Date: January 12, 2023

To: Joe Trueblood, Utility Superintendent

From: Bill Swearingen, Operations Supervisor

Subject: Filter Underdrain Monitoring and Future Planning Report

Background

An IMS cap failure on filter 5 initiated an emergency response that included an onsite visit from Leopold to which they determined that the underdrain was a good candidate for an IMS cap replacement and conversion to their IMS 200 cap. Utility staff completed all necessary underdrain preparations and IMS cap replacement work. The filter was returned to service on December 12, 2022 and is operating within the manufacturer's specifications and WDNR standards. In parallel to this work, operations staff have also participated in filter underdrain replacement alternatives and review workshops organized by utility engineering consulting firm CDM Smith.

Underdrain Pressure Testing

The Operations Department operates and maintains 11 gravity sand filtrations systems installed by Leopold in the mid-1990s. Based on recommendations, additional filter assessments and pressure monitoring have also been completed by staff. Details are below (oldest to newest):

Filters #9, #8, and #7
Installation year: 1996/1997
Age: 26/25 years
Underdrain Type: S Underdrain with I.M.S Cap media retainer
Modifications: None

Pressure testing across existing I.M.S cap (Head loss):

- Filters 9
    - Pressure reading at high-rate backwash = 9.2 psi
    - Pressure reading at static (water level at trough weir) = 2.7 psi
    - Pressure differential = 6.5 psi
- Filters 8
    - Pressure reading at high-rate backwash = 9.2 psi
    - Pressure reading at static (water level at trough weir) = 3.5 psi
    - Pressure differential = 5.7 psi

- Filter 7
    - Pressure reading at high-rate backwash = 10 psi
    - Pressure reading at static (water level at trough weir) = 3.0 psi
    - Pressure differential = 7.0 psi

Both 8 and 9 filters are experiencing elevated headloss pressure differentials of 6.5 psi and 5.7 psi. The estimated pressure differential on non-clogged system is approximately 2.0 psi.

Like filters 8 and 9, filter#7 is experiencing a higher elevated headloss at a pressure differential of 7.0 psi. The estimated pressure differential on non-clogged system is approximately 2.0 psi.

Plan of Action:
Continue with monitoring and operational contingency planning to further reduce risk of over pressurizing the IMS caps. Filters 7, 8, and 9 should be targeted for replacement within 1-2 years. Replacement underdrain systems would be based on filter underdrain alternatives and review workshops conducted by utility staff and CDM Smith. Total underdrain replacement cost for all three filters is estimated to be $1,275,000 installed with media. This cost would include initial air scour equipment purchase. Recommend scheduling replacement in years 2023/2024.

Filter #6
Installation year: 1997
Age: 25 years
Underdrain Type: S Underdrain with I.M.S Cap media retainer
Modifications: None

Pressure testing across existing I.M.S cap (Head loss):

- Pressure reading at high-rate backwash = 12 psi
- Pressure reading at static (water level at trough weir) = 2.6 psi
- Pressure differential = 9.4 psi

Filter #6 is experiencing extremely high headloss at a pressure differential of 9.4psi. The estimated pressure differential on non-clogged system is approximately 2.0 psi

Plan of Action:
I would recommend that the utility engage Leopold on an IMS cap replacement project as we have done with filter 5. Media would need to be removed to determine that the underdrain is not damaged and make sure it's a good candidate for an IMS cap replacement. Utility staff can complete all necessary underdrain preparations and IMS cap conversion to the IMS 200 cap. Leopold indicates that an IMS cap conversion extends the working life of an underdrain 5-10years. IMS cap replacement project returns the filter to service within 4 months at a total cost of $120,000 plus utility labor. IMS Cap replacement project can be scheduled in year 2023

The utility would then need to look at an underdrain replacement after 5 years. The replacement underdrain would ideally be the same underdrain system installed in other filtrations systems based on the underdrain evaluation report generated by CDM Smith. Total underdrain replacement cost for filter 6 after 5 years is estimated to be $425,000 installed with media. Recommend scheduling replacement in year 2028.

Filter #5
Installation year: 1998
Age: 24 years
Underdrain Type: S Underdrain with I.M.S Cap media retainer
Modifications: Original IMS cap fail in 2022. Completed IMS cap replacement in 2022 (IMS cap conversion to the IMS 200)

Pressure testing across existing I.M.S cap (Head loss):

- Pressure reading at high-rate backwash = 4.8 psi
- Pressure reading at static (water level at trough weir) = 2.9 psi
- Pressure differential = 1.9 psi

Filter #5 is not seeing significant increased pressures. The estimated pressure differential on non-clogged system is approximately 2.0 psi

Plan of Action:
After Leopold's onsite inspection, Leopold's recommendation for this filter was removal of the I.M.S Cap and replacing with I.M.S 200 media retainer. Media was removed to determine that the underdrain was not damaged and to make sure it's a good candidate for an IMS cap replacement. Utility staff completed all necessary underdrain preparations and IMS cap conversion to the IMS 200 cap. Leopold indicates that an IMS cap conversion extends the working life of an underdrain 5-10years. The utility would then need to look at an underdrain replacement after 5 years. The replacement underdrain would ideally be the same underdrain system installed in other filtrations systems based on the underdrain evaluation report generated by CDM Smith. Total underdrain replacement cost for filter 5 after 5 years is estimated to be $425,000 installed with media. Recommend scheduling replacement in year 2028.

Filters #3 and #4
Installation year: 1998
Age: 23/24 years
Underdrain Type: S Underdrain with I.M.S Cap media retainer
Modifications: None

Pressure testing across existing I.M.S cap (Head loss):

- Filter 3
    - Pressure reading at high-rate backwash = 8.4 psi
    - Pressure reading at static (water level at trough weir) = 3.5 psi
    - Pressure differential = 4.9 psi
- Filter 4
    - Pressure reading at high-rate backwash = 9.2 psi
    - Pressure reading at static (water level at trough weir) = 3.4 psi
    - Pressure differential = 5.8 psi

Filters 3 and 4 are experiencing elevated headloss at pressure differentials of 4.9 psi and 5.8 psi. The estimated pressure differential on non-clogged system is approximately 2.0 psi.

Plan of Action:
Continue with monitoring and operational contingency planning to further reduce risk of over pressurizing the IMS caps. Filters 4 and 3 should be targeted for replacement within 2-3 years. Replacement underdrain systems would be based on filter underdrain alternatives and review workshops conducted by utility staff and CDM Smith. Total underdrain replacement cost for both filters is estimated to be $800,000 installed with media. Recommend scheduling replacement in year 2025.

<u>Filters #1 and #2</u>
Installation year: 1998
Age: 23 years
Underdrain Type: S Underdrain with I.M.S Cap media retainer
Modifications: None

Pressure testing across existing I.M.S cap (Head loss):

- Filter 1
    - Pressure reading at high-rate backwash = 7.8 psi
    - Pressure reading at static (water level at trough weir) = 3.2 psi
    - Pressure differential = 4.6 psi
- Filter 2
    - Pressure reading at high-rate backwash = 7.5 psi
    - Pressure reading at static (water level at trough weir) = 2.5 psi
    - Pressure differential = 5.0 psi

Filters 1 and 2 are experiencing slightly elevated headloss at pressure differentials of 4.6 psi and 5.0 psi. The estimated pressure differential on non-clogged system is approximately 2.0 psi.

Plan of Action:
Continue with monitoring and operational contingency planning to further reduce risk of over pressurizing the IMS caps. Filters 1 and 2 should be targeted for replacement within 3-4 years. Replacement underdrain systems would be based on filter underdrain alternatives and review workshops conducted by utility staff and CDM Smith. Total underdrain replacement cost for both filters is estimated to be $800,000 installed with media. Recommend scheduling replacement in year 2026.

Filters #10 and #11
Installation year: 2018/2007
Age: 4 years and 15 years
Modifications: Original S Underdrain with I.M.S Cap media retainer replaced due to failures

- 2007 – Filter #11 underdrain failure. Replaced with Type SL underdrain with I.M.S Cap media retainer
- 2018 – Filter #10 underdrain failure. Replaced with Type XA underdrain with I.M.S 200 media retainer

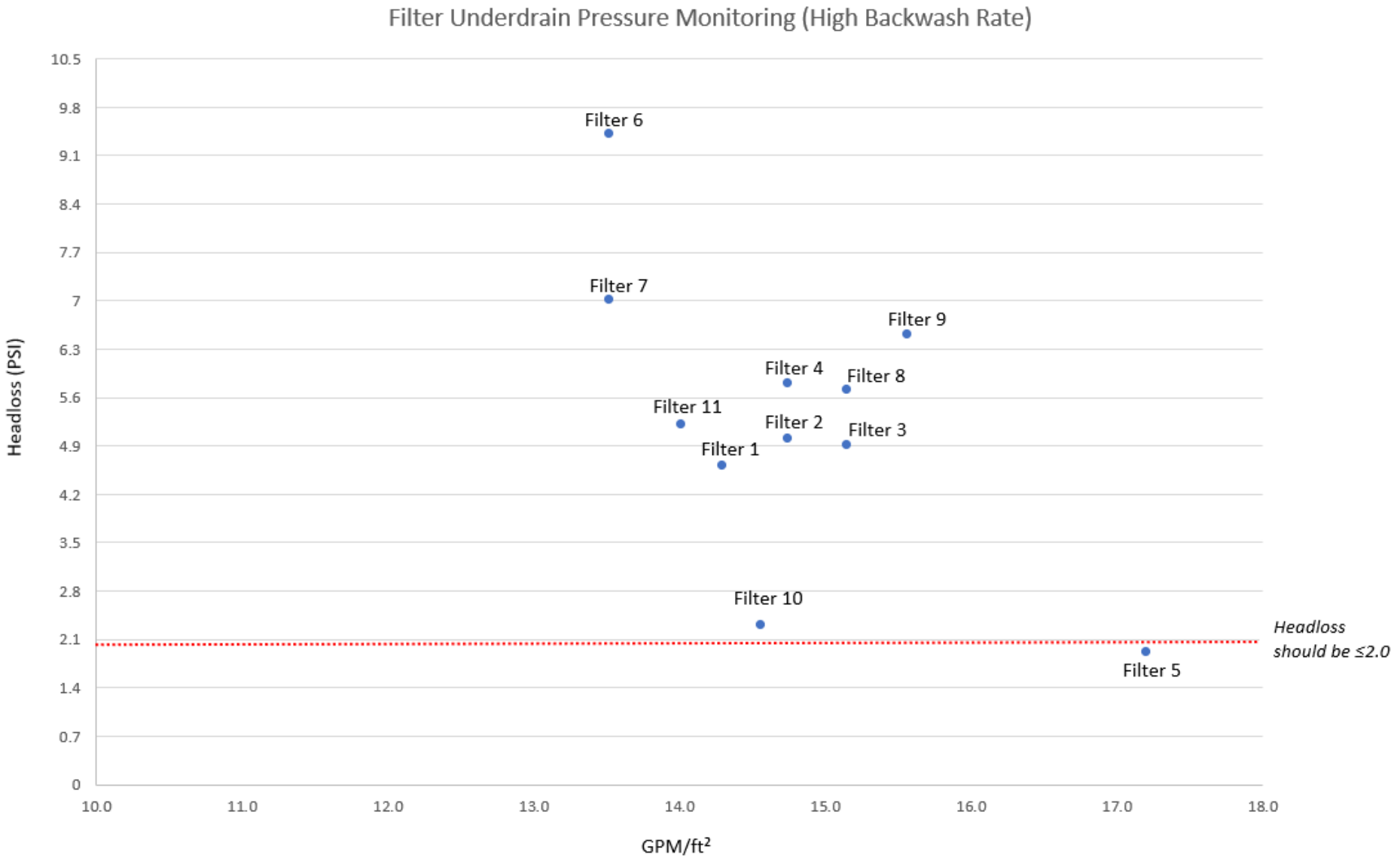
Pressure testing across existing I.M.S cap (Head loss):

- Filter 10
    - Pressure reading at high-rate backwash = 4.8 psi
    - Pressure reading at static (water level at trough weir) = 2.5 psi
    - Pressure differential = 2.3 psi
- Filter 11
    - Pressure reading at high-rate backwash = 8.5 psi
    - Pressure reading at static (water level at trough weir) = 3.3 psi
    - Pressure differential = 5.2 psi

Filters 10 is not seeing significant increased pressures. Filter 11 is experiencing slightly elevated headloss at a pressure differential of 5.2 psi. The estimated pressure differential on non-clogged system is approximately 2.0 psi.

Plan of Action:
Continue with monitoring and operational contingency planning to further reduce risk of over pressurizing the IMS caps. Filter 10 should have a working lifetime of 20-25 years based on previous replacement work and assessments. The replacement underdrain would ideally be the same underdrain system installed in other filtrations systems. Total underdrain replacement cost is estimated to be $600,000 installed with media. Recommend scheduling replacement in year 2038.

Filter 11 should be targeted sooner because it is still operating under the same style underdrain system (Type SL underdrain with I.M.S Cap media retainer) that failed in 2007. The replacement underdrain would ideally be the same underdrain system installed in other filtrations systems. Total underdrain replacement cost is estimated to be $550,000 installed with media. Recommend scheduling replacement in year 2027 when the underdrain is at 20-year life expectancy.



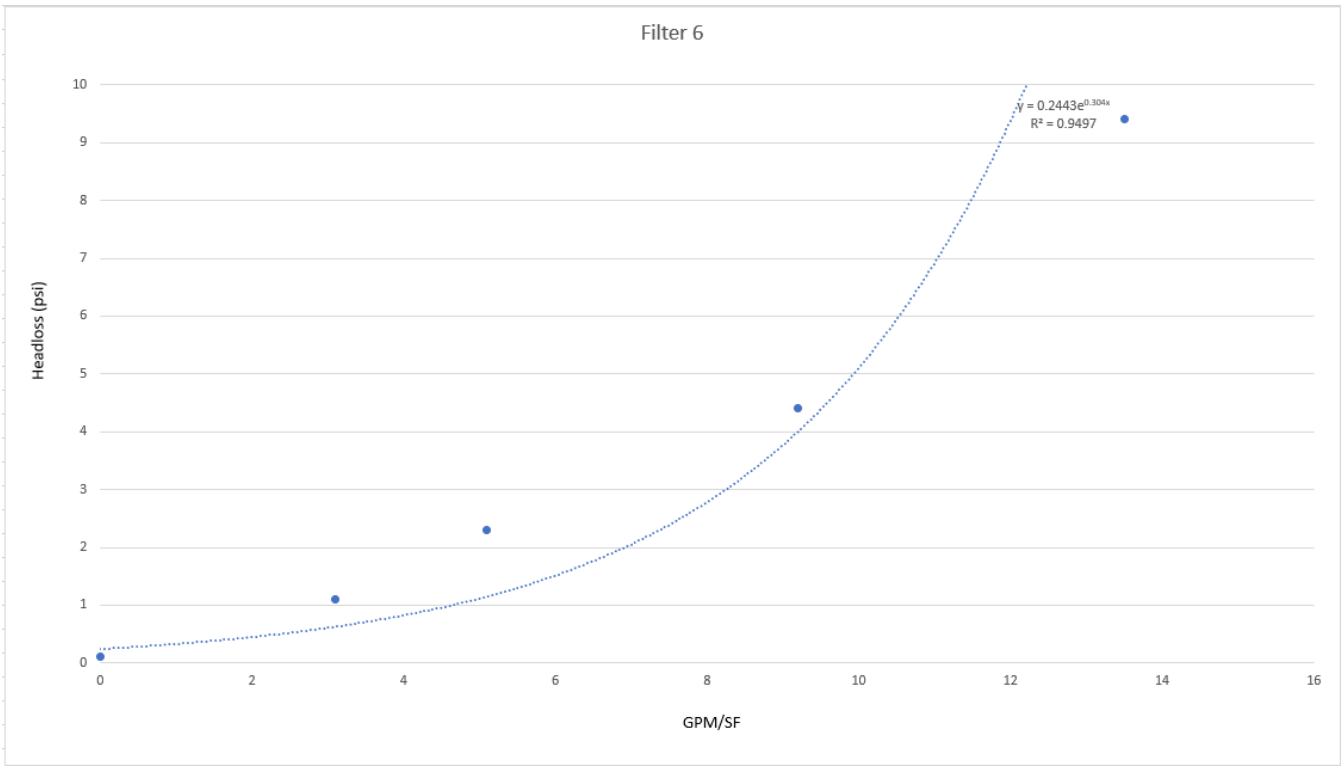
NOTE:
13-15gpm/ft² backwash rate used to minimize over pressurizing
Typical backwash rate is 15-20gpm/ft²

Contingency Planning

The Operations department has implemented the following changes to backwashing operations to further reduce risk of over pressurizing the IMS caps:

- Filter Run Hours: Filters are to be washed every 100hrs or one per shift. This action is to prevent any further clogging of the IMS cap.
- Wash Operations: To help reduce the pressure across the IMS cap, staff will wash at a lower rate. Typically, the wash valve is set to wash at a high wash rate of 15-20gpm/ft^2. Washing operations have been adjusted to 13-15gpm/ft^2.
- Operations staff have installed pressure gauges on the filters to monitor pressure across the caps. Monitoring the pressure vs gpm/ft^2 during wash operations is ongoing. Any change in pressure over time will help determine whether the underdrain IMS cap is clogging at rapid rate.

Individual Filter Underdrain Headloss Curve Example:



Replacement and Cost Schedule

Underdrain Replacement and Cost Schedule			
Year	Filter #	Cost	Total Cost
2024	9	$ 425,000.00	$ 1,275,000.00
	8	$ 425,000.00	
	7	$ 425,000.00	
2025	4	$ 400,000.00	$ 800,000.00
	3	$ 400,000.00	
2026	2	$ 400,000.00	$ 800,000.00
	1	$ 400,000.00	
2027	11	$ 550,000.00	$ 550,000.00
2028	5	$ 425,000.00	$ 850,000.00
	6	$ 425,000.00	
2038	10	$ 600,000.00	$ 600,000.00

These are initial cost estimates provided by filter underdrain manufacturers. Updated cost estimates to be included in the underdrain replacement alternatives and review report provided by CDM Smith. Design services and bidding documents would also need to be provided by CDM Smith. WDNR and PSC approvals will be required, with estimated lead times of 4-6 months. I would recommend that no more than 3 filters be out of service for replacement to maintain plant filter capacity for an average day demand. Under this replacement schedule, 54% of the filters will be either new and/or rehabilitated by spring 2024, this includes the filter 10 underdrain replacement in 2018.