Luhdorff & Scalmanini
Consulting Engineers

Technical Memorandum

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SUBJECT: **WILD WINGS COUNTY SERVICE AREA (CSA) PUBLIC WATER SYSTEM ARSENIC TREATMENT SYSTEM DESIGN TASK 2 – CONCEPTUAL TREATMENT OPTIONS**

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1. INTRODUCTION

This technical memorandum (TM) is the second prepared by Luhdorff & Scalmanini Consulting Engineers (LSCE) for the County of Yolo (County) as part of the Task 2 scope of work for design of an arsenic treatment system for the Wild Wings County Service Area (CSA) Public Water System. The first TM (Task 1 TM) provided a summary of the estimated water demand requirements for the Wild Wings CSA from an analysis of available water production records. The water requirements in the Task 1 TM are the basis for water demand and arsenic treatment system discussed in this memo.

This Task 2 TM develops conceptual arsenic treatment system options and operational strategies for removal of arsenic and improvement of overall water quality and reliability in the system. The arsenic treatment system options in this memo will be further developed in Task 3 where LSCE will obtain technical information from vendors that supply treatment systems. This Task 2 TM includes a description of existing water quality, treatment system capacity, arsenic treatment alternatives, and preliminary conclusions and recommendations.

1.1 Existing System

The Wild Wings CSA public water system serves a population of approximately 913. The CSA provides water for 337 residences, the golf course buildings, the pool building, common landscape areas, golf course landscape irrigation, the Watts-Woodland Airport, and supplementary water for stormwater retention ponds. The system uses potable (treated) water for the domestic water supply and non-potable (untreated) water for irrigation and ponds. Non-potable water for golf course irrigation and stormwater retention ponds are only used in the dry summer months.

The CSA maintains and operates two groundwater well and storage stations referred to as the Pintail well and Canvas Back well (Table 1). The Pintail well was drilled to a depth of 1,100 feet and has a capacity of 1,200 gallons per minute (gpm). The Canvas Back well was drilled to a depth of 440 feet and has a capacity of 1,400 gpm.

Each well is equipped with a 100-horsepower pump and is enclosed in a building. Each station has a 360,000-gallon storage tank, two booster pumps, a hydropneumatic (pressure) tank and chlorination equipment to supply treated water to the domestic system (potable demand). The well and storage stations are also connected to a raw water pipeline that can be used to feed the golf course lakes and the wastewater treatment plant recycled water pond (non-potable demand) or feed raw water from one well station to another to fill either tank if a well is offline. Each storage tank also has a system fill-mode that can take treated water from the distribution system to fill the tank, which is another way both tanks can be utilized if one of the wells were out-of-service.

The well and storage stations have multiple operational modes for water supply. In pump-to-waste mode water is discharged from the well to the storm drain, during startup and shutdown of the well. In domestic mode water is chlorinated, delivered to the onsite tank and then on to the distribution system using the booster pumps. In raw water mode water is directed from the well to the raw water pipeline. In system fill mode the storage tank is being filled from the distribution system.

Table 1: Well and Pump Information

Source	Status	Capacity (gpm)	Well Depth (ft)	Drilling Date	Pump
Canvas Back	Standby	1400	440	8/27/2003	100 HP Vert. Turbine
Pintail	Active	1200	1,100	9/10/2003	100 HP Vert. Turbine

2. WATER QUALITY

In 2009, the Canvas Back well was placed on “emergency standby” status by the State Water Resources Control Board Division of Drinking Water (SWRCB-DDW) for arsenic concentrations above the Primary Drinking Water Standard Maximum Contaminant Level (MCL) of 10 micrograms per liter (µg/L). The Canvas Back well has since provided non-potable water for irrigation and occasional filling of stormwater retention ponds. It has also been used for domestic water during periods when the Pintail well was offline for maintenance. The emergency standby status limits the use of the Canvas Back well in the domestic system to a maximum of five consecutive days of operation or 15 total days out of the year. This impacts the reliability of water supply, as the system is reliant on one well (Pintail) and must limit maintenance on that well to less than five (5) consecutive days. Therefore, it is necessary to treat water from the Canvas Back well to have arsenic levels below the MCL and provide a reliable supply of water for the Wild Wings CSA.

2.1 Occurrence of Arsenic and Manganese

Water quality records from 2003-2017 were reviewed for both wells. Arsenic and manganese are present at concentrations near or exceeding regulatory limits in the groundwater produced from both wells. For drinking water systems, CalEPA adopted a primary maximum contaminant level (MCL) for arsenic of 10 µg/L to and a secondary MCL for manganese of 50 µg/L. No other constituents were detected at levels approaching regulatory limits in either well.

Figures 1 and **2** (below) present historic results of arsenic and manganese, respectively, for both wells. A detailed listing of water quality results, both historic and recent, is presented in Appendix A.

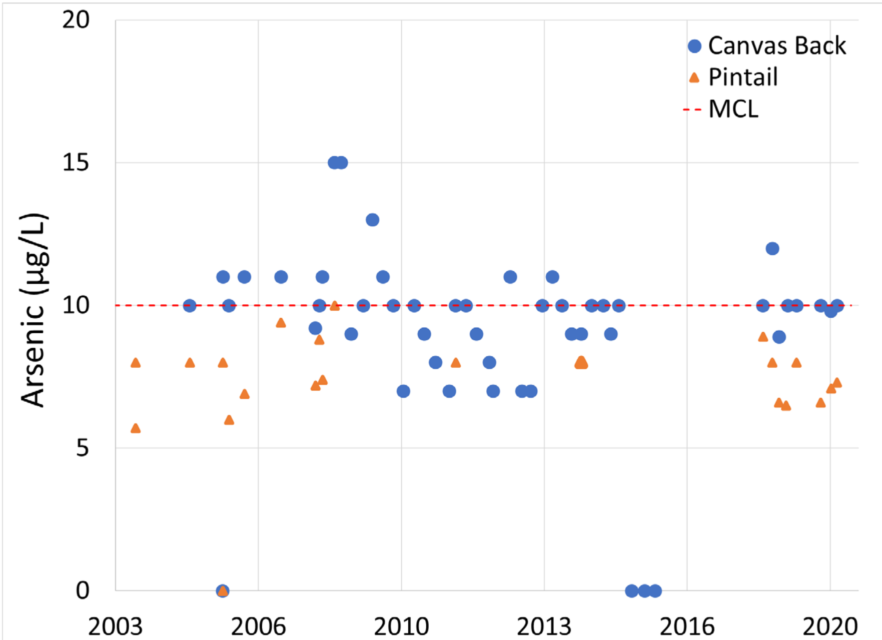


Figure 1: Historic Arsenic Concentrations

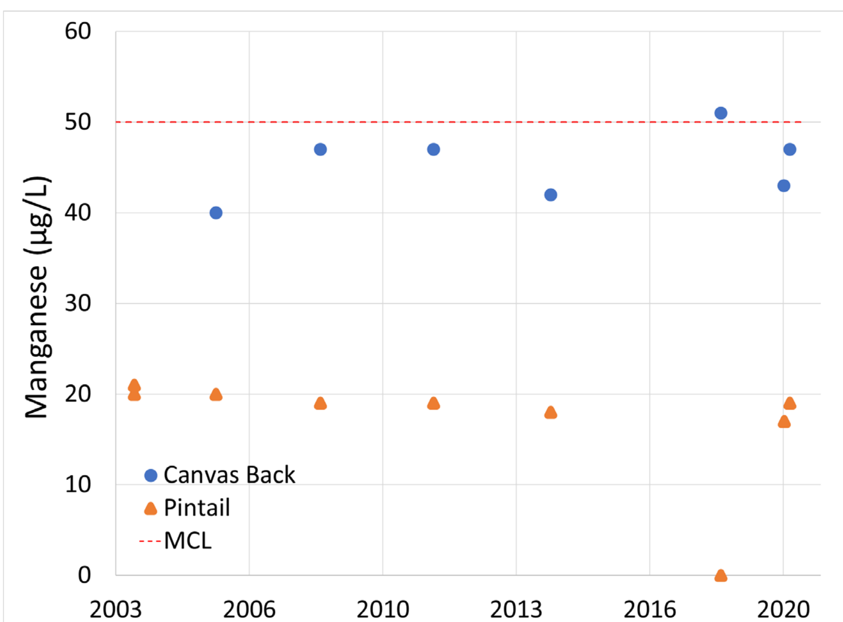


Figure 2: Historic Manganese Concentrations

2.2 Target Water Quality for the Canvas Back Well

Arsenic

Arsenic is a carcinogen and regulated by a primary MCL. California revised the primary MCL for arsenic to 10 ug/L from 50 ug/L in 2008. The current public health goal (PHG) for arsenic is 4 ug/L, corresponding to a "de minimis cancer risk". Arsenic is common in drinking water sources in California. For drinking water permitting purposes, the requirement is to provide water with arsenic below 10 ug/L.

In the Canvas Back well, arsenic levels range from 7 µg/L to 15 µg/L and more than half of the results are above the MCL of 10 ug/L. Canvas Back well requires treatment to meet the arsenic MCL. Considering the fluctuation over time and possible future increases in concentration of arsenic, a target of half the MCL (5 ug/L) was selected for the current system design.

In the Pintail well, arsenic levels range from 5.7 µg/L to 8.8 µg/L. The Pintail well has never exceeded the MCL for arsenic and therefore arsenic treatment is not required and no target was chosen for that well.

Manganese

From a public health perspective, manganese is not considered a toxic element. However, in water it is known to cause offensive color, taste and odor concerns, in addition to maintenance issues associated with build-up in infrastructure. For control of aesthetics, the CalEPA enforces a secondary MCL of 50 ug/L in drinking water systems. Utilities may meet secondary MCL standards on a running annual average. Many utilities set target concentrations for manganese in finished water of less than 20 ug/L. This is to minimize the effects of precipitating solids in the distribution system that later mobilize at higher concentrations resulting in customer complaints.

In the Canvas Back well, manganese levels range from 40 -51 ug/L, which has resulted in accumulation in the system that lead to customer complaints. Treatment is not required at the Canvas Back well because the running annual averages have always been below the MCL; however, reduction of manganese would improve water quality.

In the Pintail well, manganese levels range from 17-21 ug/L, which is below the levels that might cause issues in the system.

3. TREATMENT CAPACITY

The previous Task 1 TM evaluated the water demand of the Wild Wings CSA water system. The required treatment system capacity was determined based on water demand information presented in TM 1.

The required capacity of wells, storage, and booster pumps in the water system are determined based on the need to meet the Maximum Day Demand (MDD) and Peak Hour Demand (PHD). The Wild Wings CSA uses its wells to meet the potable water system demand in addition to a non-potable demand, as described in the Task 1 TM and summarized below (**Table 2**). Daily demand volumes are presented as million gallons per day (MGD) and an average flow in gallons per minute (gpm).

Table 2: Water System Demand

Water Uses	Maximum Day Demand (MDD)		Peak Hour Demand (PHD)
	MGD	gpm	gpm
Potable Demand	0.64	445	695
Non-Potable Demand	0.98	680	1,285

The two well sites maintain the water supply and storage in the potable system as follows. Each well is operated to fill the onsite storage tank with treated (chlorinated) water for potable supply. The booster pumps at each tank are operated to maintain pressure in the potable system using the water from the storage tank. If one well is offline, both tanks would still be used in regular operation to meet potable demands either by using the raw water pipeline from the other well or the distribution system fill connection.

The storage tanks and booster pumps must be able to meet the PHD of the potable system of 695 gpm. This is considered peak instantaneous flow of the potable. The wells must be able to meet the MDD to keep the tanks full throughout a day. Canvas Back and Pintail wells can supply 1,400 and 1,200 gpm, respectively, which means each well can supply more than twice the MDD. The wells have ample capacity. If the wells were operated at the MDD flow of 445 gpm, then there would need to be a volume of storage to account for "peaking" volume, which would be approximately 60,000 gallons to balance a 4-hour period of PHD. At their rated capacities, the wells exceed the PHD and thus a peaking storage volume is not necessary.

The total storage in the system is 720,000 gallons which exceeds the MDD of 640,000 gallons. The volume in storage can supply one day of maximum demand with both wells offline. Storage is also required to supply a reserve for fire flows in the system, which is set at 1,500 gpm for 2 hours or 180,000 gallons. The combined volume of MDD and fire storage is 820,000, which cannot be met from the existing tanks. The storage in the system is sufficient to provide the fire flows so long as at least one well is in operation.

As noted in TM #1, the wells must meet the daily requirements MDD of the potable and non-potable demands combined. The PHD of each demand is not additive because the wells can be controlled on the timing of use throughout a day to meet each demand. The combined maximum daily demand of the potable system and non-potable system is 1.6 MGD (**Table 2**). The Canvas Back well can produce 2.0 MGD (1,400 gpm) and the Pintail well can produce 1.7 MGD (1,200 gpm). Therefore, each well has the capacity to meet the potable and non-potable demands.

Based on the above operational description, the minimum capacity for a treatment system on the Canvas Back well would be to supply the MDD of the potable water system, or 445 gpm. While Canvas Back can produce 1,400 gpm, sizing of a treatment system would target the smaller MDD value for cost and spacing considerations. The nominal treatment capacity will be 500 gpm. Canvas Back can be used in a split flow configuration where potable demands are met by the 500 gpm treated flow and the non-potable irrigation demands are met through the untreated raw water line. Due to the wide variation of flows this would result in from Canvas Back (500 gpm to 1,400 gpm), a variable frequency drive (VFD) would be added to the well controls.

4. ARSENIC TREATMENT ALTERNATIVES

LSCE reviewed several options to mitigate the problem of arsenic at the Canvas Back well. The alternatives for arsenic treatment that are discussed below include:

1. Construction of a New Well
2. Blending Without Treatment
3. Arsenic Treatment Options (Coagulation/Filtration and Adsorption)
4. Combination of Arsenic Treatment and Blending

4.1 Construction of a New Well

Conceptually, Canvas Back could be replaced with a new production well. The CSA owns a parcel of land at the northwest corner of the Wild Wings CSA that could be used to host a new well and storage tank. As described above, the wells are completed at different depths, however, arsenic is present in both aquifer formations as is evident from the water quality results. Arsenic will most likely be present in any new well constructed in this area, and there is no guarantee that it will be below the MCL. The cost of a new well and pump station would likely exceed $2 million, while adding a treatment system to the existing well station would cost approximately $1 million. In addition, the existing wells can already meet the system MDD and have a remaining service life of more than fifty (50) years. Based on these factors, the option to drill a new well is generally not favorable in comparison to an arsenic treatment alternative.

4.2 Blending Without Treatment

Blending of water from both wells would allow Pintail, that has lower arsenic, to mix with Canvas Back to decrease the combined arsenic levels. This would consist of pumping water from both wells to one of the storage tanks. Canvas Back could pump through the raw water line to the Pintail site and blend in one tank prior to being sent to the distribution system. In this scenario, Pintail and Canvas Back would operate off levels in the Pintail tank. The tank at the Canvas Back site would be filled on the distribution system fill valve during low water demands. SCADA control logic changes would be required, but both sites are equipped with the components required to accomplish this change.

Blending without any treatment is not feasible because if Pintail is out-of-service for an extended period, Canvas Back would not produce water that meets the arsenic MCL standard. Furthermore, the blending concentrations without any treatment are not favorable. With Pintail having arsenic as high as 8.8 μg/L and Canvas Back as high as 15 μg/L, keeping the blended concentration below the MCL would require approximately 200 gpm from Canvas Back, which is likely not realistic with the existing pump even with a VFD.

Another blending alternative includes the addition of a third storage tank in the system to increase overall storage and lengthen the time that a well can be offline. Increasing storage with a purpose to avoid treatment would be cost prohibitive with the number of days of storage needed. If 10 days of storage were desired (for example to affect any repairs to the Pintail well), the volume would be on the order of 5 million gallons, which would exceed the cost of a new well.

4.3 Arsenic Treatment Options (Coagulation/Filtration and Adsorption)

As discussed above, a water treatment system for Canvas Back must be capable of treating 500 gpm (MDD), and a treatment target for arsenic concentration would be half the MCL or 5 ug/L. While removing manganese is not required, if manganese can also be reduced with treatment this would improve the aesthetics resulting in a noticeable improvement by the customers.

A wide range of technologies has been developed for the removal of high concentrations of arsenic from drinking water. The most common arsenic removal technologies use chemical precipitation, adsorption, ion exchange, and membranes. Ion exchange and membrane technologies, although capable of removing arsenic, were ruled out because of high process operation and maintenance costs. Both the chemical precipitation and adsorptive media processes were reviewed and are discussed further below. After the discussion of the individual treatment technologies, both options are compared in **Table 3**.

Coagulation/Filtration

Coagulation/filtration (C/F) is a precipitative process used for arsenic removal and has the added benefit of removing manganese and iron. Oxidation of dissolved iron and manganese forms a solid particle that can be filtered. Arsenic is combined in a co-precipitation process involving an iron-based coagulant, commonly ferric chloride. As the water is forced through the media bed and injected with chlorine and ferric chloride, the arsenic, iron and manganese are oxidized, forming particles that are captured in the media.

To remove solids that have accumulated on the media, the filter is generally backwashed about every day. Due to the introduction of ferric chloride and generation of solid agglomerated material, a larger amount of sludge waste is generated in these systems than typical manganese treatment systems that must be directed to a backwash tank. In the backwash tank, solids settle to the bottom of the tank where they can be removed, stored, and off hauled to an approved waste facility.

C/F technology can only remove arsenic to less than 5 µg/L (half the MCL) and would require treating the full flow of the Canvas Back well to meet the selected target concentration. Effluent manganese would likely be non-detect but guaranteed to be less than half the MCL or 25 µg/L.

The major advantages of C/F technology are the media life (10 or more years) and its ability to remove manganese that is also present in Canvas Back well water. Disadvantages include larger footprint, higher cost, higher operational complexity, and waste management.

Several media types and vendors are available for the C/F method including greensand, pyrolusite, or proprietary media. Pyrolusite media has the highest filter loading rates, which translates to smaller footprints. A vendor that uses pyrolusite is ATEC Water Treatment, who has a packaged system that tends to be lower cost than competitors at this target capacity (500 gpm). The skid-mounted system would have four filter vessels sitting on a 10x10 foot skid including the header piping and valves. Pilot Testing is required to identify the final sizing and removal efficiency of arsenic and manganese.

Because backwash occurs so frequently for these systems (daily), there are automated controls to process the backwash water, control the flow rates, store that backwash water, and recycle the water in a “reclaim” process to minimize waste.

With the packaged pyrolusite filter systems, water used for backwashing is commonly generated by the well. This lessens the burden on the distribution system during backwash. During backwash clean water is flushed in reverse in the filter creating an upflow that removes the solids from a waste line on the filter header. Backwash occurs daily and will require approximately 9,000 gallons of water.

A tank for storing spent backwash water would be about 20,000 gallons to store at least two cycles. After backwash, the water in the tank is allowed to settle and the clear supernatant is re-introduced in the raw water (i.e. "reclaim water") using a reclaim pump system. Over time solids will accumulate in the backwash tank and the "sludge" will be off hauled as a hazardous waste since it contains arsenic. **Figure 3** (attached) provides a conceptual layout of C/F system at Canvas Back.

Adsorption

Adsorption of arsenic occurs on a specialized media surface that attracts the arsenic particles and allows them to bind to the media for removal. This is facilitated by the large surface area of the media particles that offer numerous sites for arsenic to bond. Adsorption media has the ability to remove arsenic to non-detectable levels until it becomes exhausted and breakthrough occurs, and it must be removed and replaced. This process only removes arsenic and does not have the added benefit of removing iron and manganese. An important consideration is the competing ions present in the water that may negatively impact the media life. Competing ions that have an affinity for the media take up available bonding sites will likely force breakthrough to occur sooner. Competing ions include Silica, Phosphorus, and Vanadium.

There are different types of media available and selection of such is dependent on the competing ions, bed volume capacity, and pH. Bed volume is a measure of the volume of water the media can treat before breakthrough occurs and the media is exchanged. In the presence of competing ions, lowering the pH prior to treatment makes the media more effective at removing arsenic. Given the silica levels measured in Canvas Back and the pH above 8, the vendor will likely require pH adjustment to guarantee performance.

Two of the common media are Bayoxide E33 and NXT-2. Bayoxide E33 is a granular iron oxide adsorber produced by Lanxess and used in AdEdge (vendor) adsorption systems. NXT-2 is a lanthanum-based mixed metal oxy-hydroxide media produced by EP Minerals and used in Applied Process Equipment (vendor) adsorption systems. Either of these media would be appropriate for the current case. Details of their interactions with the specific water chemistry found in the Canvas Back well would inform LSCE's recommendation.

The operating of adsorption systems is simple compared to a C/F system. No solids are generated by the adsorption system because the arsenic ions are bound to the filter media. As the water passes through the filter, dissolved arsenic is removed. The media is replaced once arsenic breakthrough begins to occur, which could be on the order of months to years. Media life and water chemistry adjustments can be estimated by vendors using their proprietary models but must generally be confirmed through Pilot Testing.

Backwashes only occur once every few months to fluff the media. Minimal solids or contaminants are contained in the backwash water. The backwash water could be sent directly to the sanitary sewer (if there is capacity) or stored in a 10,000-gallon tank onsite and reclaimed in the treatment process.

Adsorption can be expected to remove arsenic to near-zero concentration. This allows for blending and side-streaming operations. Adsorption does not effectively treat manganese.

The main advantages of utilizing an adsorption system include less complex operational strategies, a smaller footprint, and arsenic removal to a non-detect level. Disadvantages of this system include the cost and frequency of media replacement, the potential for competing ions to affect the media life, materials handling concerns for pH adjustment, and the lack of manganese treatment. **Figure 4** (attached) provides a conceptual layout of an adsorption system at Canvas Back.

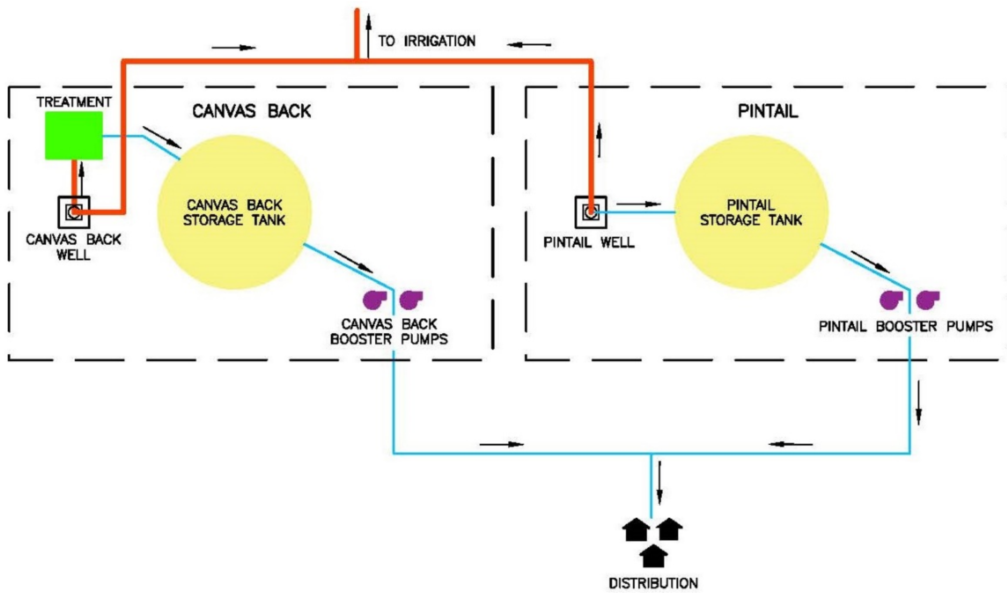
Table 3: Comparison of Treatment Technologies

Criteria	Coagulation / Filtration	Adsorptive
Water Quality	**BEST** Arsenic reduced to 5 µg/L. Manganese reduced to <20 µg/L Improves aesthetics visible to customers.	**GOOD** Arsenic reduced to 0-5 µg/L Manganese unchanged. Complies with MCLs. No improvement to aesthetics.
Chemical Feed	**TWO CHEMICALS** Sodium Hypochlorite, and Ferric Chloride.	**TWO (OR THREE) CHEMICALS** Sodium Hypochlorite, and Hydrochloric Acid. (Soda ash if pH re-adjustment required).
Footprint	**LARGER** 12 x 12 Filter Pad 20' dia Backwash Tank (20k gal.) Reclaim and backwash controls	**SMALLER** 12x12 Filter Pad 10' dia Backwash Tank (10k gal.) Limited pipe and valves.
Ease of Implementing on Existing Site	**LESS EASY** Estimated to fit on Canvas Back site, but it will be tight.	**EASIER** Smaller tank, less pipe, and controls fit better.
Ease of Operation	**RELATIVELY MORE COMPLEX** Backwashes daily, automated valves, tank decant, reclaim pumping.	**RELATIVELY SIMPLE** Manual operation is ok, backwash every 3 months, media change out 1-3 years.
Residual Waste Management	**RELATIVELY MORE COMPLEX** Solids/sludge must be discarded ~5,000 gallons once per year.	**RELATIVELY SIMPLE** Media disposal is part of media exchange purchase costs.
Cost – Capital Expenses	**HIGHER** ($1m-$1.3m) Bigger tank, more automation, pumps, and programing.	**LOWER** ($0.8m-$1m) Smaller tank, less automation and programming
Cost – O&M	**Higher operational** cost (labor) for daily backwashes and sludge disposal.	**Higher material** cost (media) – *Media replacement costs TBD by vendor proposals in Task 3.*

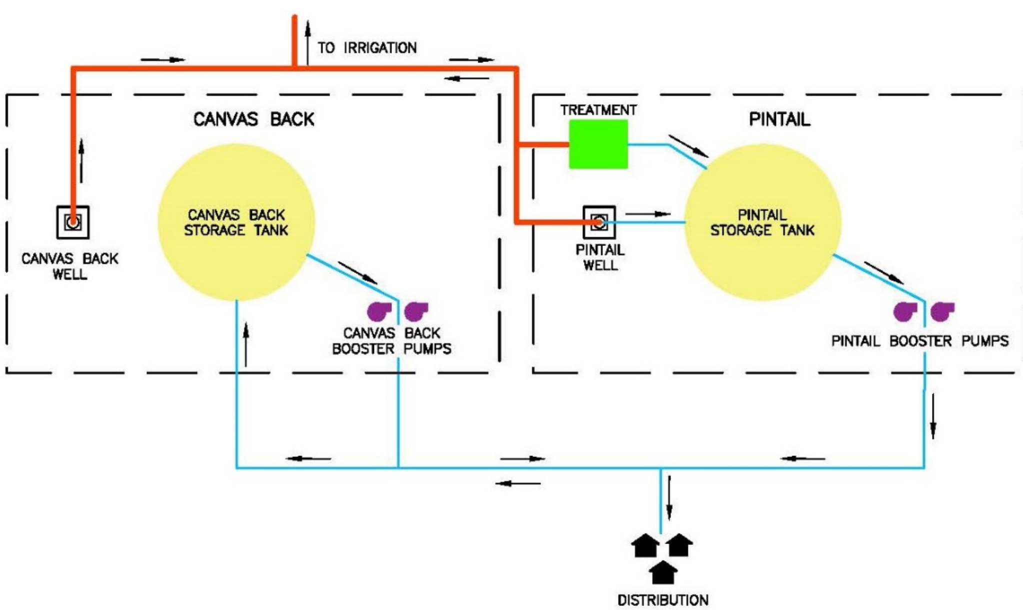
4.4 Combination of Arsenic Treatment and Blending

Blending of Canvas Back with Pintail well can be used in conjunction with the treatment systems described above to make further improvements. These blending scenarios are not necessary to meet the MCLs but are considered for their benefits. The schematics below show the concept of treatment at Canvas Back for the Canvas Back well, versus placing treatment at Pintail for the purpose of blending the Canvas Back treated water with the Pintail well.

Operational Strategy for Treatment at Canvas Back



Operational Strategy for Treatment at Pintail



One benefit of placing the treatment system at Pintail well is that there is more space at that site to fit the upgrades. Another benefit could be water quality, depending on the treatment technology.

In the case of C/F treatment, the footprint is much larger. Although C/F will fit at the Canvas Back site as shown in **Figure 3**, placing C/F at Pintail will provide better operational access (see **Figure 5** for placing C/F at Pintail). From a water quality standpoint, however, there is not much benefit in blending the C/F water with Pintail (based on historical water quality). With effluent of C/F having arsenic of less than 5 µg/L and manganese of less than 20 µg/L; these concentrations are close enough to Pintail water quality that blending does not offer an advantage as compared to the additional cost and complexity of a blending strategy (**Table 4**). C/f would be placed at Pintail primarily for siting purposes due to space constraints at Canvas Back.

In the case of adsorption, blending the treated water with Pintail water does offer a water quality benefit. Adsorption will remove all of the Arsenic in the Canvas Back well; however, no manganese will be removed so the treated effluent will be around 50 µg/L. By blending with Pintail, the manganese can be reduced to the blended ratio of the two wells, which would be about 30 mg/L with Pintail running at full flow and Canvas Back sized for treatment (**Table 4**). Without blending, the distribution system will see the same mass of manganese but blending provides a uniform quality. There is also a benefit of better spacing at Pintail to place the treatment facilities, although adsorption has a smaller footprint than C/F, so this is not as critical (see **Figure 6** for placing adsorption at Pintail).

Table 4: Delivered Water Scenarios

Treatment Technologies and Delivered Water Parameters		Pintail (No Treatment)	Canvas Back (Treated Water)	Blended (Full Flow)
Adsorption	Arsenic	6-9 ug/L	0 ug/L	4-6 ug/L
	Manganese	17-19 ug/L	50 ug/L	30 ug/L
	Flow	1,200 gpm	500 gpm	1,700 gpm
Coagulation/Filtration	Arsenic	6-9 ug/L	5 ug/L	6-8 ug/L
	Manganese	17-19 ug/L	20 ug/L	20 ug/L
	Flow	1,200 gpm	500 gpm	1700 gpm

As described above, a drawback of blending the two wells at one site is the change in operational strategy. For example, with treatment placed at Pintail, water from Canvas Back is delivered through the raw water main to the Pintail system and blended in the Pintail tank. The Canvas Back tank still supplies water to the system through the Canvas Back booster pumps, but the Canvas Back tank would also be filled by the system during low demand. SCADA control logic changes would be required, but both sites are equipped with the components required to accomplish this change.

5. CONCLUSIONS

Coagulation/Filtration systems offer the following benefits and drawbacks:

1. Best water quality improvement. MCLs are met and aesthetics are improved with Manganese reduction to less than 20 ug/L
2. Capital cost is higher.
3. Lower maintenance cost because media lasts 10 years.
4. Operationally more complex. Higher operational (labor) cost.
5. Annual sludge disposal will be required; about 5,000 gallons per year estimated.
6. Larger footprint. The C/F system can be placed at Canvas Back, but it will have better siting at Pintail for operational access.

Adsorption systems offer the following benefits and drawbacks:

1. Water quality meets all MCLs, but no improvement to manganese.
2. Blending can be used with Pintail to improve manganese to about 30 ug/L.
3. Capital cost is slightly lower.
4. Higher maintenance cost for recurring media (to be determined in Task 3).
5. Operationally simple; backwashes are infrequent, manual operation.
6. Residual waste is simple; media is discarded with exchanges.
7. Smaller footprint than C/F, no large tank required.

Our preliminary recommendation is to use a C/F treatment system based on providing the best improvement to water quality; there will be a noticeable aesthetic improvement from manganese reduction. However, the cost for C/F is higher, it is more operationally intensive, and it has larger space requirements. LSCE will make a final recommendation after the next task where LSCE will solicit cost and design information from vendors of both types of systems.

6. NEXT STEPS

Following a review and follow-up meeting with the County, System Operator, and CSA Advisory Committee, and as outlined in LSCE's scope of work, LSCE will commence on the next task (Task 3) which will be to solicit proposals from treatment system vendors that provide more detail on system sizing, capital costs, O&M costs, pilot testing requirements, and other design considerations. LSCE is currently soliciting vendor proposals and will return an updated memorandum with recommendations on proceeding with pilot testing with consideration for State funding requirements for pilot testing.

ATTACHMENTS

Figure 3	Project Setting (attached)
Figure 4	Canvas Back Conceptual Site Layout – Coagulation/Filtration (attached)
Figure 5	Canvas Back Conceptual Site Layout – Adsorption (attached)
Figure 6	Pintail Conceptual Site Layout – Coagulation/Filtration (attached)
Figure 7	Pintail Conceptual Site Layout – Adsorption (attached)
Attachment A	Canvas Back & Pintail Historic Water Quality Summary
Attachment B	Canvas Back & Pintail Recent Water Quality Results (6-29-2020)

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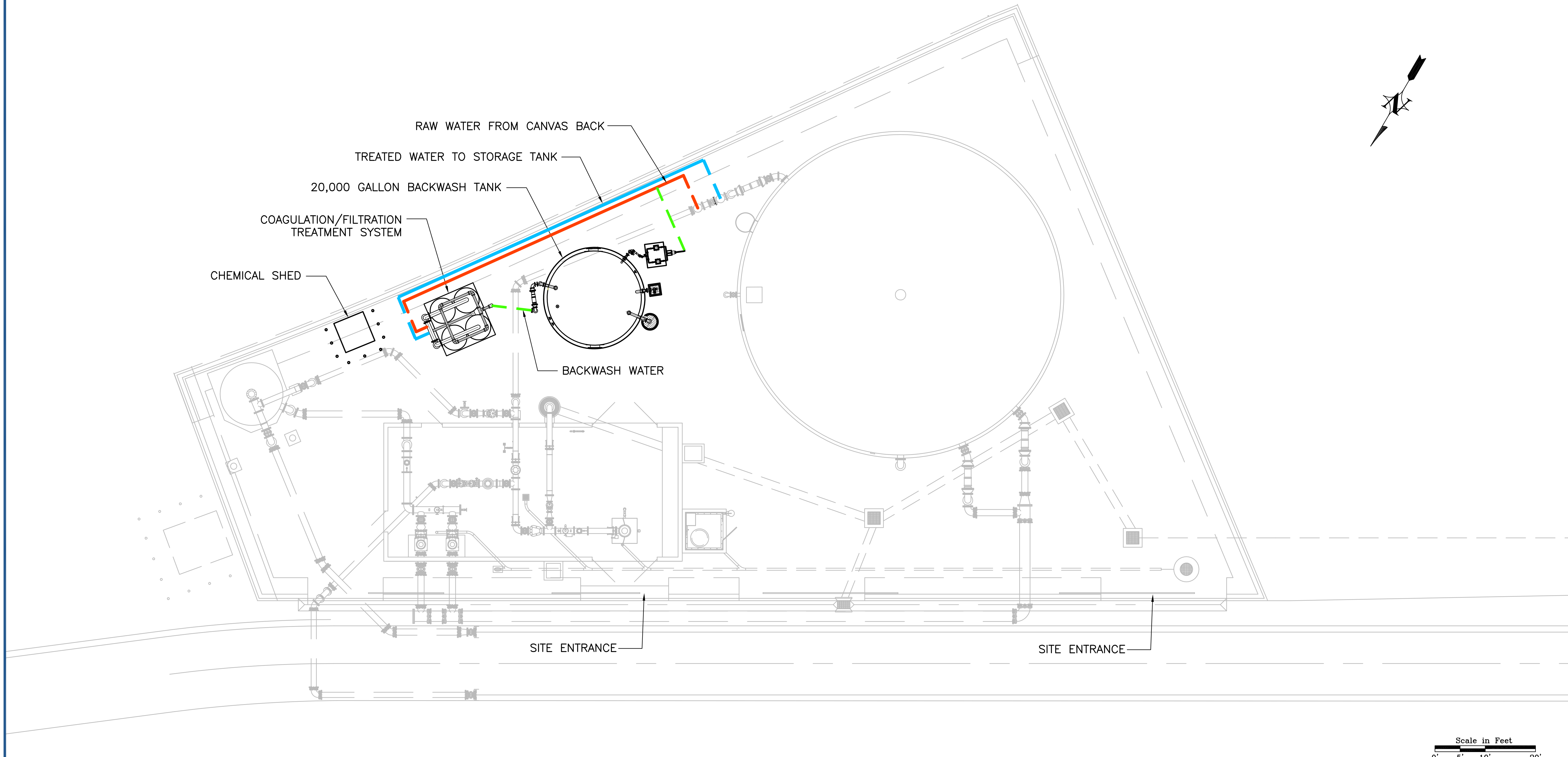
Project Setting

Arsenic and Manganese Treatment Design - Task 2 Memo
County of Yolo - Wild Wings CSA Public Water System

Figure 1



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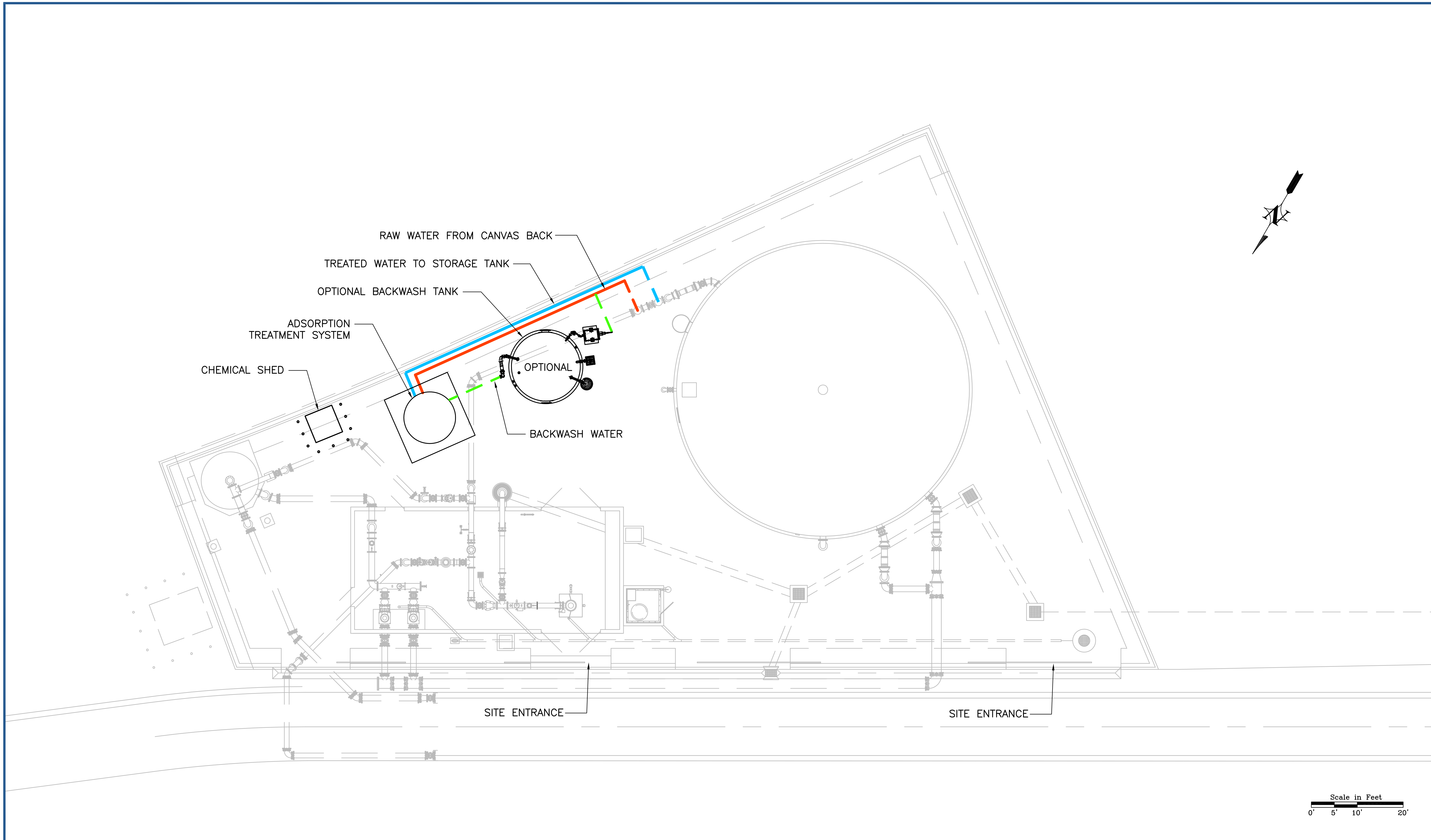
Canvas Back Conceptual Arsenic Treatment Facility Site Layout - Coagulation/Filtration

Arsenic Treatment Design - Task 2 Memo
County of Yolo - Wild Wings CSA Public Water System

Figure 4



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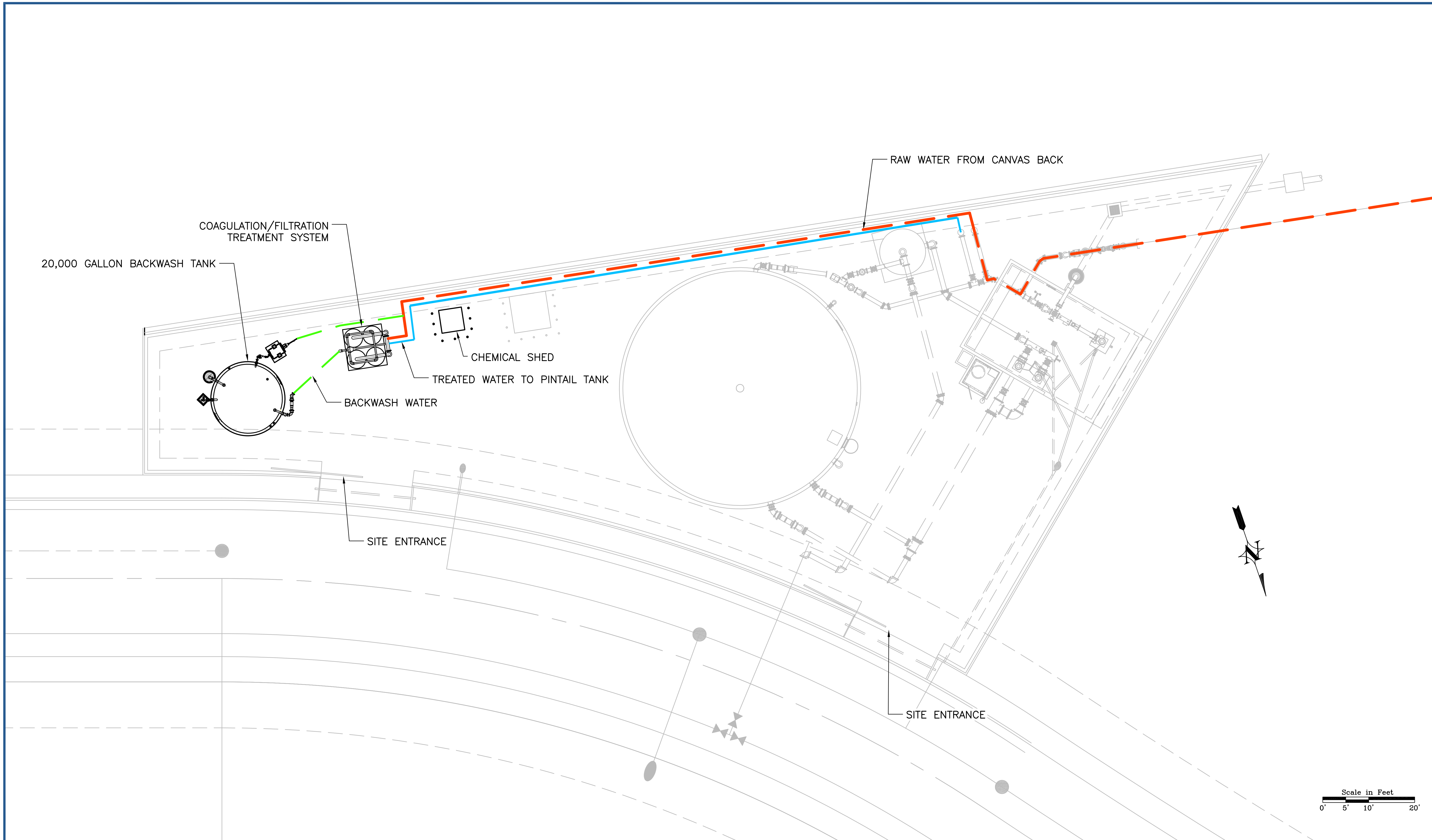
Canvas Back Conceptual Arsenic Treatment Facility Site Layout - Adsorption

Arsenic Treatment Design - Task 2 Memo
County of Yolo - Wild Wings CSA Public Water System

Figure 5



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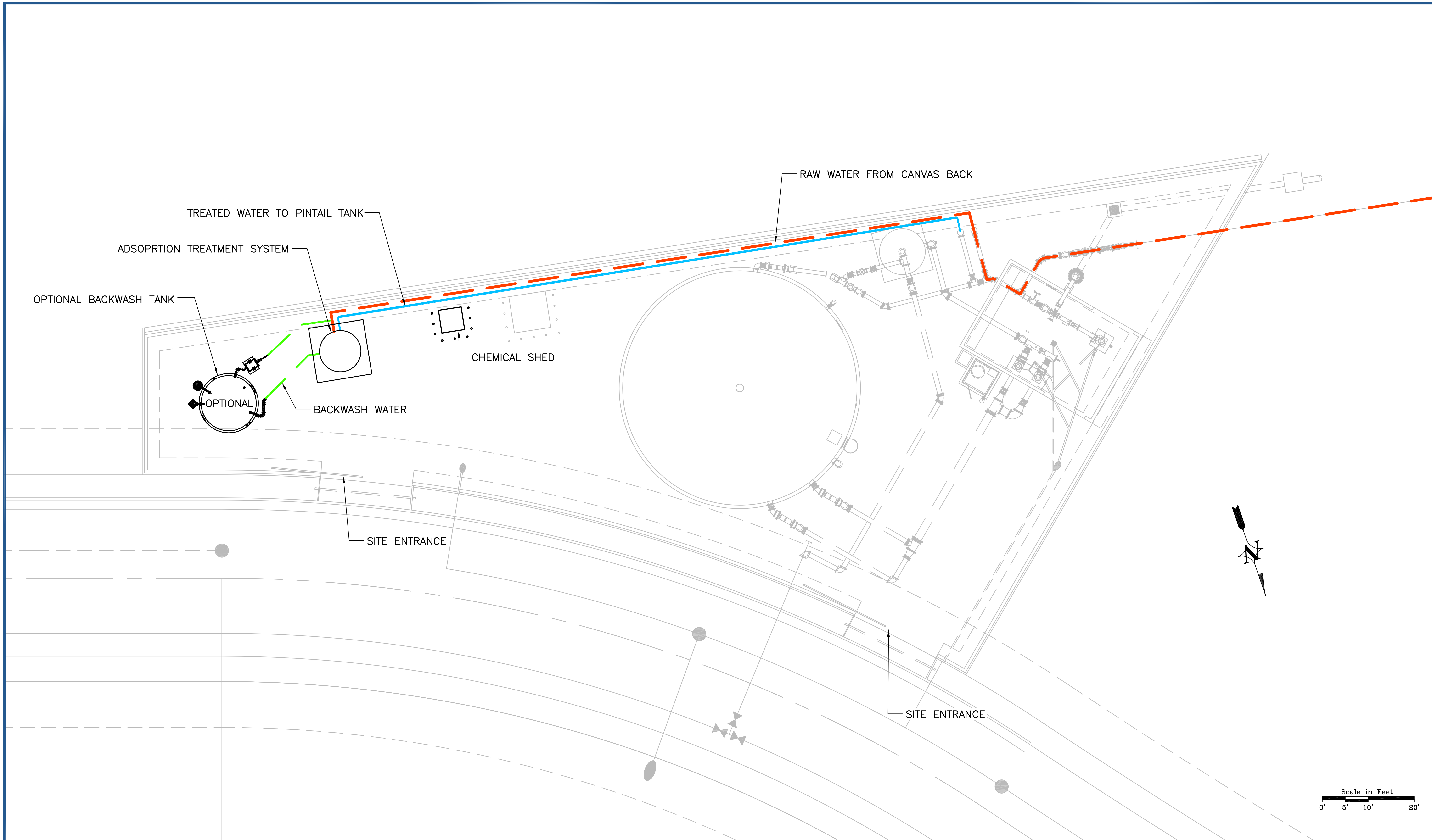
Pintail Conceptual Arsenic Treatment Facility Site Layout - Coagulation/Filtration

Arsenic Treatment Design - Task 2 Memo
County of Yolo - Wild Wings CSA Public Water System

Figure 6



CAD FILE: G:\Projects\Wild Wings Dev\18-5-034\Pintail Site Layout_AD.dwg DATE: 8/18/2020 10:25 AM

Luhdorff & Scalmanini
Consulting Engineers

Pintail Conceptual Arsenic Treatment Facility Site Layout - Adsorption

Arsenic Treatment Design - Task 2 Memo
County of Yolo - Wild Wings CSA Public Water System

Figure 7

Attachment A - Canvas Back & Pintail Historic Water Quality Summary

Wild Wings Production Wells
Water Quality Summary

ANALYTE	UNITS	METHOD	MCL	Canvas Back		Pintail	
				Minimum	Maximum	Minimum	Maximum
CATIONS							
Calcium	mg/L	200.7/2340B		9.4	11	5.6	7
Magnesium	mg/L	200.7/2340B		8.6	10	2.7	3.2
Potassium	mg/L	200.7/2340B		2.4	5	ND	5
Sodium	mg/L	200.7/2340B		110	148	150	190
Total Hardness	mg/L	200.7/2340B		59	70	25	30
ANIONS							
Bicarbonate Alkalinity	mg/L	SM 2320B		300	354	330	378
Carbonate Alkalinity	mg/L	SM 2320B		ND	8.8	ND	22
Chloride (Cl)	mg/L	300	250/500[2]	23.3	35.6	30.6	45
Fluoride	mg/L	300	2	ND	0.21	ND	0.28
Hydroxide Alkalinity	mg/L	SM 2320B		ND	1	ND	1
Nitrate (as N)	µg/L	300		ND	0.1	ND	0.1
Orthophosphate	µg/L	4500-PF		NA	NA	NA	NA
Sulfate (as SO4)	mg/L	300	250/500[2]	43	52	42	63
Total Alkalinity	mg/L	SM 2320B		260	290	290	340
PHYSICAL PARAMETERS							
Color (A.P.H.A)	Color Units	SM 2120B	15[2]	0	1	0	1
pH	pH units	SM 4500-H B	6.5/8.5[4]	8.17	8.4	8.38	8.6
Methylene Blue Active Substance	mg/L	SM 5540C	0.5[2]	NA	NA	NA	NA
Specific Conductivity	US	120.1	900/1,600[2]	650	730	770	880
Total Dissolved Solids (TDS)	mg/L	SM 2540C	500/1,000[2]	390	460	470	510
Odor	TON	140.1		ND	1	ND	1
Turbidity	NTU	180.1	5[2]	ND	0.5	ND	0.32
INORGANICS							
Aluminum	µg/L	200.7	1,000[1]/200[3]	ND	0.01	ND	0.01
Antimony	µg/L	200.8	6	ND	ND	ND	ND
Arsenic (Dissolved)	µg/L	200.8	10	NA	NA	NA	NA
Arsenic	µg/L	200.8	10	ND	**15**	ND	**10**
Arsenic (As As(III))	µg/L	3500-As B	10	NA	NA	NA	NA
Aresenic (As As(V))	µg/L	3500-As B	10	NA	NA	NA	NA
Barium	µg/L	200.7	1,000	ND	36	ND	12
Beryllium	µg/L	200.8	4	ND	ND	ND	ND
Boron	µg/L	200.7	1,000[3]	1.57	**1929**	1.7	**2111**
Cadmium	µg/L	200.8	5	ND	0.001	ND	0.001
Chromium (Total)	µg/L	200.8	50	ND	0.007	ND	0.007
Copper	µg/L	200.8	1,000[2]	ND	710	ND	0.025
Iron (Dissolved)	µg/L	200.7	300[2]	NA	NA	NA	NA
Iron	µg/L	200.7	300[2]	ND	0.06	ND	0.1
Lead	µg/L	200.8	15[3]	ND	0.001	ND	0.001
Manganese (Dissolved)	µg/L	200.7	50[2]	NA	NA	NA	NA
Manganese	µg/L	200.7	50[2]	40	**51**	ND	21
Mercury	µg/L	1631E	2	ND	0.02	ND	0.2
Nickel	µg/L	200.8	100	ND	0.8	ND	0.005
Silica	mg/L	4500-Si		40	42	33	36
Selenium	µg/L	200.8	50	ND	0.002	ND	0.002
Silver	µg/L	200.8	100[2]	ND	0.01	ND	0.01
Thallium	µg/L	200.8	2	ND	ND	ND	ND
Vanadium	µg/L	200.8	50[3]	ND	0.05	ND	0.05
Zinc	µg/L	200.8	5,000[2]	ND	0.05	ND	0.05
ORGANICS							
Total Organic Carbon (TOC)	mg/L	415.1		NA	NA	NA	NA

[1] - Primary MCL
[2] - Secondary MCL (recommended/upper range)
[3] - Action Level
[4] - Suggested lower/upper acceptable range
[*] - Various Reporting Limits
ND = Non-Detect, NA = Not Analyzed

Attachment B - Canvas Back & Pintail Recent Water Quality Results (6-29-2020)

Wild Wings Production Wells
Water Quality, 6-29-2020

ANALYTE	UNITS	REPORTING LIMIT	METHOD	MCL	Canvas Back	Pintail
ANIONS						
Chloride (Cl)	mg/L	5.0	300	250/500[2]	38	42
Fluoride	mg/L	0.10	300	2	ND	ND
Nitrate (as N)	µg/L	0.40	300		ND	ND
Orthophosphate	µg/L		4500-PF		ND	ND
Sulfate (as SO4)	mg/L	5.0	300	250/500[2]	56	63
PHYSICAL PARAMETERS						
pH	pH units	0.01	SM 4500-H B	6.5/8.5[4]	8.08	8.44
Total Dissolved Solids (TDS)	mg/L	10	SM 2540C	500/1,000[2]	430	440
INORGANICS						
Arsenic	µg/L	2.0	200.8	10	10	7.3
Iron	µg/L	100	200.7	300[2]	ND	130
Manganese	µg/L	20	200.7	50[2]	47	19
Silica	µg/L		4500-Si		37000	31000
ORGANICS						
Total Organic Carbon (TOC)	mg/L		415.1		ND	ND

1 - Primary MCL
2 - Secondary MCL (recommended/upper range)
3 - Action Level
4 - Suggested lower/upper acceptable range
* - Various Reporting Limits
ND = Non-Detect, NA = Not Analyzed