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PROJECT MEMORANDUM

Subject:	Options for Improving Disk Filter Reliability
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BACKGROUND

The City of Watsonville, in partnership with the Pajaro Valley Water Management Agency (PVWMA), operates Kruger Hydrotech Disk Filters as part of the Recycled Water Treatment Facility that produces disinfected tertiary recycled water for distribution to PVWMA customers in the Pajaro Valley. A DensaDeg® high-rate solids contact clarifier provides pre-treatment prior to the filtration process. The filtration system consists of two trains of Kruger Hydrotech Disk Filters on an elevated structure, with eighteen filter disks in each train. Each filter disk consists of panels with polyester microscreen filter material. Piping was included to facilitate construction of a third train of disk filter on a separate structure to the north of the existing filter structure.

PVWMA and the City of Watsonville are considering construction of the third disk filter train to provide redundancy in the system so a train can be taken out of service for maintenance without effecting the ability to meet recycled water demands. The purpose of this project memorandum is to summarize existing filter operational issues and outline options for improving disk filter reliability.

EXISTING DESIGN CRITERIA

The existing disk filter design criteria are summarized in Table 1. The filters were designed at a loading rate of 3.89 gallons per minute per square foot (gpm/ft^2) at a filter feed flow of 7.9 million gallons per day (mgd). The associated treatment plant production capacity is given at 7.7 mgd, which takes into account a design average waste backwash rate of 3%. The maximum filter capacity is given at 12.2 mgd at a loading rate of 6.0 gpm/ft^2. Current summer flows are around 5 mgd, which corresponds to a filter loading rate of approximately 2.5 gpm/ft^2.

Table 1 Existing Disk Filter Design Criteria	
Description	**Criteria**
No. of Filter Trains	2
No. of Filter Disks per Train	18
Submerged Filtration Area per Filter Disk, ft^2	39.13
Filtration Area per Filter Train, ft^2	704
Total Filtration Area, ft^2	1,409
Filtration Rate at 7.9 mgd with All in Service, gpm/ft^2	3.89
Average Reject Rate, percent	3
Average Waste Backwash Water at 7.9 mgd, mgd	0.23
Maximum Filter Process Capacity at 6.0 gpm/ft^2, mgd	12.2

Source: Record Drawings for Watsonville Area Water Recycling Project Recycled Water Treatment Component (WW-06-02), City of Watsonville and PVWMA 2010.

FILTER MEDIA FOULING

The existing disk filters have experienced media fouling which has affected their production and reliability. The filter media fouling has decreased filter runtimes and increased the backwash frequency. There have been times when the filters have been unable to produce sufficient filtered water to meet demands.

Fouling of microscreen disk filter media is typically due to (1) chemical precipitation, (2) biogrowth, or (3) blinding of the filter fabric with coagulant. During visual inspection of the filter cloth, evidence of scaling due to iron precipitation was observed, as can be seen in Figure 1. Plant staff indicate that the scale is not removed during filter backwashing, but can be removed with muriatic acid cleaning, which is generally done during the annual winter recycled water plant maintenance shutdown.

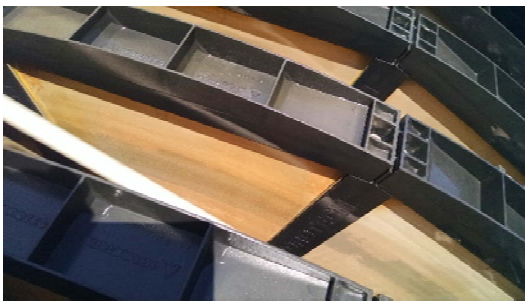

Figure 1: Discoloring of the disk filters indicates evidence of iron precipitation

A piece of fouled filter fabric was sent to Kruger and tested by Hydrotech staff. The testing determined that cleaning with acid, either HCl or Hydrex 4921 (a Kruger proprietary blend of organic acids and citric acid), was effective in cleaning the filter fabric (see Figure 2 and Appendix A). Hydrotech staff concluded the filter media fouling was likely caused by iron

precipitation. Some treatment facilities have found UV quartz sleeve cleaner to be effective at cleaning scaling on Kruger filter panels.

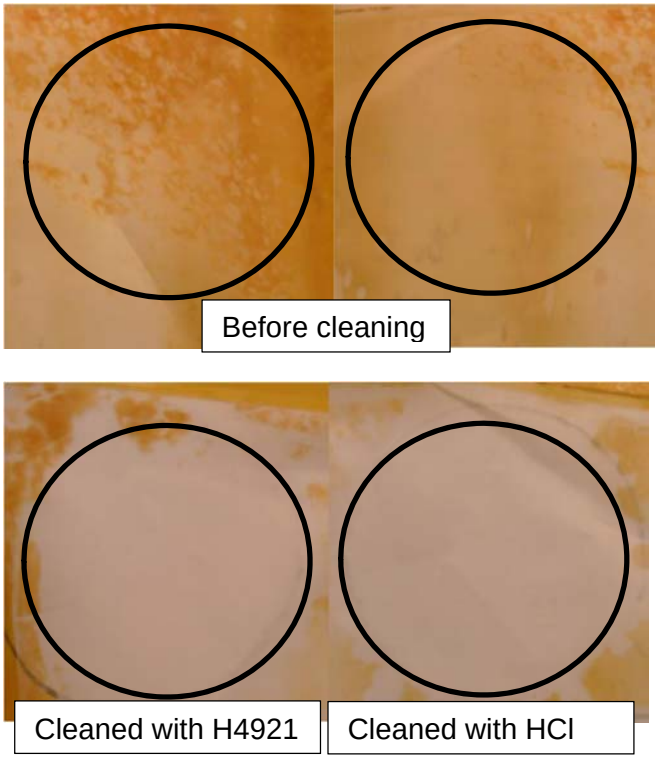

Figure 2: Filter fabric before and after cleaning with HCl and Hydex 4921 (courtesy of Kruger)

SOURCES OF IRON

A partial iron balance for the wastewater treatment plant based on sampling done by City staff in July 2015 is shown in Figure 3. Potential sources of iron in the filter feed include iron present in potable water, iron added in the generation of domestic and industrial wastewater, and iron added in the wastewater treatment process. City of Watsonville potable water averages 0.03 mg/l of iron.[1] Total iron is measured in the plant influent once per year, and averages around 1 mg/l. Therefore it can be concluded that the iron contribution from City of Watsonville potable water is negligible. Iron is added in the wastewater treatment process through ferric chloride addition in the gravity thickener and belt press sludge dewatering.

It is possible that reductions in iron concentrations in the wastewater influent through source control, or reductions in the amount of iron added in the wastewater treatment process through use of alternative coagulants could reduce iron scaling on the disk filters. Improvements to the filter cleaning system or addition of a third filter train, however, should provide a more dependable solution, and are outlined in the following sections.

[1] City of Watsonville Water Quality Report 2014.

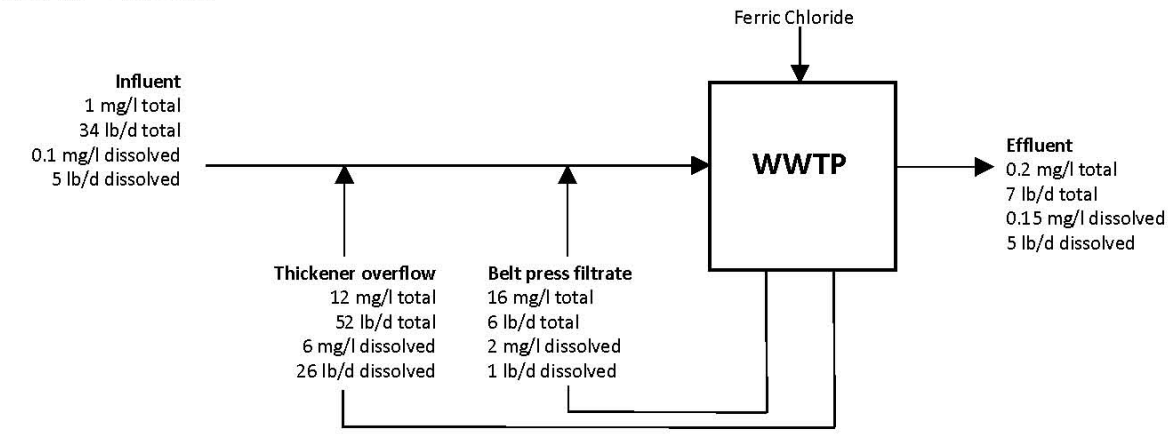

Figure 3: Average wastewater treatment plant iron data July 2015

OPTIONS FOR IMPROVING FILTER RELIABILITY

Option 1: Add Kruger Automated Cleaning System to Existing Filter Trains

Since the Recycled Water Treatment Facility was constructed and the Hydrotech disk filters were installed, Kruger has developed an automated cleaning system (ACS) for the Hydrotech disk filter to address problems with filter clogging and scaling. Photos of an ACS system are shown in Figure 4. The ACS consists of a chemical spray header with spray nozzles on both sides of each filter disk, and piping or a hose connecting the spray nozzles to a pump and storage tank with cleaning chemical. Control logic is incorporated into the system controls to sequence the spraying of cleaning chemical on to the filter disks so there is sufficient chemical contact time on the disk surface.

Figure 4: Kruger ACS System (courtesy of Kruger)

Automated cleaning systems could be installed on the existing filter trains to allow chemical cleaning of the filter disks in a matter of minutes rather than hours. Shortening the required application and cleaning time could allow for a more frequent chemical cleaning system in a shorter period of time (requiring less filter down time) which could mitigate filter media fouling and improve reliability.

Option 2: Add Third Filter Train Matching Existing Trains

Installing a third filter train identical to the two existing trains would give plant operators the redundancy needed to take one of the three filter trains offline during the summer irrigation season for chemical cleaning and still have two trains available to meet the recycled water demand. Chemical cleaning of the filter disks would be performed manually as currently done by plant staff.

Option 3: Add Third Filter Train and Kruger Automated Cleaning Systems

A third filter train with an automated cleaning system could be installed, as well as adding automated cleaning systems to the existing filter trains. This approach allows increased redundancy as well as chemical cleaning of the filter disks with minimal down time and labor.

Option 4: Add Third Filter Train from Different Manufacturer

Alternatively, a pile fiber disk filter system which is less susceptible to scaling, such as the Aqua-Aerobics cloth media filter, could be installed for the third filter train. The Aqua-Aerobics disk filter would require a less elevated structure compared to the Kruger disk filter since the Aqua-Aerobics disks are fully submerged. The main disadvantage of this option is that the plant would have two different types of disk filters, which complicates operations and maintenance.

Appendix A:

Hydrotech Test of Fouled Filter Media

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Test of filter panel from Watsonville CA, USA

Filter cloth sent by: Mark Stewart
Origin of panel: Watsonville CA, USA
Receiving date: 13th October 2014
Date of testing: 15th October 2014
Test performed by: Petter Olsson
Type of filter panel: 10 µm Hydrotech 11/5 Standard Cloth from a HSF 2200-panel

Background

Two HSF2218 disc filters were installed on the site in 2008. In October 2014, Hydrotech received a piece of filter cloth from a broken panel that showed some clogging. Hydrotech was asked to determine the cause of the fouling and to offer a recommendation for a possible treatment strategy to recover the original filtration rate.

Information about the filter inlet

The immediate upstream process to the filter is a Densadeg unit (similar to Actiflo), which is located downstream of the plant's biological treatment process (a trickling filter with a solids contact process followed by secondary clarifiers). The Discfilter is used as a polishing step to insure the reuse quality.

Materials and method

ET-test

The ET-test equipment (**Error! Reference source not found.**Figure 1) is used to measure the filtration capacity of filter media. The test procedure can be described as follows: The filter media under study is secured and sealed above an opening which can be opened and closed with compressed air. A cylinder is then secured and sealed above the filter cloth and filled up with 2.7 litres of tap water (equivalent to a 200 mm head). Thereafter the lid is opened and the tap water is filtered through the filter media. The filtration capacity is calculated from the time it takes for two litres of water to be filtrated.

The filtration capacity Q_{filt} (m/h) is calculated from the formula below;

$$Q_{filt} = \frac{V * 10^{-6}}{A * \frac{t}{3600}} \left(\frac{m^3}{m^2 * h} \right)$$

V is the volume of water that has passed through the filter media (ml), A is the net filtration area (m^2) and t is the filtration time (s). Filtration speeds obtained in this test are only a relative measurement in m/h and cannot be directly applied to a full scale plant.

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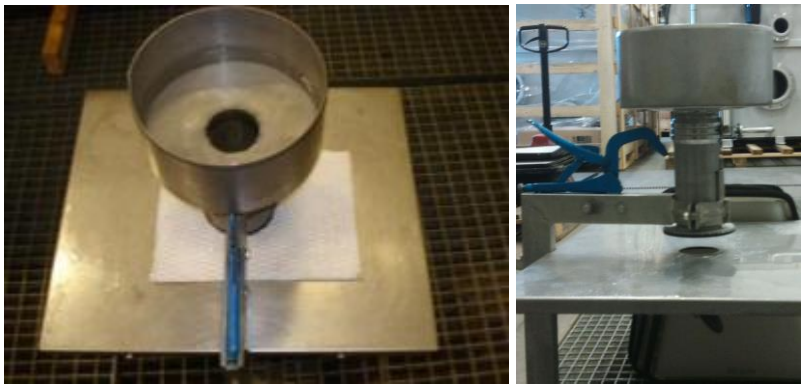

Figure 1: The equipment used for the ET-test to estimate the filtration rate

Chemicals used for treatment

Hydrotech filters for tertiary treatment usually experience some clogging if they are operated for a long time. Usually there are two kinds of clogging that requires different treatments. Some metal can form precipitates on the filter cloth when a coagulant like Iron is used in the upstream process. Such precipitates can be removed by the use of an acid liquid as for example Hydrochloric acid (HCl) (15 % solution) or Hydrex 4921 (Blend of organic acids and citric acid, 10 % solution). Biofilm growth can also cause clogging which can be removed by using bleach with concentrations of about 3 % NaClO.

Treatment before the test of filtration rate for drinking water

Testing of the panel was performed with Hydrotech's ET-test equipment with the following pre-treatments:

1. Wetted in tap water for 30 minutes with 2 minutes backwash (BW) at 8 bar /8 cm distance
2. Treated with Hydrochloric acid (HCl) (15 %) with four minutes contact time and then 2 min BW
3. Treated with Hydrex 4921 (10 %) with four minutes contact time and then 2 min BW
4. Treated with bleach (2.7 % NaClO) with four minutes contact time and then 2 min BW
5. HCl (15 %) 4 min + 2 min BW and then Bleach (2.7 % NaClO) 4 min and then 2 min BW

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Results

All results from the tests are presented in table 1. The filtration rate (drinking water) for a new Hydrotech 11/5 standard 10 µm cloth is (approximately) 280 m/h.

Table 1: Results from ET-testing with drinking water with the filter cloth from Watsonville CA. * There was a variation in the filtration rate of the previous used 10 micron filter media, so the stated number may not be representative for the received sample.

	Net filtration rate, drinking water (m/h)		
	Before treatment	After treatment	% of new media
4 min HCl + 2 min BW	153	212	76
4 min HCl + 2 min BW	65	208	74
4 min Hydrex 4921 + BW	163	210	75
4 min Hydrex 4921 + BW	7	211	75
4 min Bleach +BW	152	184	66
4 min HCl + BW and 4 min Bleach + BW	153	224	80
New Hydrotech 10 micron (11/5) *	280*		100

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The results were similar with all acid treatments and the clogging tends to be almost removed, even in the most affected areas (


Figure 2). The most likely cause for clogging is the coagulant used in the Densadeg process. It is assumed that the client is using some kind of Iron compound which would explain the coloring and why it is easily removed when treating it with an acid. Using only bleach was not as efficient as the acids. However combining Hydrochloric acid and thereafter bleach seemed to improve the capacity with another 5 % compared to only using an acid.

The filtration capacity after the tested treatments was only 75-80 % of the filtration rate expected for a new sample of the same type of filter cloth. However the sample from Watsonville looked completely clean after being treated with Hydrex 4921 or HCl, an explanation to this could be that there was a diffrence between different batches of filter media sent from the manufacturer.

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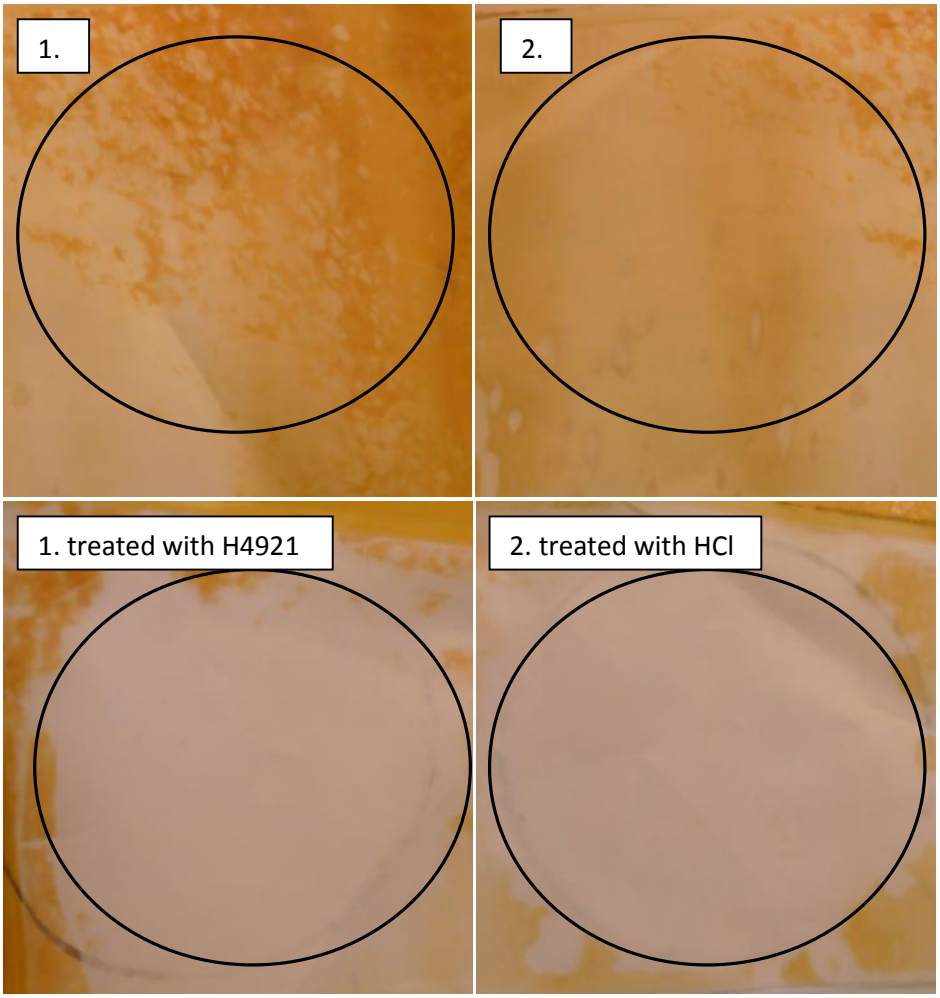

Figure 2: Pictures of the filter media before and after treatment with Hydrex 4921 (10%) and HCl (15%).

Conclusions

- The fouling of the filter is most likely due to Iron
- Hydrex 4921 with a 10 % (weight) solution can be recommended to use to recover the filtration capacity since it will remove the fouling
- The recovered capacity of the sample was lower than the expected capacity of a new sample of the 10 micron media that was used in 2008.
- Replacement of old panels to Hydrotech's current 10 micron media will most likely increase the capacity of the filters with at least 10-20 %.

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