep grassland and woodland of the Sierra Nevada foothills on the far eastern side, transitioning to the plains of the Central Valley downstream. Approximately 17% of the watersheds are dedicated to agriculture (Brown and Caldwell, 2008).

The SRWA plans to construct a new 30 mgd surface water treatment plant (WTP) to provide high quality, treated water to the Cities of Ceres and Turlock, to largely supplement their current groundwater supply. The intake for this new WTP is a partially constructed Infiltration Gallery, with piping already in-place below the riverbed (Figure 3). This piping is comprised of 16, 45-foot long sections of 24-inch slotted pipe, covered by four to five feet of pea gravel, washed rock and river cobble. The wet well and raw water pump station to which these pipes will ultimately be connected has not been constructed.

Since there are no nearby WTPs on the Tuolumne River, characterization of the source water quality will be an important part of the design process, facilitating selection and construction of cost-effective and efficient treatment process capable of producing a stable supply of high-quality potable water to the Cities of Ceres and Turlock.

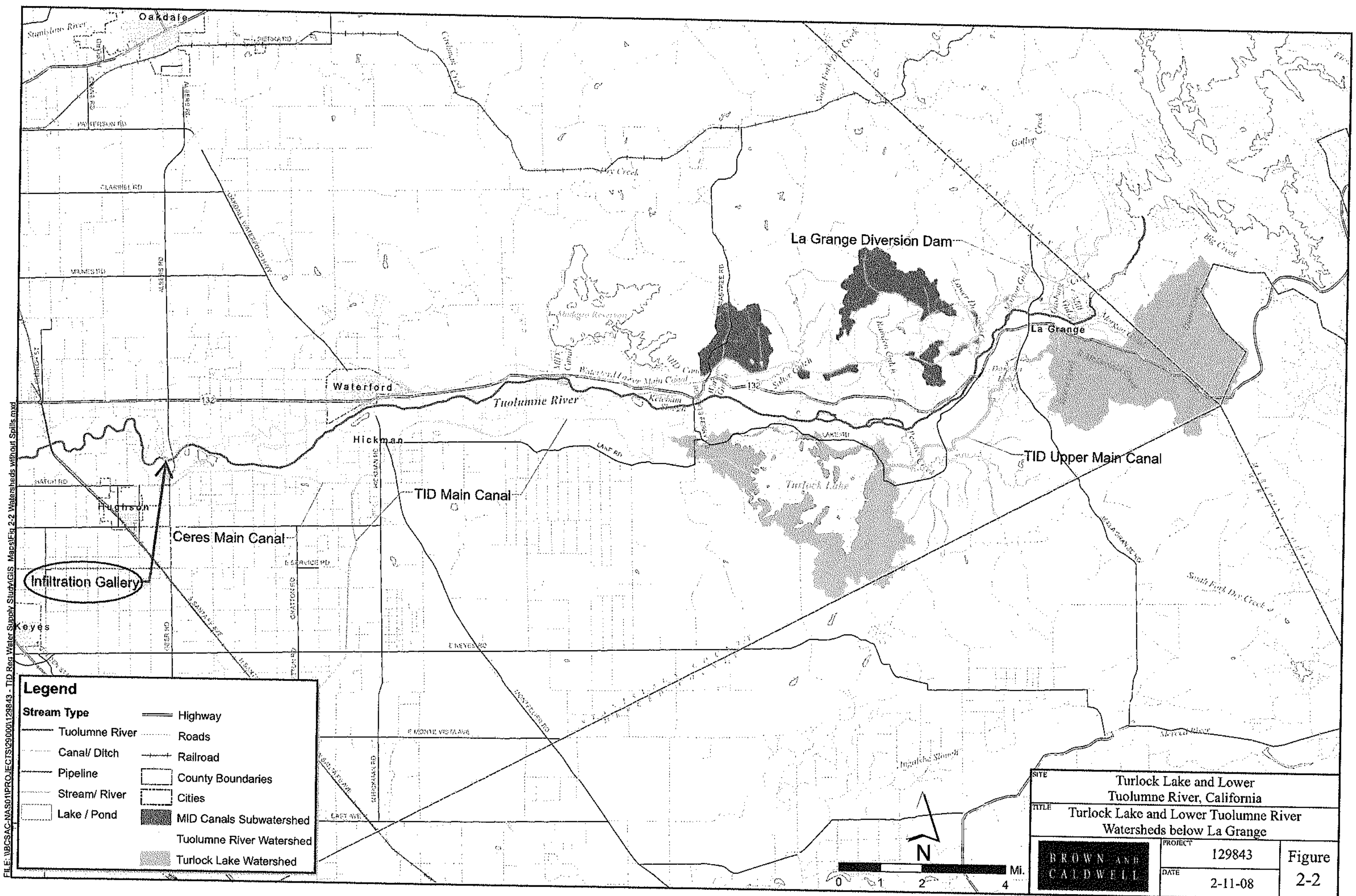


Figure 1. Lower Tuolumne River Watershed (Brown and Caldwell, 2008)

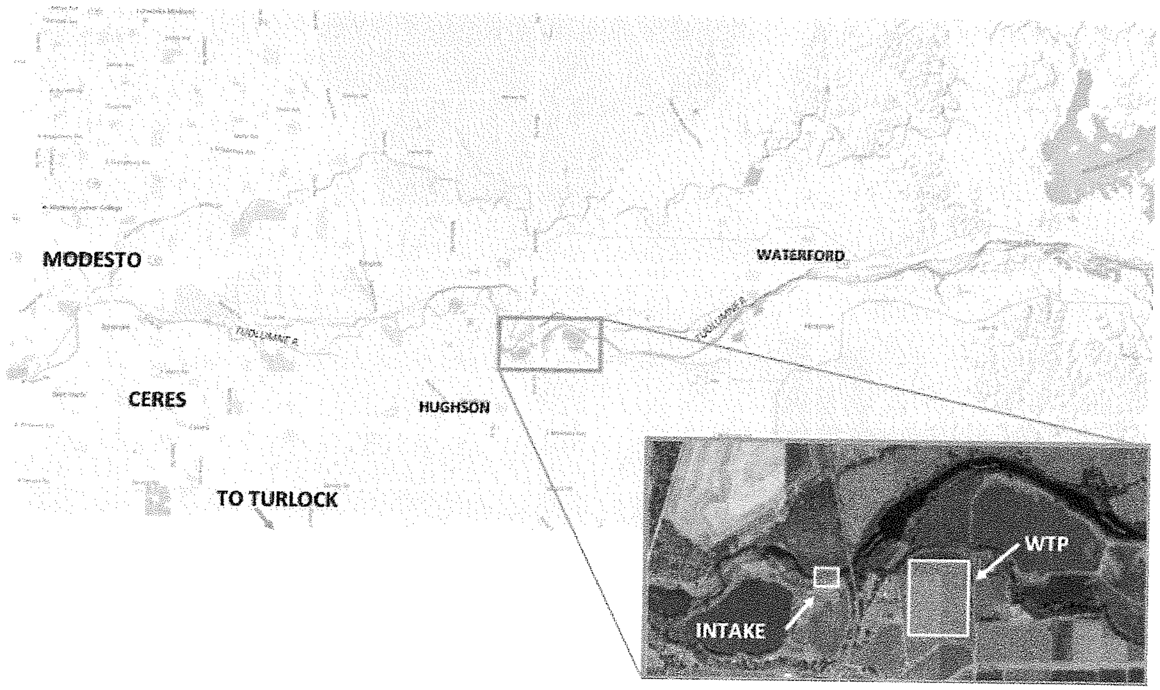


Figure 2. Infiltration Gallery Location on the Tuolumne River

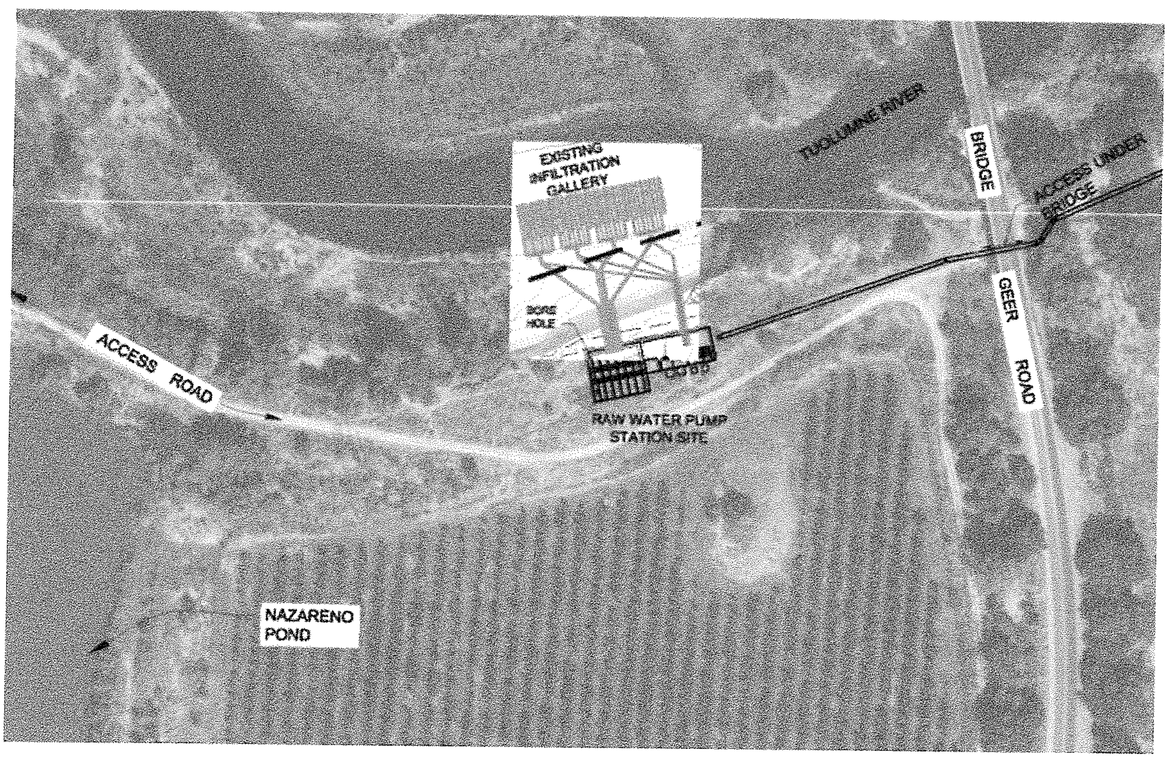


Figure 3. Enlargement of Infiltration Gallery Location on the Tuolumne River

2 - POTENTIAL CONTAMINATION SOURCES

The following potential sources of contamination were identified in the TID Watershed Sanitary Survey (WSS) of the Lower Tuolumne River and Turlock Lake (Brown and Caldwell, 2008), and online visual searches using Google Earth (US Dept. of State Geographer © 2016 Google) between La Grange Dam and the Infiltration Gallery. Locations of the main potential contaminating activities are shown in Figure 4, and discussed below:

- City of Waterford Wastewater Treatment Plant (WWTP). This is the only municipal WWTP in this reach of the River that could impact water quality at the Infiltration Gallery site; the remainder of the study area uses septic systems for wastewater disposal. The WWTP has a capacity of 1 mgd and an average flow of approximately 0.585 mgd. The facility uses four reinforced concrete aeration ponds (128,000 ft^2) on the North side of the River, followed by storage ponds. The effluent from the storage ponds is pumped to four drying beds/percolation basins across (South side) the Tuolumne River. As of 2006, the facility met existing requirements of the Central Valley Regional Water Quality Control Board, but upgrades were needed to meet secondary treatment standards and future discharge standards (City of Waterford, 2006).

- Dairy, Poultry and Ranch Operations[1]. There are a number of dairy, poultry, and ranch operations near the bank of the River: J & T Cattle Co. Bret Warner Ranch, Right Fork Cattle Co., Golding Farms, Hayes Ranch, Donald & Patricia Mason Farm, Sunset Farms, Alberto Dairy, Michel Ranch and Dairy, Foster Poultry Farms, and Jeg Ranch. Only the larger operations are shown in Figure 4.

- Geer Road Landfill. The Geer Road Landfill, which is closed now, is located directly across the river from the site of the Infiltration Gallery. As discussed in the 2008 TID WSS, although there are no active solid waste or hazardous waste disposal facilities within the study area, this closed landfill continues to be regulated by RWQCB waste discharge requirements during its closure (Brown and Caldwell, 2008). Per a Brown and Caldwell Technical Memorandum, the RWQCB does not consider the landfill to be a threat to the water quality of the Tuolumne River (Brown and Caldwell, April 13, 2004). Additionally, results from the Second

[1] According to the United States Department of Agriculture (USDA, 2012), Stanislaus County ranks 7th among California's 58 counties in total value of agricultural products sold, 4th in value of livestock, poultry, and their products, and 3rd in value of sales for both poultry and eggs, as well as milk from cows (4th overall in the United States). In addition to livestock, the top three crops, in terms of land area, grown locally include almonds (3rd in the state and U.S.), forage land (hay and haylage, grass silage, and greenchop; 10th in the state and 84th in the U.S.), and corn for silage (3rd in the state and 4th in the U.S.). In terms of land use, approximately 50% of the county's farmland is pastureland and 44% is cropland.

Semiannual and Annual 2015 Detection, Evaluation and Corrective Action Monitoring Report do not indicate degradation of the Tuolumne River from the landfill site (Tetra Tech BAS, January 2016). Toluene was the only volatile organic chemical (VOC) detected in the Tuolumne River samples collected to monitor the landfill.

- Recreational Areas: There are several recreational areas nearby and in the upper reaches of the Lower Tuolumne watershed, including La Grange Off-Highway Vehicle Use, Basso Bridge River Access, Turlock Lake State Recreational Area, and Fox Grove County Park.
-
- Pesticide and Herbicide Application to Agricultural Areas[1]: Given the large percentage of the watershed dedicated to agriculture, stormwater and irrigation runoff from these areas is a known source of contamination to the River. The Lower Tuolumne River, downstream of Don Pedro Reservoir, is listed as an impaired water body under USEPA Clean Water Act Section 303(d) (California State Water Resources Control Board, 2010).

This sampling plan considers all of these potential contamination sources, so that the future treatment facility will be effectively designed to produce a finished water meeting all State and Federal regulatory standards.

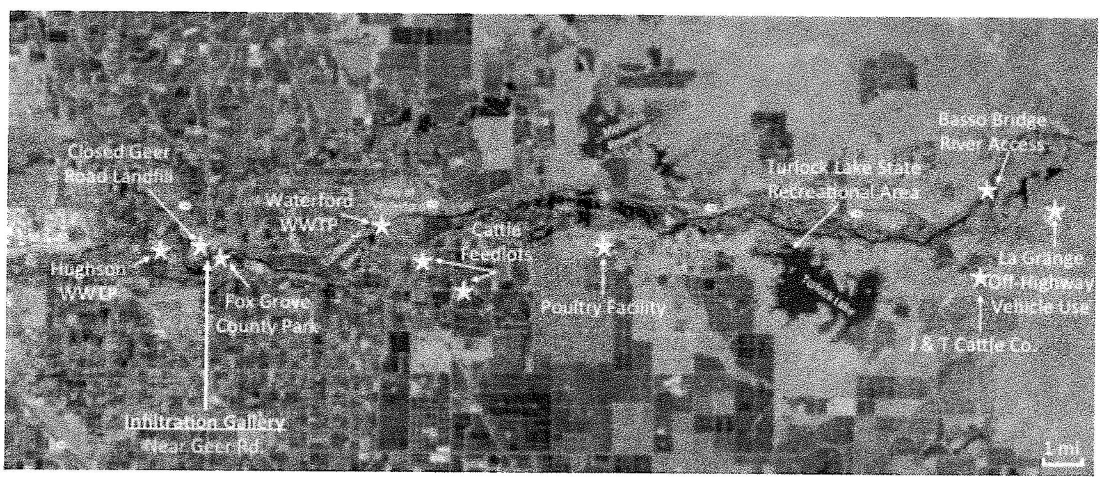


Figure 4. Potential Sources of Contamination in Project Vicinity

3 - HISTORICAL MONITORING LOCATIONS AND WATER QUALITY DATA

As part of the source water characterization process, historical water quality data collected on the Tuolumne River at locations between Don Pedro Reservoir and the confluence of Dry Creek at Modesto were reviewed. These water quality data and any observed temporal or spatial trends in water quality, in relation to treatment train selection and drinking water regulations, are discussed in a separate Technical Memorandum (currently in preparation by Trussell Technologies, anticipated submission in July 2016). These sampling locations are indicated in Figure 5. These historical water quality data have been used in developing the proposed sampling plan, particularly with respect to specific pesticides used in the area and other select constituents related to the potential contaminating activities described above.

The monitoring agencies and corresponding unique ID(s) associated with each of the historic sampling locations shown in Figure 5 are as listed below in Table 1.

Table 1. Historic Sampling Locations in the Lower Tuolumne River Watershed

Monitoring Agency or Reference Document	Location ID	Approx. Miles from Infiltration Gallery[1]	Location Description	Monitored Parameters	Monitoring Dates
USGS California Water Science Center National Water Information System	A	+ 23.9	USGS Station Code 11289650; Upstream of Infiltration Gallery near Old La Grange Bridge	Temperature, Flow from La Grange Dam	Oct 2007 – April 2016
MID Modesto Regional Water Treatment Plant (MRWTP) WSS	B	+ 13.90	Inlet to Modesto Reservoir from La Grange Dam	Cryptosporidium, Giardia	May 2009 – Sept 2012
	C	--	MRWTP raw water intake in Modesto Reservoir	General, Turbidity, TOC, Microbiological, Cryptosporidium, Giardia, Metals,	Jan 2009 – Dec 2012
TID WSS of the Lower Tuolumne River and Turlock Lake, plus additional monitoring data collected May 2007 to April 2008	D	+ 21.7	Near Roberts Ferry Bridge	General, Turbidity, Bromide, Nutrients, Fe, Mn, TOC, DOC, DO, Chlorophyll, Microbiological, Pesticides, SOCs	May 2006 - Oct 2008
	E	+ 13.90	Near Basso Bridge	General, Turbidity, Bromide, Nutrients, Fe, Mn, TOC, DOC, DO, Chlorophyll, Microbiological, Pesticides, SOCs	May 2006 - Oct 2008
SWRCB California Environmental Data Exchange Network (CEDEN)	F	+ 9.45	SWRCB Station Code 535PS0265; Four miles upstream of Hickman Rd.	General, Turbidity, Nutrients (1 data point)	Aug 2009 – Aug 2012
	G	+ 5.71	SWRCB Station Code 535TR5xxx; Waterford Road	Field data, Microbiological, Cryptosporidium, Giardia	Aug 2009 – Aug 2012
	H	+ 0.1	SWRCB Station Code: 535STC218; Fox Grove	Field data, Microbiological, Cryptosporidium, Giardia	Aug 2009 – Aug 2012
TID WSS of the Lower Tuolumne River and Turlock Lake, plus additional monitoring data collected May 2007 to April 2008	I	0	At Infiltration Gallery near Geer Road	General, Turbidity, Bromide, Nutrients, Fe, Mn, TOC, DOC, DO, Chlorophyll, Microbiological, Pesticides, SOCs	May 2006 - Oct 2008
TID Regional Surface Water Supply Pilot Study Report	J	- 2.54	Tuolumne River at Hughson WWTP	General, Fe, Mn, TOC, Turbidity	Sept 2006 – April 2007

Monitoring Agency or Reference Document	Location ID	Approx. Miles from Infiltration Gallery[1]	Location Description	Monitored Parameters	Monitoring Dates
SWRCB California Environmental Data Exchange Network (CEDEN)	K	- 6.96	SWRCB Station Code: 535STC217; Ceres River Bluff Park	Field data, Microbiological, Cryptosporidium, Giardia	Aug 2009 – Aug 2012
City of Modesto – Stormwater Management Program	L	- 7.74	Near Mitchell Road	Nutrients, Microbiological	Feb 2006 – June 2015
SWRCB California Environmental Data Exchange Network (CEDEN)	M	- 9.86	SWRCB Station Code: 535STC216; Modesto City-County Airport at Legion Park	Field data, Microbiological, Cryptosporidium, Giardia	Aug 2009 – Aug 2012

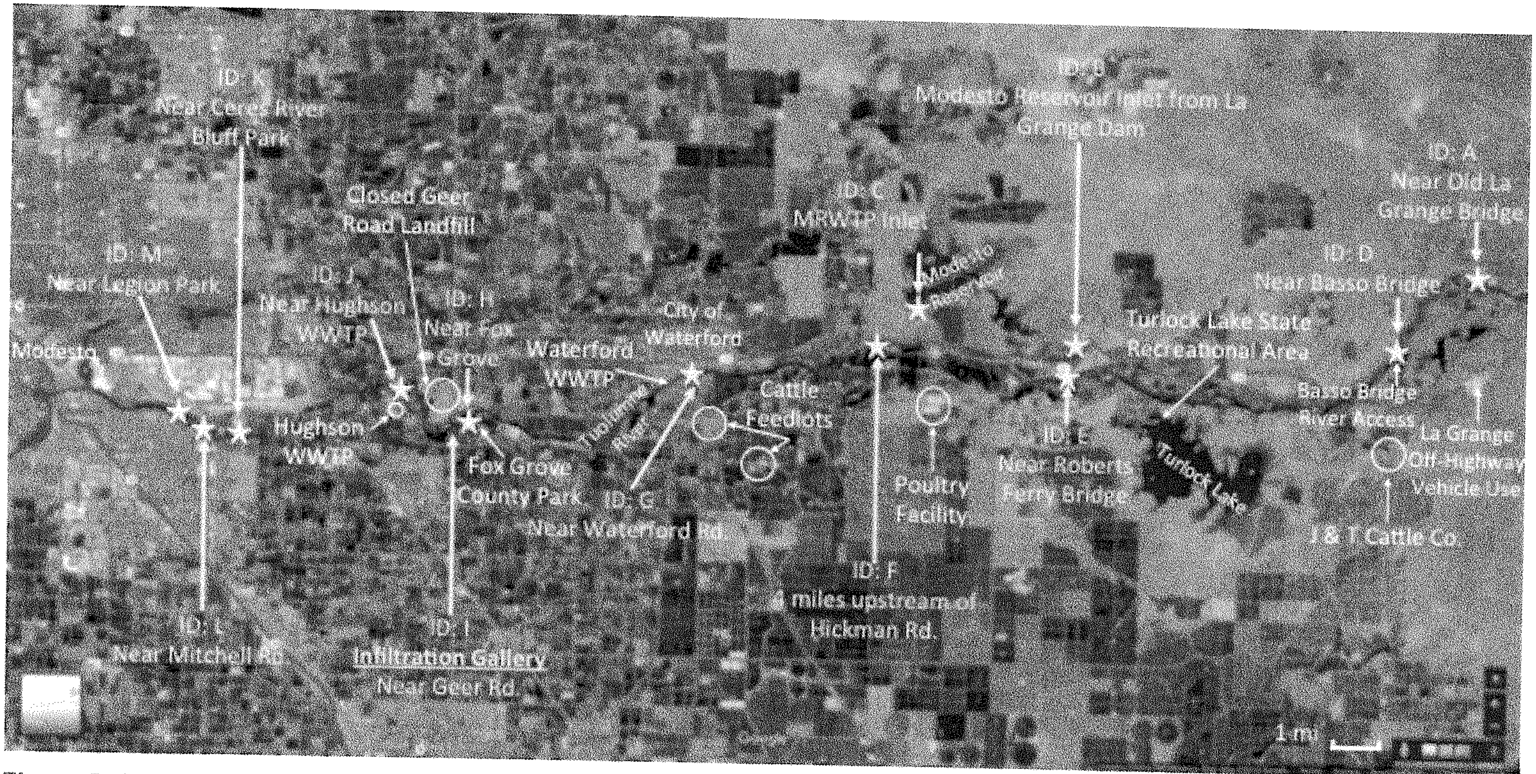


Figure 5. Historic Sampling Locations in Relation to Potential Contaminating Activities

Based on initial review of these historical data, preliminary findings and planned sampling frequencies for select parameters are discussed below:

- **Turbidity**. Turbidity at the Infiltration Gallery site is low—consistently less than 10 NTU—and does not seem to exhibit seasonal fluctuations (Figure 6). It is difficult to tell if or how much the turbidity increases in response to a significant storm event. Additionally, filtration through the rock and gravel media above the Infiltration Gallery is expected to reduce storm related turbidity spikes, should they occur in the River. Given the remote nature of the Infiltration Gallery, the proposed sampling frequency for turbidity is twice per month. However, SRWA plans to operate a pilot Infiltration Gallery at representative flow rates to monitor turbidity and particulate removal through the rock and gravel media, under ambient and simulated high turbidity conditions.

- **Total Organic Carbon (TOC)**. The average TOC concentration at the Infiltration Gallery site is somewhat higher than at upstream locations and downstream locations. The average at the Infiltration Gallery was 3.3 mg/L (ranging from 1.4 mg/L – 6.5 mg/L) versus 2.9 mg/L at Robert Ferry Bridge approximately 14 river miles upstream, and 1.7 mg/L at Mitchell Road downstream near Modesto. The concentrations reported at the Infiltration Gallery location are high enough that disinfection by-product (DBP) formation will be a concern with free chlorine unless TOC reduction is achieved during treatment. According to the 2008 TID pilot report, total trihalomethane (TTHM) formation in samples of raw water (based on a 3 mg/L chlorine dose) was close to 100 micrograms per liter (µg/L), and well above the regulatory limit of 80 µg/L.

  TOC concentrations reported at the Infiltration Gallery location seem uncharacteristically high and variable, as shown in Figures 7 and 8. In order to obtain a better understanding of the TOC levels at this location, and potentially to characterize seasonal and storm related influences, TOC will be measured monthly as part of this monitoring program. These data will aid in evaluating TOC removal requirements under the Enhanced Coagulation component of the Disinfection and Disinfection Byproducts Rule (D/DBPR), which is discussed in more detail later in this document.

- **Ammonia, Nitrite, and Nitrate.** The nitrate levels measured in the study area reflect the presence of upstream cattle and poultry facilities, and possibly the City of Waterford's WWTP percolation ponds. Ammonia (NH_3) and nitrite (NO_2) concentrations at the Infiltration Gallery location were below detection, but nitrate (NO_3) concentrations were measured between 1.3 mg/L and 3.8 mg/L as NO_3 (Figure 9). Nitrate concentrations at the upstream Basso Bridge and Roberts Ferry Bridge sites were below the detection level. These nitrate concentrations measured at the Infiltration Gallery location are not a regulatory concern and nowhere near the primary MCL of 45 mg/L as NO_3. They are, however, indicative of the potential for biological and algae growth in stagnant areas of the river, along with the potential for taste and odor occurrences. Nutrients as well as threshold odor number (TON) are included in the proposed monitoring program.

- **Pesticides and Other Synthetic Organic Chemicals (SOCs)**. Because of the numerous pesticides available on the market for agricultural and residential use, the number of pesticides, herbicides and other SOCs included in this sampling program has been narrowed to focus on only those with an enforceable regulatory limit and those used in the Lower Tuolumne River watershed. The SOCs included in this sampling program include (a) those constituents with a primary or secondary maximum contaminant level (pMCL or sMCL), (b) those detected above the analytical detection limit in the available historical data, and (c) those with high application rates (>5,000 lbs/yr or applied to >10,000 acres) in the watershed. Pesticide application within the Lower Tuolumne River watershed is discussed in a later section of this Sampling Plan. The pesticides and other SOCs measured above their respective analytical detection limits are shown in Table 2. The sources of historical SOC data were TID's 2007-2008 sampling database, the California Department of Pesticide Regulation (CDPR) Surface Water Monitoring of Pesticides database, and the 2007 TID Treatment Process Evaluation TM (Brown & Caldwell, 2007).

- **Total Coliform and E. coli.** The median total coliform concentration at the Infiltration Gallery location (between May 2006 and October 2008) was 130 MPN/100mL, based on 73 data points. Higher total coliform concentrations were reported both upstream and downstream, but with substantially smaller datasets. The median concentration at Waterford Road (5.7 miles upstream) was 1,733 MPN/100mL, and the median concentration at Ceres River Bluff Park (7 miles downstream) was 2,076 MPN/100mL.

  The median *E. coli* concentration at the Infiltration Gallery location was 12.7 MPN/100mL. Higher *E. coli* levels were measured upstream and downstream of the Infiltration Gallery location, but again with significantly fewer data points. A plot of the of median, maximum and minimum E. coli concentrations between Waterford Road (5.7 miles upstream) and Mitchell Road (7.7 miles downstream) are shown in Figure 10.

  In order to effectively characterize the microbial quality of the Tuolumne River at the Infiltration Gallery location, total coliform and *E. coli* samples will be collected twice per month. DDW may elect to follow the DDW Surface Water Treatment Rule Guidance Document for guidelines on additional *Giardia* and virus treatment, depending on measured microbial concentrations. These guidelines are discussed in more detail later in this Sampling Plan. DDW has requested that sampling for these constituents be more frequent than monthly.

Water quality data gathered as part of this proposed sampling program will be compared with the historical water quality data in a follow-up report that will be submitted to DDW as part of the required Source Water Quality Analysis component of the Drinking Water Permit.

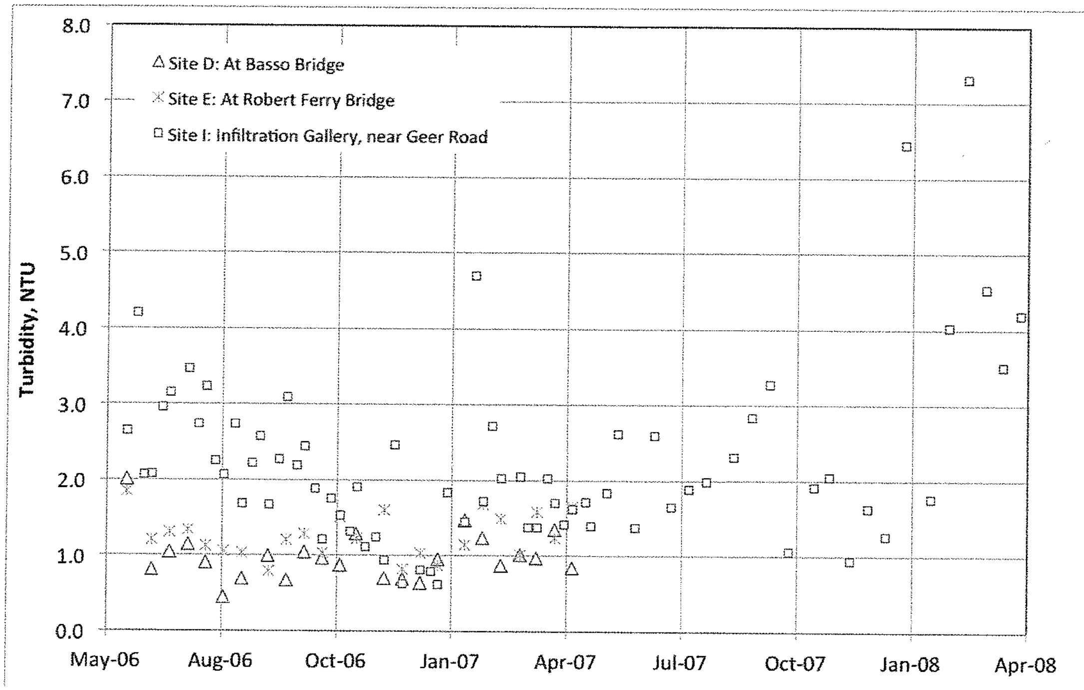


Figure 6. Turbidity of the Tuolumne River Sites D, E, and I Corresponding to TID's Sampling Locations

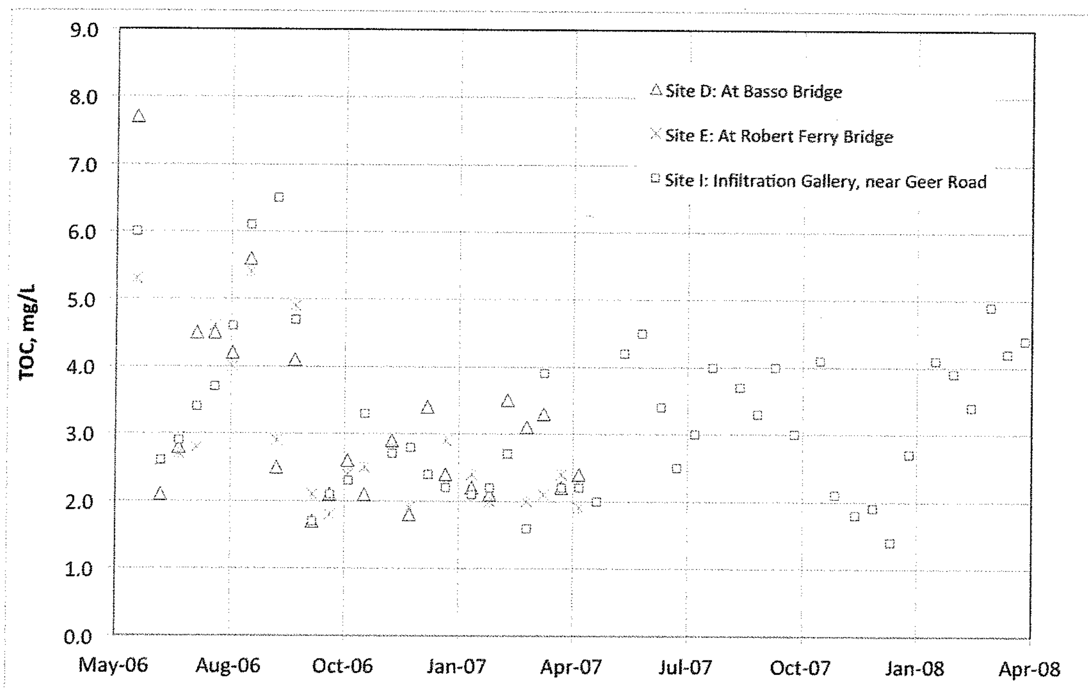


Figure 7. TOC of the Tuolumne River Sites D, E, and I Corresponding to TID's Watershed Sanitary Survey Sampling Locations

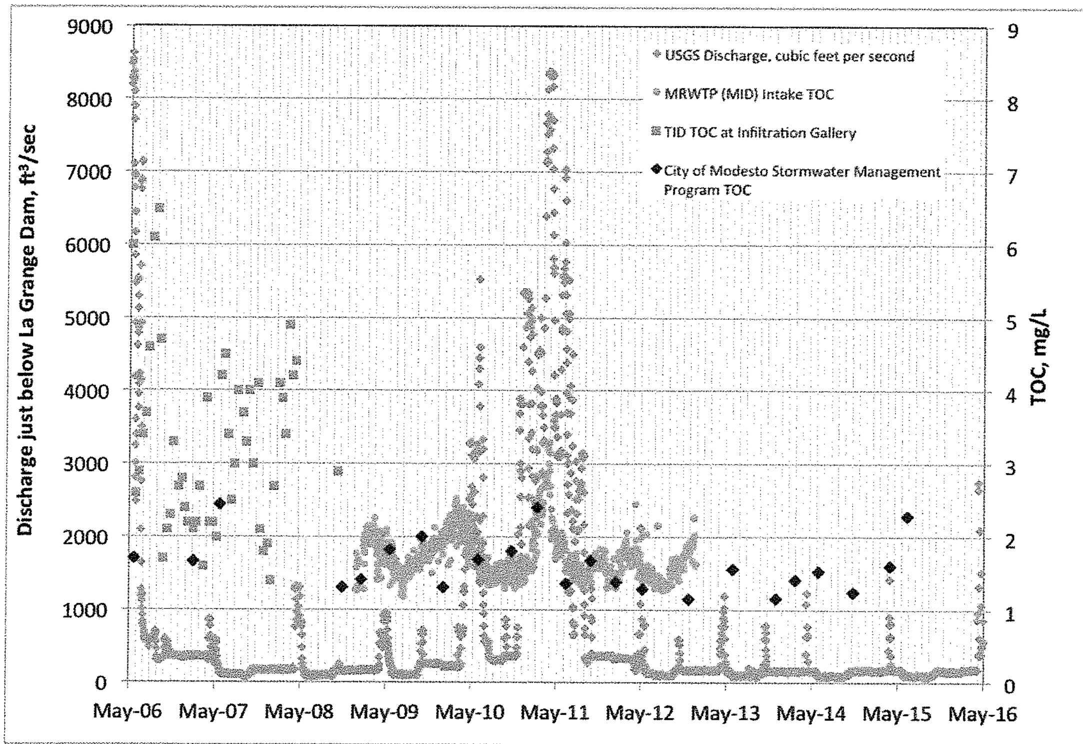


Figure 8. TOC of Modesto Reservoir and the Tuolumne River at the Infiltration Gallery and Downstream Modesto near Mitchell Road

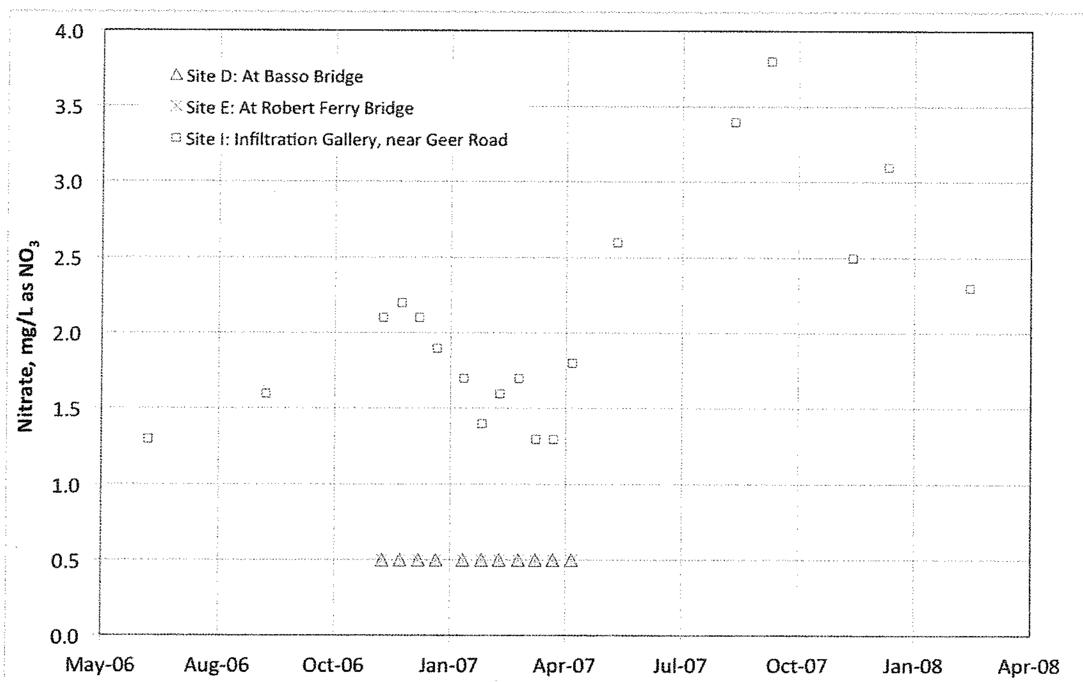


Figure 9. Nitrate of the Tuolumne River Sites D, E, and I Corresponding to TID's Watershed Sanitary Survey Sampling Locations (values plotted at 0.5 mg/L are non-detects)

Table 2. Summary of Detected Pesticides and SOCs on the Tuolumne River, between La Grange Dam and Modesto

Location	Year	Pesticides Detected	Reference
Between La Grange Dam and Modesto	1995	Diazinon Napropamide Simazine Chlorpyrifos Chlorthal-dimethyl Trifluralin	California Department of Pesticide Regulation (CDPR)
Waterford LM Spill; Regional Board Irrigation Lands Monitoring site code: 535MIDWFS	2005 - 2008	Diuron Glyphosate Isoxaben Norflurazon Oryzalin Prodiamine	California Department of Pesticide Regulation (CDPR)
Between La Grange Dam and Modesto	Unknown	Chlorpyrifos Chlorthal-dimethyl Diazinon Malathion Metolachlor Napropamide Simazine	CDPR and reported in 2007 TID Treatment Process Evaluation TM
Fox Grove County Park	2007-2008	2,4-Dichlorophenylacetic acid 3,4-Dinitrotoluene Bis(2-Ethylhexyl) Phthalate EPN (ENT) N-Nitrosopyrrolidine Tert-Butyl alcohol (TBA)	TID Pilot Study and WSS Database

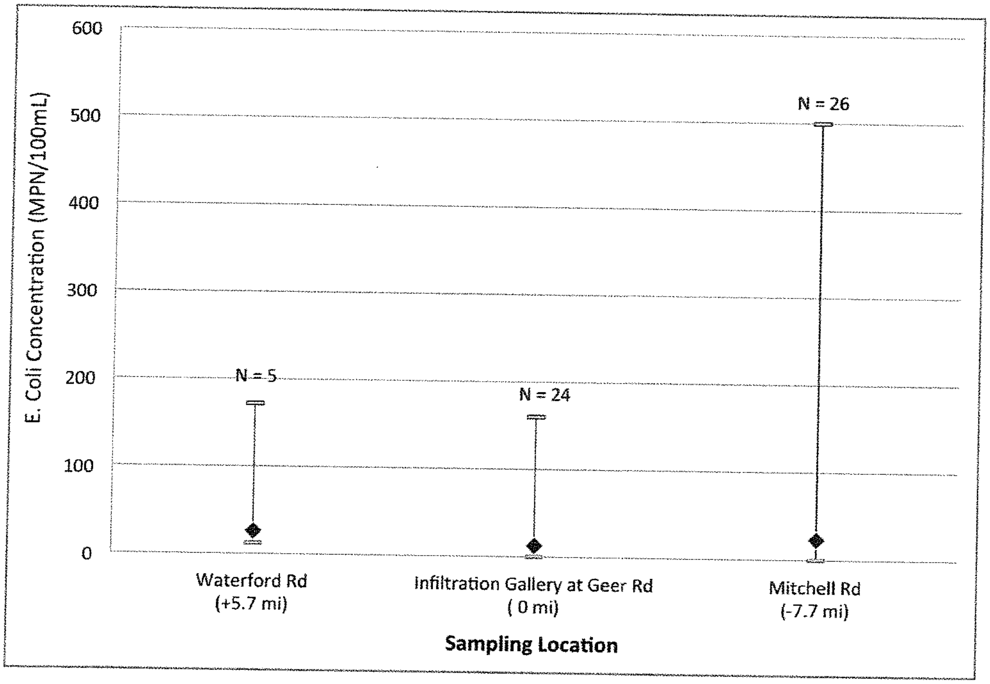


Figure 10. E. Coli Concentrations Measured at the Infiltration Gallery Location and Upstream and Downstream Locations

4 - PESTICIDE USAGE IN THE WATERSHED

As stated in the previous section, the Lower Tuolumne River (downstream of Don Pedro Reservoir) is listed as an impaired water body under USEPA Clean Water Act Section 303(d) (California State Water Resources Control Board, 2010). This designation is largely due to the presence of several pesticides, including chlopyrifos, diazinon, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane - including lindane, endosulfan, and toxaphene), as well as pollution from mercury, water temperature, and an unknown toxicity. As of 2014, total maximum daily loads (TMDLs) were established by the California Regional Water Quality Control Board Central Valley Region to limit diazinon and chlorpyrifos in the San Joaquin River and Sacramento River basins.

The pesticides of local concern for this project were determined through an evaluation of pesticide usage in the local watersheds. CDPR maintains a Pesticide Use Reporting (PUR) database and the most recent available dataset for the project area was from 2014 (CDPR, 2016). The project area was defined using geographic information system (GIS) software (ArcMap 10.3, 2016) to include the Lower Tuolumne River downstream of Don Pedro Reservoir to the confluence with Dry Creek on the east side of Modesto, as well as Turlock Lake, and the Modesto Reservoir. The location information from GIS was used to filter the pesticide use data from the PUR database (CDPR, 2016), from which the top pesticides applied within the project area were determined on the basis of mass (lbs/yr) using a threshold of 5,000 lbs applied per year, as well as by area treated (acres) with a threshold of 10,000 acres treated. These top pesticides are presented in Tables 3 and 4, respectively. The top 5 pesticides used in the project area on a mass basis are further defined by use for specific crops in Table 5.

Of these many pesticides applied in the Lower Tuolumne River watershed, only pesticides with an appropriate analytical method can be included in the sampling program. Eurofins Eaton Analytical Laboratory was used as the "reference" laboratory regarding availability of an analytical method; they are a large State certified commercial laboratory that analyzes for all regulated and potentially future regulated contaminants, along with a long list of pharmaceutical and personal care products (PPCPs). If Eurofins does not have an analytical method for a specific contaminant, it is assumed the contaminant cannot be readily measured and therefore it is not included in the sampling program.

Table 3. Top Pesticides Applied in the Project Area by Mass (CDPR, 2016)

Chemical Name	Mass Applied (lbs/year)	Area Treated (acres)
Mineral Oil [2]	220,210	27,311
Sulfur [2]	113,438	10,443
1,3-Dichloropropene	98,091	319
Methyl Bromide	90,452	286
Glyphosate, Isopropylamine Salt	48,081	31,209
Copper Hydroxide	47,160	14,212
Kaolin [2]	34,514	1,105
Petroleum Oil, Unclassified [2]	33,353	3,283
Glyphosate, Potassium Salt	31,311	14,160
Chlorothalonil	20,133	6,826
Mancozeb [1]	10,373	5,219
Pendimethalin	9,867	4,048
Oxyfluorfen	8,989	28,536
Paraquat Dichloride	8,982	12,122
2,4-D, Dimethylamine Salt	6,932	7,603
Chloropicrin	6,753	125
Copper Sulfate (Basic) [2]	5,167	1,508
Copper Oxide (ous) [2]	5,101	1,036

[1] No method available at reference commercial laboratory, Eurofins Eaton Analytical Laboratory
[2] Not considered a synthetic organic chemical

Table 4. Top Pesticides Applied in the Project Area by Area (CDPR, 2016)

Chemical Name	Mass Applied (lbs/year)	Area Treated (acres)
Bacillus Thuringiensis [1]	155	157,278
Piperonyl Butoxide [1]	155	157,278
Reynoutria Sachalinensis [1]	155	157,278
Streptomyces Lydicus WYEC 108 [1]	155	157,278
Abamectin [1]	572	32,293
Glyphosate, Isopropylamine Salt	48,081	31,209
Oxyfluorfen	8,989	28,536
Mineral Oil [2]	220,210	27,311
Bifenthrin [1]	2,206	19,715
Methoxyfenozide [1]	3,760	15,464
Pyraclostrobin [1]	1,458	15,208
Saflufenacil [1]	546	14,425
Copper Hydroxide [2]	47,160	14,212
Glyphosate, Potassium Salt	31,311	14,160
Boscalid [1]	2,358	12,340
Paraquat Dichloride	8,982	12,122
Sulfur [2]	113,438	10,443

[1] No method available at reference commercial laboratory, Eurofins Eaton Analytical Laboratory
[2] Not considered a synthetic organic chemical

Table 5. Top Five Pesticides Applied in the Project Area by Mass and Crop

Pesticide	Application	Mass Applied (lbs/year)	Area Treated (acres)
Mineral Oil	Almond	179,884	21,624
	Walnut	29,872	4,842
	Peach	5,545	438
	Cherry	3,635	292
	Apple	698	50
	Other	1,274	116
Sulfur	Grape, wine	97,388	8,508
	Peach	9,363	1,172
	Outdoor Transplants	6,320	692
	Other	366	72
1,3-Dichloropropene	Almond	33,783	102
	Walnut	29,793	113
	Outdoor Plants in Containers	18,181	54

Pesticide	Application	Mass Applied (lbs/year)	Area Treated (acres)
	Outdoor Transplants	10,657	33
	Peach	5,677	17
Methyl Bromide	Almond	88,858	273
	Outdoor Plants in Containers	1,177	13
	Walnut	338	–
	Cherry	40	–
	Peach	39	–
Glyphosate, Isopropylamine salt	Almond	31,726	21,039
	Walnut	6,636	4,954
	Corn (Forage - fodder)	2,757	2,146
	Outdoor Plants in Containers	1,982	537
	Grape, wine	1,488	581
	Other	3,491	1,952

5 - SUMMARY OF REGULATORY REQUIREMENTS

Compliance with State and Federal drinking water regulations is a primary driver for process train selection of the new WTP. Consequently, these same regulations are also a primary driver of the constituents selected for this sampling plan. It is important to effectively characterize the quality of this source water in order to design a plant that will produce a high-quality finished water that meets all current drinking water regulations. A summary of these key regulations are discussed in the sections below.

5.1 Maximum Contaminant Levels (MCLs)

The proposed project will be subject to all applicable State of California and Federal drinking water regulations. The constituents with corresponding primary and secondary MCLs are specified in the following sections of Title 22 of the California Code of Regulations.

- §64431 – Maximum Contaminant Levels—Inorganic Chemicals
- §64442 – MCLs and Monitoring – Gross Alpha Particle Activity, Radium-226, Radium-228, and Uranium
- §64444 – Maximum Contaminant Levels – Organic Chemicals
- §64449 – Secondary Maximum Contaminant Levels and Compliance
- §64533 – Maximum Contaminant Levels for Disinfection Byproducts
- §64674 – Lead and Copper Rule – Large Water System Requirements

5.2 Pathogen Treatment

In addition to the MCLs, treatment techniques have been legislated which regulate microbial treatment through removal and disinfection. Microbial contaminant monitoring efforts will be driven by the following regulations:

- Surface Water Treatment Rule (SWTR)
- Total Coliform Rule (TCR)
- Interim Enhanced Surface Water Treatment Rule (IESWTR)
- Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), which requires at least monthly monitoring of *Cryptosporidium*, *E. Coli*, and turbidity over a 2-year period

The SWTR was promulgated in 1989. It required that all public water systems (PWS) using surface water or groundwater under the direct influence of surface water, which practiced conventional or direct filtration, do the following:

1. Achieve 4-log (99.99%) removal/inactivation of viruses and 3-log (99.9%) removal/inactivation of *Giardia lamblia*,
2. Maintain a disinfectant concentration of at least 0.2 mg/L at the entrance to the distribution system, and maintain a detectable disinfectant residual throughout the distribution system, and
3. Maintain a combined filter effluent turbidity less than 0.5 NTU.

The IESWTR, promulgated in 1998, built on the treatment techniques required by the SWTR and required PWSs that filter to achieve a 2-log removal of *Cryptosporidium* by increasing the stringency of the combined filter effluent turbidity standards to 0.3 NTU.

The LT2ESWTR, promulgated in 2006, requires utilities to monitor their source water on a monthly basis for *Cryptosporidium*, *E. coli*, and turbidity. Depending on the maximum running annual average (RAA) *Cryptosporidium* concentration, the water is placed into a "Bin" which dictates the level of treatment required to achieve the required log removal/inactivation of *Cryptosporidium*. Bin classification is summarized in Table 6. The required level of *Cryptosporidium* treatment is determined by the source water's Bin classification and the type of filtration technology employed, as shown in Table 7.

Table 6. Bin Classification as Stipulated Under LT2ESWTR

Bin	*Cryptosporidium* Concentration (oocysts/L)
1	<0.075
2	0.075 to <1.0
3	1.0 to <3.0
4	≥3.0

Table 7. Treatment Requirements for *Cryptosporidium* Treatment Based on Bin Classifications Under LT2ESWTR

Bin Classif-ication	Conventional, Diatomaceous Earth, or Slow Sand Filtration	Direct Filtration	Alternative Filtration Technologies
Bin 1	No additional treatment	No additional treatment	No additional Treatment
Bin 2	1-log treatment[1]	1.5-log treatment[1]	As determined by State[1]
Bin 3	2-log treatment[2]	2.5-log treatment[2]	As determined by State[2]
Bin 4	2.5-log treatment[2]	3-log treatment[2]	As determined by State[2]

[1]Public water systems (PWSs) may use any technology or combination of technologies from microbial toolbox

[2]PWSs must achieve at least 1-log of required treatment using ozone, chlorine dioxide, UV, membranes, bag filtration, cartridge filtration, or bank filtration

In addition to stipulating the overall pathogen treatment requirements, these rules require a multi-barrier treatment approach to ensure effective microbial treatment. The specific treatment credit awarded for pathogen *removal* depends on the filtration technology applied, and the credit awarded for pathogen *inactivation* depends on the disinfectant type, dose and contact time. As such, regardless of the removal credit attained, at least 0.5-log Giardia inactivation and 2-log virus inactivation must be provided.

Although DDW and Federal SWTR regulations require treatment for only 3-log *Giardia* removal/inactivation and 4-log virus removal/inactivation, DDW independently developed a guidance document (Appendix B, DDW SWTR Guidance) at the time the Federal SWTR was being developed, which provides guidance on additional treatment for dirtier waters based on source water total coliform concentrations. This guidance document suggests that more than 3-log *Giardia* treatment and 4-log virus treatment may be needed when the source water mean monthly total coliform concentration is greater than 1,000/100 mL or *E. coli* concentration is greater than 200/100 mL. (A criterion of 1,000 total coliform/100 mL is considered equivalent to 200 fecal coliform/100 mL, which is considered equivalent to 200 *E. coli*/100 mL (NRC, 2004)). DDW has suggested it may follow these guidelines when permitting the new SRWA's WTP.

5.3 Enhanced Coagulation for DBP Control

The Stage 1 Disinfectants and Disinfection Byproducts Rule (D/DBPR), promulgated in 1998, was legislated to minimize the public's exposure through drinking water to potentially carcinogenic disinfection byproducts (DBPs). In addition to setting MCLs for total trihalomethanes (TTHMs), haloacetic acids (HAA5), bromate and chlorite, the D/DBPR set a treatment technique for TOC removal—referred to as "enhanced coagulation"—to reduce DBP formation during disinfection. The amount of TOC removal required by the D/DBP Rule is a function of the source water TOC concentration and alkalinity, as summarized in Table 8. The D/DBP Rule also provides "alternative compliance criteria" which systems have the option of meeting for compliance in lieu of the TOC removal requirement.

Table 8. TOC Removal Required Under the Stage 1 D/DBPR

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0-60	>60-120	>120
>2.0 – 4.0	35%	25%	15%
>4.0 – 8.0	45%	35%	25%
>8.0	50%	40%	30%

6 - PROPOSED WATER QUALITY MONITORING PLAN

All samples will be collected at the same location in the Tuolumne River, near the site of the Infiltration Gallery. The goal is to collect samples as close to the infiltration gallery location as practical. The proposed sampling site, shown in Figure 9, is at the Infiltration Gallery location. The exact location may move slightly depending on site accessibility and field crew safety. Once identified though, the same location will be used throughout the sampling program.

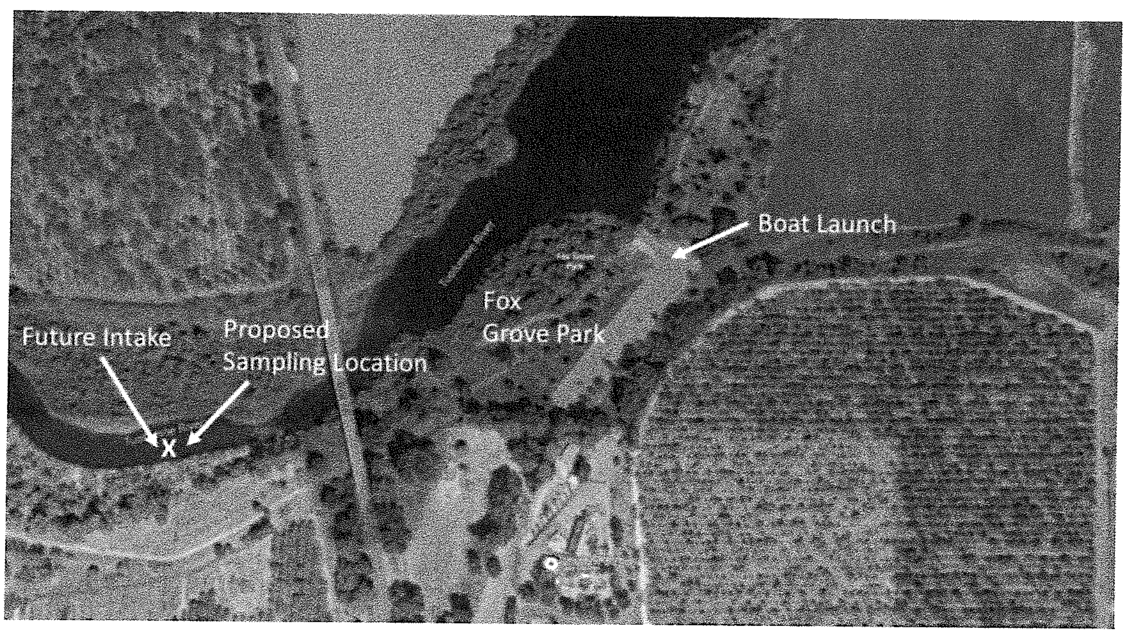
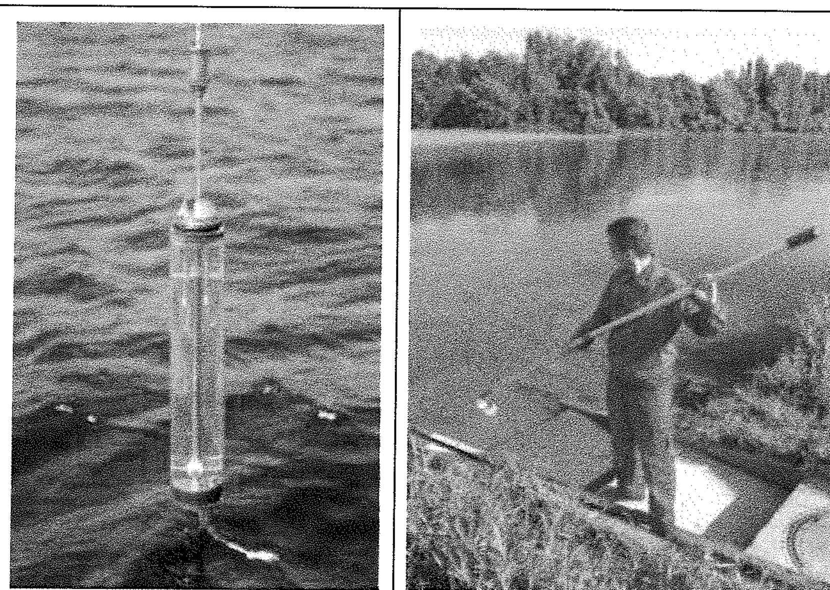


Figure 9. Candidate Sampling Location

6.1 Sampling Collection Methodology

Most samples will be collected from shore with Kemmerer water sampler attached to a pole (Figure 10a). Some constituents in the sampling plan will be sampled quarterly, some monthly, and a select few will be sampled twice monthly. During the bi-monthly sampling trips when only a small volume of water is needed (< 1L), the water will be collected from the shore using some type simple pole/bottle sampling apparatus (Figure 10b). All samples will be collected in the flowing segment of the river, below the surface but off the bottom so as to not pull bottom sediments into the sample that would skew water quality characterization.



(a) Kemmerer Sampler | (b) Pole/Bottle

Figure 10. Water Sampler Alternatives

6.2 Monitored Constituents and Sampling Frequency

Several categories of constituents will be monitored during the first year of sampling. These categories include:

- General water quality parameters needed to assess treatability
- Regulated contaminants with a DDW pMCL or sMCL
- Select unregulated contaminants that are of interest because of potential contamination sources in the watershed
- Select unregulated pesticides and other SOCs with a high usage rate in the watershed
- Select unregulated pesticides and other SOCs that have been detected previously in this reach of the Tuolumne River.

Most constituents will be monitored quarterly for four consecutive quarters (one year), with sampling beginning in Summer or Fall 2016. Quarterly monitoring includes general water quality parameters, all regulated contaminants with a pMCL or sMCL (i.e., inorganic and organic chemicals, radionuclides, and DBPs) and the select group of unregulated pesticides and other SOCs applied to agricultural areas within the watershed or measured in the River during prior monitoring programs.

A few parameters will require monthly sampling. To satisfy the LT2ESWTR requirements, *E. Coli*, *Cryptosporidium* oocysts, and turbidity will be monitored monthly over a period of 24 months. Total coliform and *Giardia* cysts will also be monitored concurrently to characterize microbial contaminating activities in this reach of the Tuolumne River. TOC also will be sampled monthly—concurrent with the LT2ESWTR samples—to assess variation in TOC levels and enhanced coagulation requirements of this source water. Because DDW has expressed that more frequent monitoring may be needed for total coliform and *E. coli*, these parameters will also be sampled every other week (i.e., in between the LT2 sample collection events).

The nitrogen compounds associated with wastewater—ammonia, nitrite and nitrate—will also be sampled monthly. The purpose for monthly rather than quarterly sampling is to assess the impact of the upstream cattle feedlots and poultry facilities, and the upstream Waterford WWTP percolation ponds.

The monitoring frequency for this sampling program is summarized in Table 9 below. The sampling frequency shown in Table 9 is for the first year only (i.e., Phase 1 – Intensive Monitoring), except for the LT2ESWTR parameters, which require 24 months of sampling. Phase 2 of the monitoring program—after the first year of sampling—will be scaled-back and redesigned to accommodate monitoring of any changes in water quality prior to construction and startup of the treatment plant.

Table 9. Summary of Sampling Frequency for each Category of Constituents[1]

Category	Sampling Frequency	Estimated Total Number of Samples
General Water Characteristics (Physical and Chemical)	Quarterly	4
Select Field and Other General Parameters (pH, Temperature, Dissolved Oxygen, Alkalinity, Bromide, Conductivity, Iron, Manganese, TOC, DOC)	Monthly	12
Turbidity[2]	Twice per month	48
Inorganic chemicals with DDW MCLs	Quarterly	4
Organic chemicals with DDW MCLs	Quarterly	4
Radionuclides with DDW MCLs	Quarterly	4

Category	Sampling Frequency	Estimated Total Number of Samples
Microbial Parameters:		
Cryptosporidium[2], Giardia[3]	Monthly	24
Total Coliform[3], E. coli[2]	Twice per month	48
Nitrogen Compounds (NH_3, NO_2, NO_3)	Monthly	12
Select Unregulated Pesticides and SOCs	Quarterly	4

[1] First year of monitoring, except as noted for LT2ESWTR required parameters
[2] Parameters will be sampled monthly for 24 consecutive months, per LT2ESWTR requirements
[3] Not a required parameter for LT2ESWTR, so sampling frequency may be reduced the second year.

The category "Select Unregulated Pesticides and SOCs" includes all pesticides applied to crops within the Lower Tuolumne River watershed, plus constituents measured during prior sampling events, provided that an appropriate analytical method is available. (Regulated pesticides are included in the category of constituents with DDW MCLs). Pesticides applied in the watershed are divided into two categories: (a) high usage based on mass applied per year and acreage covered, and (b) those on one of the candidate future regulatory lists—Unregulated Contaminant Monitoring Rule (UCMR), Candidate Contaminant List (CCL), Notification Level (NL), or archived Notification Level (aNL)—or with a USEPA health advisory (HA) level. Pesticides considered to be high-use were applied at a rate of 5,000 lbs/yr or greater or applied to an area of 10,000 acres or greater.

In addition, the category "Select Unregulated Pesticides and SOCs" includes all pesticides and other SOCs measured in water samples collected within the study area (i.e., between the La Grange dam and the Infiltration Gallery location) since 1995, provided that appropriate analytical methods are available. The amount of data for these constituents is very limited, which is the reason for looking back as far as 1995. Contaminants detected in the River are discussed in more detail in the Water Quality Assessment TM (In preparation by Trussell Technologies, 2016).

After the first year of sampling, the monitoring program will be scaled back to fewer constituents, being limited to those needed for establishing design criteria and those needed to document long-term changes in source water quality. This reduced monitoring program will be submitted to DDW for review and approval, along with a Technical Memorandum summarizing the first year monitoring results.

6.3 Laboratory and Analytical Methods

A detailed list of the constituents to be monitored under each category of this proposed sampling program is shown in Table 10. The corresponding analytical method, regulatory list (where applicable), MCL or Notification Level (NL), Detection Limit for Reporting (DLR), and sampling frequency are also provided for each constituent. A State of California certified laboratory will be used for all analyses.

Table 10. Detailed list of Constituents to be Monitored

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
General Water Characteristics (Physical and Chemical)						
Alkalinity, total	--	SM 2320B	mg/L	--		m
Ammonia	--	EPA 350.1	mg/L	--		m
Bromide	--	EPA 300.0	mg/L	--		m
Calcium	--	EPA 200.7	mg/L	--		q
Chloride	sMCL	EPA 300.0	mg/L	250		q
Color	sMCL	SM 2120B	units	15		q
Dissolved Oxygen (Field Measurement)	--	--	mg/L	--		m
Foaming Agents (MBAS)	sMCL	SM 5540C	mg/L	0.5		q
Iron (total and dissolved)	sMCL	EPA 200.8	mg/L	0.3		m
Magnesium	--	EPA 200.7	mg/L	--		q
Manganese (total and dissolved)	sMCL/NL	EPA 200.8	mg/L	0.05/0.5		m
Nitrate (as N)	pMCL	EPA 300.0	mg/L	10		m
Nitrate + Nitrite (as N)	pMCL	addition	mg-N/L	10	--	m
Nitrite (as N)	pMCL	EPA 300.0	mg-N/L	1	0.4	m
Odor-Threshold	sMCL	SM 6040E	units	3		q
Organic Carbon, Total (TOC)	--	SM5310C	mg/L	TT	0.3	m
Organic Carbon, Dissolved (DOC)		SM5310C	mg/L	--		m
pH	--	SM 4500-H+ B	--	--		m
pH (Field Measurement)						m
Phosphorus (total as P)	--	SM 4500-PE/ EPA 365.1	mg/L	--		q
Potassium	--	EPA 200.7	mg/L	--		q

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Sodium	--	EPA 200.7	mg/L	--		q
Specific Conductance (field measurement)	sMCL	SM 2510B	µS/cm	900		m
Sulfate	sMCL	EPA 300.0	mg/L	250		q
Temperature	--	--	°C	--		m
Total Dissolved Solids (TDS)	sMCL	SM2540C	mg/L	500		q
Total Suspended Solids (TSS)	--	SM2510D	mg/L	--		q
Turbidity	pMCL/sMCL	EPA 180.1	NTU	TT/5		2x/m
Turbidity (field measurement)	pMCL/sMCL	EPA 180.1	NTU	TT/5		m
UV-254	--	SM 5910	cm^{-1}	--		m
Inorganic Contaminants with a primary (p) or secondary (s) MCL (not included in general water characteristics)						
Aluminum	pMCL/sMCL	EPA 200.8	mg/L	1/0.2	0.05	q
Antimony	pMCL	EPA 200.8	mg/L	0.006	0.006	q
Arsenic	pMCL	EPA 200.8	mg/L	0.010	0.002	q
Asbestos	pMCL	EPA 100.2	MFL*	7	0.2	q
Barium	pMCL	EPA 200.8	mg/L	1	0.1	q
Beryllium	pMCL	EPA 200.8	mg/L	0.004	0.001	q
Cadmium	pMCL	EPA 200.8	mg/L	0.005	0.001	q
Chromium (Total)	pMCL	EPA 200.8	mg/L	0.05	0.01	q
Chromium-6 (Hexavalent)	pMCL	EPA 218.6	mg/L	0.010	0.001	q
Copper	pMCL/sMCL	EPA 200.8	mg/L	1.3/1.0	0.05	q
Cyanide	pMCL	SM4500CN-F	mg/L	0.15	0.1	q
Fluoride	pMCL	SM4500F-C	mg/L	2.0	0.1	q
Lead	pMCL	EPA 200.8	mg/L	0.015	0.005	q
Mercury (inorganic)	pMCL	EPA 245.1	mg/L	0.002	0.001	q

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Nickel	pMCL	EPA 200.8	mg/L	0.1	0.01	q
Perchlorate	pMCL	EPA 314.0	mg/L	0.006	0.004	q
Selenium	pMCL	EPA 200.8	mg/L	0.05	0.005	q
Silver	sMCL	EPA 200.8	mg/L	0.1	0.01	q
Thallium	pMCL	EPA 200.8	mg/L	0.002	0.001	q
Zinc	sMCL	EPA 200.8	mg/L	5	0.05	q
* MFL = million fibers per liter; MCL for fibers exceeding 10 µm in length						
Organic Contaminants with a primary or secondary MCL (excludes DBPs)						
1,1,1-Trichloroethane (1,1,1-TCA)	pMCL	EPA 524.2	mg/L	0.200	0.0005	q
1,1,2,2-Tetrachloroethane	pMCL	EPA 524.2	mg/L	0.001	0.0005	q
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	pMCL	EPA 524.2	mg/L	1.2	0.01	q
1,1,2-Trichloroethane (1,1,2-TCA)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,1-Dichloroethane (1,1-DCA)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,1-Dichloroethylene (1,1-DCE)	pMCL	EPA 524.2	mg/L	0.006	0.0005	q
1,2,4-Trichlorobenzene	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,2-Dichlorobenzene	pMCL	EPA 524.2	mg/L	0.6	0.0005	q
1,2-Dichloroethane (1,2-DCA)	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
1,2-Dichloropropane	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
1,3-Dichloropropene [1]	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
1,4-Dichlorobenzene (p-DCB)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
2,3,7,8-TCDD (Dioxin)	pMCL	EPA 1613	mg/L	3.E-08	5. E-09	q
2,4,5-TP (Silvex)	pMCL	EPA 515.4	mg/L	0.05	0.001	q
2,4-Dichlorophenoxyacetic acid (2,4-D) [1]	pMCL	EPA 515.4	mg/L	0.07	0.01	q

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Alachlor	pMCL	EPA 505	mg/L	0.002	0.001	q
Atrazine	pMCL	EPA 525.2	mg/L	0.001	0.0005	q
Bentazon	pMCL	EPA 515.4	mg/L	0.018	0.002	q
Benzene	pMCL	EPA 524.2	mg/L	0.001	0.0005	q
Benzo(a)pyrene	pMCL	EPA 525.2	mg/L	0.0002	0.0001	q
Carbofuran	pMCL	EPA 531.2	mg/L	0.018	0.005	q
Carbon Tetrachloride	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
Chlordane	pMCL	EPA 505	mg/L	0.0001	0.0001	q
cis-1,2-Dichloroethylene	pMCL	EPA 524.2	mg/L	0.006	0.0005	q
Dalapon	pMCL	EPA 515.4	mg/L	0.2	0.01	q
Di(2-ethylhexyl)adipate	pMCL	EPA 525.2	mg/L	0.4	0.005	q
Di(2-ethylhexyl)phthalate (same as Bis (2-ethylhexyl)phthalate [2])	pMCL	EPA 525.2	mg/L	0.004	0.003	q
Dibromochloropropane (DBCP)	pMCL	EPA 551.1	mg/L	0.0002	0.00001	q
Dichloromethane (Methylene chloride)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
Dinoseb	pMCL	EPA 515.4	mg/L	0.007	0.002	q
Diquat	pMCL	EPA 549.2	mg/L	0.02	0.004	q
Endothall	pMCL	EPA548.1	mg/L	0.1	0.045	q
Endrin	pMCL	EPA 508	mg/L	0.002	0.0001	q
Ethylbenzene	pMCL	EPA 524.2	mg/L	0.3	0.0005	q
Ethylene Dibromide (EDB)	pMCL	EPA 551.1	mg/L	0.00005	0.00002	q
Glyphosate [1]	pMCL	EPA 547	mg/L	0.7	0.025	q
Heptachlor	pMCL	EPA 505	mg/L	0.00001	0.00001	q
Heptachlor Epoxide	pMCL	EPA 505	mg/L	0.00001	0.00001	q

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Hexachlorobenzene	pMCL	EPA 505	mg/L	0.001	0.0005	q
Hexachlorocyclopentadiene	pMCL	EPA 505	mg/L	0.05	0.001	q
Lindane	pMCL	EPA 505	mg/L	0.0002	0.0002	q
Methoxychlor	pMCL	EPA 505	mg/L	0.03	0.01	q
Methyl tert butyl ether (MTBE)	pMCL/sMCL	EPA 524.2	mg/L	0.013/0.005	0.003	q
Molinate	pMCL	EPA 525.2	mg/L	0.02	0.002	q
Monochlorobenzene	pMCL	EPA 524.2	mg/L	0.07	0.0005	q
Oxamyl	pMCL	EPA 531.2	mg/L	0.05	0.02	q
Pentachlorophenol	pMCL	EPA 515.4	mg/L	0.001	0.0002	q
Picloram	pMCL	EPA 515.4	mg/L	0.5	0.001	q
Polychlorinated Biphenyls (PCBs)	pMCL	EPA 505	mg/L	0.0005	0.0005	q
Simazine [2]	pMCL	EPA 525.2	mg/L	0.004	0.001	q
Styrene	pMCL	EPA 524.2	mg/L	0.1	0.0005	q
Tetrachloroethylene (PCE)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
Thiobencarb	pMCL/sMCL	EPA 525.2	mg/L	0.07/0.001	0.001	q
Toluene	pMCL	EPA 524.2	mg/L	0.15	0.0005	q
Total Xylenes	pMCL	EPA 524.2	mg/L	1.750	0.0005	q
Toxaphene	pMCL	EPA 505	mg/L	0.003	0.001	q
trans-1,2-Dichloroethylene	pMCL	EPA 524.2	mg/L	0.01	0.0005	q
Trichloroethylene (TCE)	pMCL	EPA 524.2	mg/L	0.005	0.0005	q
Trichlorofluoromethane (Freon 11)	pMCL	EPA 524.2	mg/L	0.15	0.005	q
Vinyl Chloride	pMCL	EPA 524.2	mg/L	0.0005	0.0005	q
Disinfection By-Products						

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Haloacetic acids (HAA5)	pMCL	SM 6251B	mg/L	0.060	--	q
Total Trihalomethanes (TTHMs)	pMCL	EPA 551.1	mg/L	0.080	--	q
Bromate	pMCL	EPA 317.0	mg/L	0.010	0.0010	q
Chlorite	pMCL	EPA 300.0	mg/L	1.0	0.020	q
Radionuclides with an MCL						
Gross Alpha Particle (excluding radon and uranium)	pMCL	EPA 900	pCi/L	15	3	q
Gross Beta Particle	pMCL	EPA 900	mrem/yr	4	4	q
Radium-228 and -226 (combined)	pMCL	GA Method	pCi/L	5	1 for each	q
Strontium-90	pMCL	EPA 905	pCi/L	8	2	q
Tritium	pMCL	EPA 906	pCi/L	20,000	1,000	q
Uranium	pMCL	EPA 200.8	pCi/L	20	1	q
Microbiological						
Cryptosporidium	pMCL	EPA 1623	oocysts/L	TT	--	m
E. coli	pMCL	SM 9223F	MPN/100mL	TT	--	2x/m
Giardia	pMCL	EPA 1623	cysts/L	TT	--	m
Total Coliform	pMCL	SM 9223B	MPN/100mL	TT	--	2x/m
Applied in Watershed - Unregulated, High-Use Pesticides (>5,000 lbs/yr)						
Chloropicrin	aNL	551.1	mg/L	0.05	--	q
Chlorothalonil	HA (1-day)	525.2	mg/L	0.2	--	q
Methyl Bromide	CCL3, CCL4	524.2	--	--	--	q
Oxyfluorfen	CCL3, CCL4	EPA 525.2	--	--	--	q
Paraquat Dichloride	HA (1-day)	549.2	mg/L	0.1	--	q
Pendimethalin	none	525.2	mg/L			q

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Additional Unregulated Pesticides Applied in the Watershed, with a Health Advisory Level or Considered for Future Regulation						
Acephate	CCL3, CCL4	LCMS-MS		--	--	q
Carbaryl	aNL	531.2	mg/L	0.7	--	q
Dimethoate	aNL	525.2	mg/L	0.001	--	q
Diuron	HA (1-day); CCL4	EPA 532	mg/L	1	--	q
Hexazinone	HA (1-day)	EPA 525.2	mg/L	3	--	q
Methomyl	HA (1-day)	531.2	mg/L	0.3	--	q
Metolachlor [2]	UCMR2; HA (1-day)	525.2	mg/L	2	--	q
Permethrin	CCL3, CCL4	525.2		--	--	q
Tebuconazole	CCL3, CCL4	LCMS-MS		--	--	q
Thiamethoxam	UCMR3	LCMS-MS		--	--	q
Thiophanate-Methyl	CCL4	LCMS-MS		--	--	q
Ziram	CCL4	630.1		--	--	q
Additional SOCs Reported in Historical Data						
Diazinon	aNL; HA	EPA 525.2	mg/L	0.0012	--	q
Tertiary butyl alcohol (TBA)	NL	EPA 524.2	mg/L	0.012	--	q
Chlorpyrifos (Dursban)	UCMR4; HA	525.2	mg/L	0.03	--	q
EPTC	UCMR1	525.2		--	--	q
Malathion	aNL; HA	525.2	mg/L	0.16	--	q
Trifluralin	HA (1-day)	525.2	mg/L	0.08	--	q
Select Additional Unregulated Constituents of Interest						
1,2,3-Trichloropropane (1,2,3-TCP)	Forthcoming pMCL, NL	EPA 524.2	mg/L	5.00E-06	5.00E-06	q

Parameter	List	Method	Units	DDW MCL/NL	DDW DLR	Collection Frequency[3]
Footnotes: [1] Also a high-use pesticide in this watershed. [2] Also measured during prior water sampling. [3] m=monthly; q-quarterly, 2x/m=twice per month TT = Treatment Technique pMCL = Primary Maximum Contaminant Level sMCL = Secondary Maximum Contaminant Level NL = DDW Notification Level aNL = DDW Archived Notification Level UCMR = Unregulated Contaminant Monitoring Rule CCL = EPA's Contaminant Candidate List HA = EPA Health Advisory Level Note: Yellow highlighted methods in this final version of the Source Water Sampling Plan are different from the Draft version based on information provided by Eurofins Eaton Analytical Laboratory.						

7 - REFERENCES

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Brown and Caldwell (2008). *Turlock Irrigation District Watershed Sanitary Survey of the Lower Tuolumne River and Turlock Lake.*

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City of Waterford Planning Department (2006). *The City of Waterford General Plan Program Environmental Impact Report,* Vision 2025 General Plan Update Program EIR.

National Research Council, 2004, Indicators For Waterborne Pathogens, National Academies Press, Washington. D.C.

Tetra Tech BAS, January 2016. *Second Semiannual and Annual 2015 Detection, Evaluation, and Corrective Action Monitoring Report.*

Trussell Technologies (September 7, 2016). *Tuolumne River Water Quality Assessment for the Stanislaus Regional Water Authority Water Supply Project,* Technical Memorandum.

SRWA
Stanislaus Regional Water Authority

Item 7F
Board Synopsis
September 22, 2016

From: Michael Brinton, Interim General Manager

Prepared by: Michael Brinton, Interim General Manager

1. ACTION RECOMMENDED:

Motion: Approving Amendment No. 1 to the Agreement for Special Services with West Yost Associates for Raw Water Sampling and Analysis for an amount not to exceed $105,000.

Resolution: Appropriating $105,000 to account number 950-53-552.43060_012 "Contract Services – Program Management Services" to be funded via equal contributions from SRWA participating agencies.

2. DISCUSSION OF ISSUE:

In order to operate a drinking water system, agencies must obtain a domestic water supply permit from the State of California. A source water quality analysis is a required component of the application. Improved knowledge of the characteristics of the water supply assists in process train selection and facilitates treatment system design.

The Stanislaus Regional Water Authority (SRWA) project representatives, along with their program management consultant (West Yost Associates) and their treatment process consultant (Trussell Technologies, Inc.), met with the Division of Drinking Water (DDW) on June 29, 2016. The purpose of the meeting was to introduce DDW to the SRWA's Surface Water Supply Project, review historical water quality data, and present a draft sampling plan for source water characterization. The intent of this initial discussion was to receive preliminary feedback from DDW prior to formal submittal of the Draft Sampling Plan for DDW's review and consideration.

On July 14, 2016, Trussel Technologies finalized the Water Quality Sampling Plan based on the input from DDW provided at the June 29, 2016 meeting. In essence, the Sampling Plan establishes which constituents have to be sampled and how often.

The sooner we know more about the quality of the river water, the sooner the Board can make decisions on the construction of the water treatment plant. After the Wet Well is completed, the water samples will be collected through the Wet Well. In the meantime, samples will be taken directly from the river. This sampling procedure will allow decisions to be made at a much earlier date.

The requested SRWA Board action allows West Yost to award a subcontract to Fishbio and Eurofins Analytical in an amount Not to Exceed One Hundred Five Thousand Dollars ($105,000) to conduct raw water sampling and analysis for source water characterization.

3. FISCAL IMPACT / BUDGET AMENDMENT:

The total cost of this amendment is $105,000 which will be split evenly between the cities of Ceres and Turlock. This project was not contemplated when the 2016-17 budget was approved; therefore, if the contract amendment is approved, a budget amendment is necessary. Staff requests the approval of an appropriation of $105,000 to account number 950-53-552.43060_012 "Contract Services – Program Management Services" to be funded via contributions from the SRWA's current participating agencies (Ceres and Turlock). The additional cost will be split 50/50 between each agency in accordance with the JPA Agreement.

4. INTERIM GENERAL MANAGER'S COMMENTS:

Recommend approval.

5. ENVIRONMENTAL DETERMINATION: N/A

6. ALTERNATIVES:

The alternative would be to postpone testing of the raw water until a later date which would result in delays in completing the treatment facility design and construction.

SRWA
Stanislaus Regional Water Authority

AMENDMENT NO. 1
to the
AGREEMENT FOR SPECIAL SERVICES
between
STANISLAUS REGIONAL WATER AUTHORITY
and
WEST YOST ASSOCIATES
for
PROGRAM MANAGEMENT SERVICES

THIS AMENDMENT, dated September 22, 2016, is entered into by and between the **STANISLAUS REGIONAL WATER AUTHORITY**, a Joint Powers Authority of the State of California, hereinafter referred to as "SRWA" and WEST YOST ASSOCIATES, a Consulting Engineering Firm, hereinafter referred to as "CONSULTANT".

WHEREAS, the parties hereto previously entered into an agreement dated April 13, 2016, whereby CONSULTANT will perform program management services (hereinafter the "Agreement").

NOW, THEREFORE, the parties hereto mutually agree to amend said Agreement as follows:

1. Paragraph 1 of the Agreement is amended to read as follows:

   "1. **SCOPE OF SERVICES:** CONSULTANT shall undertake and complete the preparation of the scope of work as set forth and described in the documents attached to the Agreement as Exhibit A and the additional scope of work as set forth and described in the documents attached to this Amendment No. 1 as Attachment A. The CONSULTANT shall perform the services as described in Exhibit A and Attachment A in a manner compatible with the standards of its profession, and shall produce a fully complete project that is acceptable to the SRWA."

2. Paragraph 4 of the Agreement is amended to read as follows:

   "4. **COMPENSATION:** SRWA agrees to pay CONSULTANT additional compensation in the amount of **One Hundred Five Thousand Dollars ($105,000.00)** in accordance with Attachment B attached hereto and made a part hereof. The compensation for completion of all items of work, as set forth in the Agreement and this Amendment No. 1 shall not exceed **Two Million One Hundred Twelve Thousand Four Hundred Seventy-Two Dollars ($2,112,472)** which includes a ten percent contingency as set forth in the Agreement. Such maximum amount shall be compensation for all of CONSULTANT's expenses incurred in the performance of the Agreement and this Amendment No. 1."

3. Paragraph 5 of the Agreement is amended to read as follows

"5. **TERM:** This Agreement shall become effective April 15, 2016, and end upon satisfactory completion, as determined by the SRWA, of the entire Scope of Work as set forth in the Agreement and this Amendment No. 1."

All other terms and conditions of the Agreement shall remain in full force and effect.

IN WITNESS WHEREOF, the parties have caused this Agreement to be executed by and through their respective officers thereunto duly authorized.

STANISLAUS REGIONAL WATER AUTHORITY,
a Joint Powers Authority

By __________________________
Gary Soiseth, Board Chair

Date ________________________

APPROVED AS TO FORM:

By __________________________
Phaedra A. Norton, Interim General Counsel

Date ________________________

ATTEST:

By __________________________
Tish Foley, Board Secretary

Date ________________________

WEST YOST ASSOCIATES,
a Consulting Engineering Firm

By __________________________

Name ________________________

Title ________________________

Date ________________________

Attachment "A"

ADDITIONAL SCOPE OF WORK

Raw Water Sample Collection by Fishbio

As delineated in the finalized Sampling Plan, nearly 150 individual parameters must be sampled and analyzed at frequencies ranging from bi-weekly to quarterly. The majority of the parameters are to be sampled and analyzed quarterly over a 12-month period, while the remaining parameters will be sampled over a 24-month period at varying frequencies. The parameters can be broadly categorized as follows:

- General water quality characteristics (physical and chemical)
- Inorganic contaminants
- Organic contaminants
- Disinfection byproducts
- Radionuclides
- Microbiological contaminants
- Pesticides
- Additional synthetic organic chemicals

Samples will be collected directly from the Tuolumne River, in the area above the existing buried infiltration gallery. Sample containers will be labeled, packaged in ice coolers and either handed off to a courier or transported to a local express shipping facility for shipment to the analytical laboratory.

Laboratory Analysis of Raw Water Samples by Eurofins Analytical

Samples collected during each of the sampling events will be analyzed in an appropriately certified laboratory according to the analytical methods identified in the Sampling Plan. Samples will be collected, shipped and analyzed within the specified holding times. The analytical laboratory will be responsible for preparing, labeling and shipping to the sample collection company all of the sample vessels and ice coolers necessary to complete each sampling event, along with chain-of-custody forms. The analytical laboratory will also be responsible for all courier and shipping fees necessary to transmit the physical samples collected by Fishbio to the appropriate laboratory location.

Attachment "B"

COMPENSATION

The sampling company, **Fishbio**, will complete the sampling work as a subconsultant to West Yost Associates for an amount of $39,000.

The analytical laboratory, **Eurofins Analytical**, will complete the analytical work as a subconsultant to West Yost Associates for an amount of $66,000.

SRWA

Stanislaus Regional Water Authority

BEFORE THE BOARD OF THE STANISLAUS REGIONAL WATER AUTHORITY

IN THE MATTER OF APPROPRIATING $105,000 TO ACCOUNT NUMBER 950-53-552.43060_012 "CONTRACT SERVICES - PROGRAM MANAGEMENT SERVICES" TO BE FUNDED VIA EQUAL CONTRIBUTIONS FROM SRWA PARTICIPATING AGENCIES	**RESOLUTION NO. 2016-xxx**

WHEREAS, on March 24, 2016 the SRWA Board selected West Yost Associates as the best qualified consultant to provide Program Management Services for the SRWA; and

WHEREAS, by a separate action, the SRWA Board approved an agreement between the SRWA and West Yost Associates for Program Management Services in an amount not to exceed $2,007,472; and

WHEREAS, on September 22, 2016, the SRWA Board approved the recommendation by West Yost to award a subcontract to Fishbio and Eurofins Analytical in an amount Not to Exceed One Hundred Five Thousand Dollars ($105,000) to conduct raw water sampling and analysis for source water characterization; and

WHEREAS, this project was not contemplated when the 2016-17 budget was prepared; therefore a budget amendment is now necessary.

NOW, THEREFORE, BE IT RESOLVED that the Board of the Stanislaus Regional Water Authority does hereby appropriate $105,000 to account number 950-53-552.43060_012 "Contract Services – Program Management Services". The cost for this appropriation will be split evenly 50/50 between the current SRWA participating agencies in accordance with the JPA Agreement.

PASSED AND ADOPTED at a regular meeting of the Board of the Stanislaus Regional Water Authority this 22nd day of September, 2016, by the following vote:

AYES:
NOES:
NOT PARTICIPATING:
ABSENT:

ATTEST:

____

Tish Foley, Board Secretary