Date: September 9, 2022

To: Joe Trueblood, Utility Superintendent

From: Bill Swearingen, Operations Supervisor

Subject: Filter 5 Summary Report

This report is meant to provide a timeline of events in identifying filter #5 IMS cap failures and discussions with the underdrain representative and manufacturer.

The report also includes contingencies planning items and associated timelines:

- Operational Changes
- Media Removal/Standby Media
- IMS Cap Replacement Options
- Catastrophic Underdrain Fail
- Emergency Underdrain Design

Filter 5 Event Timeline

August 24, 2022

During our annual inspection we found a low spot in filter 5 media. Ops staff dug the area up for further inspection and found that the beaded underdrain cap was cracked and had failed.

The filter was last inspected in December 2021. At that time, there was no indication of an underdrain failure, and the filter turbidity has been normal. Ops staff did well and caught this in the early stages before a catastrophic failure. Water quality standards were maintained, and filter effluent turbidity remained unchanged during the event.

The filter is currently out of service.

I initiated contact via email with Drydon (Leopold Rep) and Xylem (Leopold Underdrain Manufacturer). Xylem responded indicating that it's possible that a simple IMS cap replacement, with sealant and screws could be a good course of action. But before doing so, they suggested the following:

- Removal of damaged IMS cap and evaluation of volume of media that migrated into the underdrain system
    - Worst case the system will need flushed and a few more IMS cap will require replacement
- Test of the structural integrity of the grout to ensure the underdrain system was not jeopardized
    - Hammer test (tapping of grout joints and listening for hollow or solid sounds)
    - Drill/water test of grout joints to determine grout/basin floor retention (if hammer yields questionable results)

August 25, 2022

It was determined that the media needed to be removed to complete a more thorough inspection. I contacted three different hydrovac vendors for media removal: Alberts HydroVac, CoreVac, and Valley HydroVac. Valley HydroVac was the only vendor that responded.

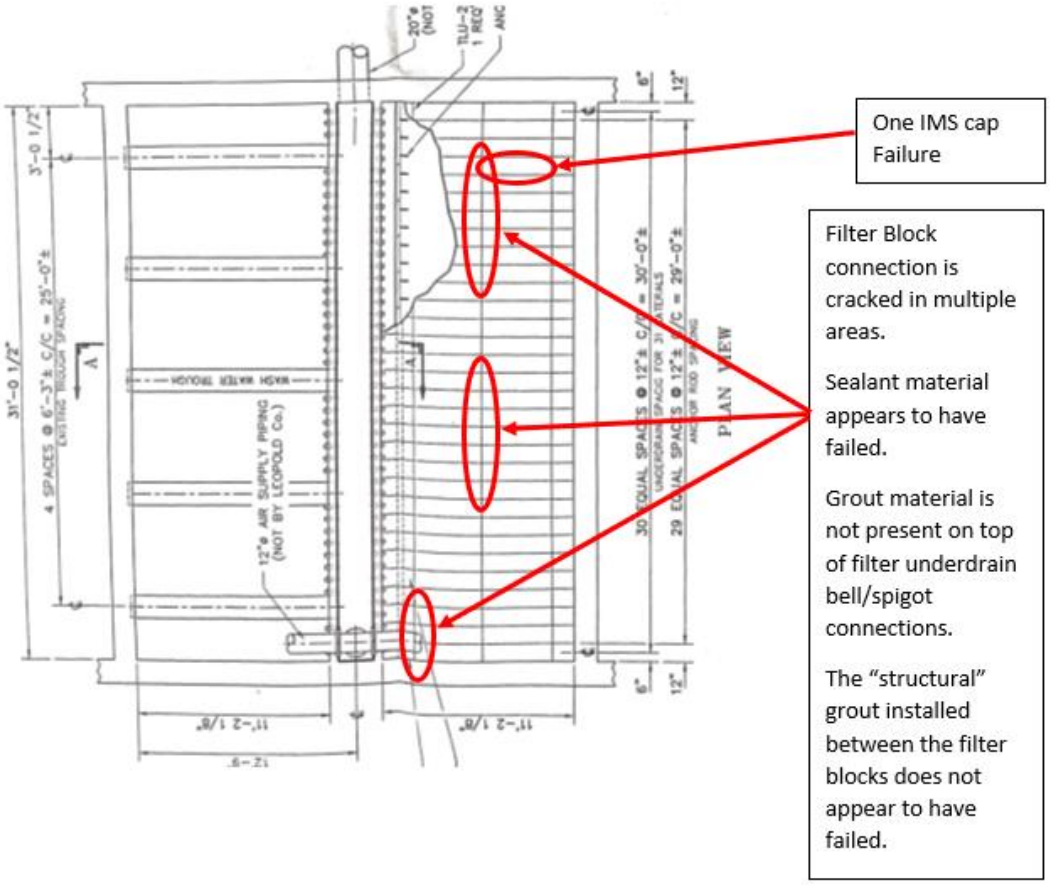
August 26, 2022

Valley HydroVac indicated they would be able to remove the media with his two vac trucks. They anticipated 1 day to completely remove the media in the south bay. The media was hauled off site and stored on N. 36th street utility property. South filter bay media was removed on August 26th.

August 27, 2022

I completed an initial inspection with photos and observations. There appeared to be only one IMS cap that has failed. No "filler" grout appeared to have failed as with filter 10 and 11 (this would be the grout installed between the filter blocks). But did I find multiple areas where grout at the filter underdrain bell/spigot plastic connection itself is cracked. Sealant material is also present and appears to have failed at these connections. Details and photos below:

Filter Bay Overview- Damaged area locations



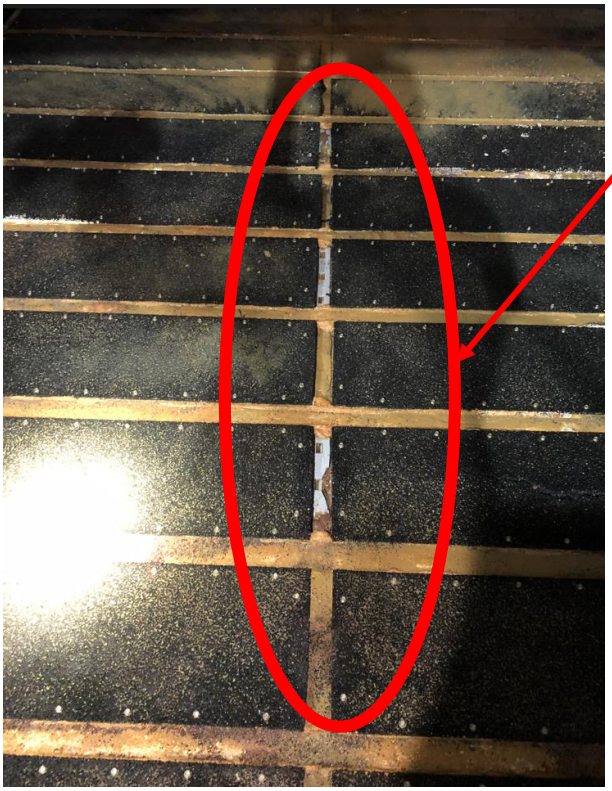
IMS Cap Failure

One IMS cap fail.

No grout is present at the filter underdrain bell/spigot connection.

Filter underdrain bell/spigot connection is also cracked in multiple areas

Filter underdrain bell/spigot connection, grout, & sealent failure



No grout is present at the filter underdrain bell/spigot connection.

Filter underdrain bell/spigot connection is also cracked in multiple areas

No grout is present at the filter underdrain bell/spigot connection.

Filter underdrain connection is cracked

No grout is present at the filter underdrain bell/spigot connection.

Sealant material is present and appears to have failed.

August 29, 2022

The decision was made to remove media from the north bay based on initial inspection and observations in the south bay underdrain. Ops staff took video footage during backwashing and found several end cap sealant fails. I emailed Drydron and Xylem the inspection report and video of additional end cap sealant fails. Xylem responded with three “engineering guidelines” for repairs:

1. IDENTIFICATION AND REPAIR OF LEAKS FOR UNDERDRAIN BELL & SPIGOT JOINTS
2. I.M.S CAP FIELD INSTALLATION PROCEDURE
3. SEAL REINFORCEMENT REPAIR

NOTE: These guidelines were dated 2007 and 2013. The utility was never informed of these “service announcements”. Rather, Xylem refers to them as product improvements.

Ops staff discussed repair work internally, with having uncertainty on the life expectancy and reliability of the proposed repairs. More information was needed from Xylem.

August 30, 2022

At this point, several items remained unclear, so a teleconference was scheduled with Xylem and Drydron to address additional concerns. CDM Smith on behalf of the utility was also present. Topic's of discussion:

1) How can we determine if the O-rings are properly placed and no leaks are present? Is there a possibility of having someone from Xylem available to make this determination. If the O-rings are compromised, we aren't clear if the repair can proceed.

2) There is a sense that IMS caps are partially clogged, and, in the event of repairs, we should consider replacing all of them and making the additional screw modification. For one bay, I believe that is 62 caps, plus partials. Does Xylem have availability in short timeframe for that amount?

3) Given this damage, we think it makes sense to investigate the other bay on this filter and it might make sense to replace those caps as well. So that would be another 62, plus partials.

4) What is the availability/timeframe of replacing original IMS cap with new/improved laser-etch caps if those are determined to be the best solution to the failure? Is this feasible?

5) Regarding sealant failure, if multiple IMS caps are leaking in a given filter, this could have the effect of reducing the head drop measured across the filter bed and this could make it appear to have a normal head loss and flow rate even if the caps are significantly plugged. As we have direct visual observation of the exposed caps on #5 leaking during a simulated backwash, we would have to assume other caps in other filters are also leaking during backwash.

The Superintendent made Xylem aware of additional backwash water testing that Operations staff conducted. Testing revealed about 92% of the end cap sections are showing seal failure and backwash water is bubbling out of those areas. It was discussed that this demonstrates that backwash water is at least partially leaking out of those areas rather than going through the cap material. This suggests that significant areas of the caps are plugged and/or the end of the caps are flexing in a very significant fashion. The evidence of the actual cracked cap further suggests stress beneath that cap at a high level due to plugging and caused that damage even with water leaking out the end.

Xylem and Drydron decided that they wanted to schedule an onsite inspection with their service tech to help determine the condition of the underdrain and existing IMS caps. Xylem also requested that the utility ship IMS caps for further evaluation and testing.

August 31, 2022

WDNR was made aware of the filter failure and notification of it being taken offline.

September 7, 2022

Xylem arrived onsite at 7:30am. Mark White from CDM Smith was also present on behalf of the utility. Xylem staff quickly began inspection work regarding filter #5: further inspection on the grout, underdrain, and IMS caps. They did find one additional IMS cap fail in the north bay.

At the request of Xylem, ops staff also conducted filter washes on filter 6, 10, and 11. Xylem wanted to monitor the pressure across the IMS caps and backwash performance. It was noted that filter #6 headloss/pressure during backwashing was high and not ideal. Filter #11 was not "abnormally" high and filter #10 was good (new IMS cap in 2018). Xylem will include the pressure data in their report for follow-up.

Xylem's lab reported a preliminary hydraulic test on one of the shipped IMS caps: the headloss was ~ 100" at 15 gallons per minute per square foot backwash rate. Which is much higher than normal. Typically, you would expect to see approximately 16" of headloss. Additional headloss testing will be performed next week after further prep is completed.

Furthermore, Xylem will generate a complete inspection/service report by September 20th and schedule a follow-up meeting thereafter.

Contingency Planning

Operational Changes

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

1. Filter Run Hours: Filter's need to be washed every 100hrs or one per shift. This may prevent any further clogging of the IMS cap.
2. Wash Valve Operations: To help reduce the pressure across the IMS cap, staff need to wash at a lower rate. Typically, the wash valve is set at 62%-65% during a high wash. We need to adjust this setpoint to 50%-52% and extend the length of the wash. Staff will need to keep in mind the backwash basin capacity before filter washes.
3. OM Techs will be installing pressure gauges on the filters to monitor pressure across the caps.
    a. Pressure gauges should be delivered by September 14th. Plumbing work will need to take place, installation work will begin September 19-30. Pressure data testing can begin September 30th.

Media Removal

Valley Hydro Vac truck operations will take two days to remove media. CDM Smith has indicated that there is a vac truck company with "clean trucks" specifically used for filter media. This is another resource that would be available for media removal and maintain the ability to reinstall the media once underdrain/cap repairs are complete. Timeline is estimated 2-4 days

Media Standby

Media quote received from Red Flint Sand and Gravel, LLC. With an 8–10-week delivery timeline. A total of 56 Super Sacs will need to be stored on utility property as standby. North 36th Street, Paine Ave, EAPS, and Taylor Reservoir locations have been discussed for storage. Temporary cover will need to be provided to protect media from the elements.

Spot Replace Damage IMS Caps

The idea of replacing the damaged IMS caps with the original beaded caps and keeping media on standby was acknowledged as being a good contingency plan, but collectively staff feels this is a temporary fix. Staff are very willing to be available at a moment's notice to put filter 5 back into service if there was an emergency. Media can be installed in 2-3 days.

IMS Cap Full Replacement

Pressure Washing Existing IMS Caps:

- Ops staff have been removing additional caps and conducting testing. They've used pressure washing to clean existing IMS caps to get the IMS cap weight back to its original ~8lbs vs 10lbs, indicating that the IMS cap is free of material. Ops staff continue to investigate the possibility of leaving the caps installed, pressure washing from the top, and then backwashing from the underdrain side. But this may not dislodge the fines/sand trapped in the cap, but this has merit.
- Media: Staff have also measured that 3"-6" of media is present in the underdrain (measured via underdrain orifices with wire into the bottom of underdrain). The media that is present in the underdrain will need to be removed via wash water.
- Testing: A headloss/pressure test across caps without media can be measured for underdrain performance. If the pressure data follows the Leopold spec curve and no visual sealant leaks are present, then media could be installed, and filter reliability is improved. Although the caps may be "clean" it's unknown that they have not been compromised due the sealant fail and flexing.
- Labor: Staff can remove existing IMS caps, clean and reinstall with new sealant. This work is labor intensive and challenging.
- This is approach is feasible. However, this comes with uncertainly if media cannot be removed entirely.

IMS Cap Replacement with Improved Laser Etched IMS Cap:

- If Xylem were to supply replacement upgraded IMS laser etched caps, ops staff would only need to remove existing caps and replacement with laser etched caps and new sealant.
- Media: Staff have also measured that 3"-6" of media is present in the underdrain (measured via underdrain orifices with wire into the bottom of underdrain). The media that is present in the underdrain will need to be removed via wash water.
- Testing: A headloss/pressure test across caps without media can be measured for underdrain performance. If the pressure data follows the Leopold spec curve and no visual sealant leaks are present, then media could be installed, and filter reliability is improved.
- Labor: Staff can remove existing IMS caps and install upgraded laser IMS cap with new sealant. It is unknown how labor intensive and challenging the installation work, but if Xylem can provide guidance that may be help.
- This is approach is feasible. However, this comes with uncertainly if media cannot be removed entirely.

NOTE: IMS cap cleaning and/or replacement does not address cracks at the bell and spigot joints. Xylem does offer engineering guidelines for these bell/spigot repairs, but the at this time, it's unknown if these repairs will maintain the underdrain's structural integrity.

Both options could return the filter to service quickly and with confidence. The filter can arguably be returned to service within 8-10 weeks based on media delivery.

Future IMS Cap Failures

Media would need to be replaced in other filters to complete IMS cap cleaning/maint work. This doesn't seem very cost effective at $56K. But if staff were to see additional signs of cap failures on other filters, staff felt that they would not need to remove media entirely, but rather spot replace the cap and continue service. This would be more of a "band-aid" approach, but the filter is still serviceable. Xylem indicated that they could ship overnight a replacement IMS cap. Ops staff can install within 2-3 days.

Catastrophic Underdrain Fail

If there is a grout failure and a filter underdrain is lifted, then that is catastrophic.

It is probable, that the utility may have no choice but to direct replace with a Xylem XA underdrain system; because the original underdrain design drawings can be modified more quickly than a new design, and project contract can be expedited. This new style underdrain system was installed on filter #10 in 2018. Based on 2018 filter 10 replacement value and inflation, estimated replacement cost would be ~$325,000.00 (Xylem XA underdrain system). Underdrain replacement project is estimated to have a 9–10-month lead-time.

Emergency Underdrain Design

CDM Smith is reviewing filter 5 design and different underdrain alternatives for the utility. They will provide an alternative report that include emergency design work based on different underdrain designs and project lead times. This report will be ready for review at the September 19th board meeting.