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Technical Memorandum

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To: Jonathan Batista, Assistant Director (RBUSD)

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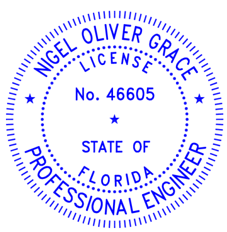

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Limitations:

This document was prepared solely for Riviera Beach Utility District in accordance with professional standards at the time the services were performed and in accordance with the contract between Riviera Beach Utility District and Brown and Caldwell dated August 20, 2018. This document is governed by the specific scope of work authorized by Riviera Beach Utility District; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Riviera Beach Utility District and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Section 1: Introduction

The City of Riviera Beach Utility Special District (RBUSD) owns and operates a Water Treatment Plant (WTP), located at 600 West Blue Heron Boulevard, Riviera Beach, Florida 33404. The major process elements of the existing WTP, built from the 1950's to the 1970's, provides treatment using raw water aeration, lime softening, filtration, secondary disinfection with chloramines, before finished water is stored and pumped to the distribution system. The WTP has been challenged to consistently achieve desired performance due to varied constraints arising from inoperable equipment, inadequate monitoring and control capabilities, equipment that is approaching the end of its functional and reliable useful life, sub-optimal process applications and deferred maintenance.

RBUSD has prioritized the need for improvements and is expediting the implementation of an aggressive program to improve the condition of the WTP and studying the feasibility of building a new WTP to replace this old plant. To facilitate the required improvements, the City has engaged two (2) design Build Contractors to complete various high-priority improvements that will enhance the consistency and control of chemical treatment practices as well as process monitoring capabilities. Brown and Caldwell was retained to provide limited technical support during the design/permitting phase of the City's ongoing improvements and additionally, conduct supplemental investigation of the existing filtration process to identify critical needs that should be prioritized and potentially included in the design builder scope of work. This Technical Memorandum summarizes the findings and recommendations of the Filter Evaluation.

This Technical Memorandum includes the following main components:

- Approach to Complete Evaluation
- Design Characterization of Filtration System
- Condition Assessment of Filtration System
- Preliminary Recommendations.

The assessment and recommended guidance provided in this Technical Memorandum shall be considered to be preliminary based on the judgement of Brown and Caldwell and limited scope of this assessment. Additionally, Brown and Caldwell relied on data from various sources without completing an independent validation. As part of next steps and before implementation, the Engineer of Record shall conduct further investigation and field validation as part of the preliminary and detailed design development effort.

Section 2: Scope of Services and System Evaluation Approach

2.1 Filter Evaluation Scope of Services

The objective of the evaluation of the existing filtration system is to identify performance limitations at the plant filtration system, identify improvements, and prioritize those improvements. Field visits for visual assessments were conducted with the City's Operation's staff to obtain their input on system operation and condition. The intent of this evaluation is to establish the critical improvements that may be added to the scope of the design-build Contractors working on the improvements to the plant.

The following summarizes the activities conducted as part of the Filter Evaluation:

1. Kickoff and Filter Evaluation Test Plan – Brown and Caldwell developed a preliminary filter evaluation test plan and participated in a Kickoff Meeting with the City's staff to review the plan and discuss other task requirements

2. Field Site Visits – Brown and Caldwell personnel participated in multiple site visits to the plant to conduct field inspection and assessment of the components of the plant filtration system, conducted detailed examination of select filters and support systems.

3. Visual Filter Operational Inspection - Conducted visual observation of each filter during normal filtration operation and interviewed operators.

4. Visual Backwash System Inspection - Conducted a visual observation to observe limited backwash sequences representative of water-only backwashed filters and air/water backwashed filters. During this inspection, visual observation and data collection was conducted to characterize filter condition and backwash performance.

5. Core of Filter Media - Conducted core sampling of filter media (one filter).

6. Technical Memorandum - Prepared a summary of the findings and recommended improvement priorities.

2.2 Filter Evaluation Approach

Brown and Caldwell developed written protocols for the evaluation of the existing filter system. These protocols were developed to also provide resources that may be used by RBUSD O&M staff for routine inspection of the filters in the future. The protocols, presented in Appendix A, provide the following evaluation guidelines that were applied where determined to be appropriate:

1. Visual Inspection Checklist – identifies readily observable conditions to look for to provide an indication of potential filter limitations.

2. Backwash Review Protocols – identifies visual observations to note during backwashing as well as data that may be collected to establish performance parameters.

3. Core Sampling Protocols – defines method of retrieving samples of filter media for closer examination of condition.

4. Mud Deposition Profile Testing – defines method of testing the effectiveness of backwashing operation in cleaning the filter media.

Section 3: Existing Filtration System

3.1 Existing Filters and Improvement History

The WTP has a total of sixteen filters that are configured in two (2) trains that are aligned with the following groupings of lime softening (LS) treatment units:

1. Filters 1 to 8 (South Train) – receive and treat settled water from LS Unit 1 with a permitted treatment capacity of 3.5 mgd. Filters 1-4 were constructed in 1957, and filters 5-8 constructed in 1964. These eight (8) filters were refurbished in 1996. The refurbishment included the following elements:
    a. Addition of air scour capabilities as a replacement of the surface wash system;

   b. Replacement of underdrain system with a Leopold Type S underdrain with integral media support cap (IMS).
   c. Dual media (anthracite and sand) were replaced and modifications were made to the depth of each filter cell.
   d. Improvements to the control system and valves

2. Filters 9 to 16 (North Train) – receive and treat settled water from LS Units 2 and 3 which have a combined treatment capacity of 14 mgd. These filters were originally constructed in 1979 and underwent the most recent upgrades in 1997 including:
   a. Replacement of the surface wash system.
   b. Replacement of anthracite and sand media as well as supporting gravel bed.
   c. Control system and valve improvements.
   d. Modifications to the backwash supply and metering systems.

3. While the south filtration train (Filters 1 to 8) receive flow from the smallest LS Unit 1, due to difference in the hydraulic gradeline between the two trains, it is important to maintain adequate filtration capacity in this train particularly for operating scenarios where either LS Unit 2 or 3 is out of service thereby increasing the need to rely on LS Unit 1.

3.2 Design Configuration of Existing Filters

Based on the review of available drawings and reports, the design characteristics of the existing filters are summarized below in Table 3-1. Noteworthy design considerations include the following:

1. Filters 1 to 8 together with LS Unit 1 are positioned at a lower elevation than Filters 9 to 16 and their corresponding LS Units and are therefore operated in hydraulic isolation from each other. Consequently, though Filters 1 to 8 have 50% of the combined filtration surface area, they currently are configured to treat only 17% of the design flow and would require further piping and flow control modifications to uniformly distribute settled water flow among all filters.

2. Due to the above-noted hydraulic configuration, Filters 1 to 8 have a firm (i.e., with one unit out of service) design rated loading rate of 1.14 gpm/sf, approximately one-fourth the design loading rate of 4.57 gpm/sf for Filters 9 to 16. The loading rate in Filters 9 to 16 is higher than desired and could benefit from the ability to redistribute flow uniformly among all filters.

3. Interconnect piping and normally closed isolation valves are in place that could allow flow from LS Units 2 and 3 to be directed to Filters 1 to 8; however, without appropriate flow meeting and regulating valves to compensate for the head differential between the two filter trains, redistribution of settled water flow between the two filtration trains is an impractical consideration without further capital improvements. It should be noted that the head differential favors controlled redistribution of flow.

4. There are two existing constant speed transfer pumps that are used to either transfer treated water from the clearwell to the existing ground storage tank (GST) or provide a supply of backwash water. The capacity of the transfer pumps are different, 1500 gpm and 4500 gpm, to develop slow rate backwash flows using the smaller of the two pumps and rapid rinse flows when both pumps are operated in parallel.

5. The direction of flow from the transfer pumps to either the GST or the filters is determined by an electrically actuated valve which when open, allows the GST to be filled and when closed, redirects

flow to the filters for backwashing. The condition and reliability of the valve to actuate on demand and achieve a tight seal when closed is critical to the ability to develop adequate flow to backwash the filters.

Table 3-1. Design Configuration of Existing Filters

	Units	Filters 1 – 8 (South)	Filters 9 – 16 (North)
No. of Filters		8	8
Unit Filtration Surface Area	sq. ft	304	304
Nominal Capacity	MGD	3.5	14.0
Firm Surface Load Rate - design	Gpm/sq. ft	1.14	4.57
Unit Backwash Rate – slow rinse	Gpm/sq. ft	4.9	4.9
Unit Backwash Rate – rapid rinse	Gpm/sq. ft	18.9 (max)	18.9 (max)
Auxiliary Wash	Type	Air Scour	Surface Sweeps
Backwash Supply Delivery		Transfer Pumps	Transfer Pumps
Backwash Supply Control		Modulated Metering	Modulated Metering
Media Type	Type	Dual – anthracite/sand	Dual – anthracite/sand
Filter Rate Control		Rate of Flow Modulation	Rate of Flow Modulation

Historically, backwash water was supplied from a dedicated elevated tank (ET) that was filled with finished water. As part of past plant modifications, the ET was demolished, and alternative provisions were made to directly backwash from finished water (i.e., post high service pumping). This was an unusual arrangement due to the large demands required that can adversely impact system pressures. Plant operations staff acknowledge challenges maintaining system pressure during this operating mode and indicated the issues created in the system contributed to the decision to implement the current arrangement of utilizing transfer pumps to deliver backwash supply from the clearwell. From a review of available record drawings, the piping and valve arrangement that was previously used to support direct backwashing using finished water appear to remain in place. However, due to the adverse impact on system pressures, this operating mode is considered impractical and has not been utilized since the current arrangement has been in place.

Section 4: Filtration System Condition Assessment and Preliminary Recommendations

This section describes the findings and preliminary recommendations resulting from the filter assessment and evaluation. This evaluation was conducted using a combination of record drawings, visual inspections, testing and available reports to assess the condition of the filters. This assessment and preliminary recommendations are conceptual in nature and assumes that further investigation will be conducted during detailed design that will be completed by the Design-Builder who will serve as the Engineer of Record.

4.1 Field Inspection and Evaluation of Filters

This section includes the findings of the visual observation of various process elements of the filtration system inclusive of the readily observable content of the filter bays. The findings of the visual inspection were augment with input from the operational staff. Table 4-1 includes a high-level summary of the key observations and associated recommendations.

Table 4-1. Key Observations Relating to Condition of Existing Filters				
Observed Condition		General Applicability		Consequence, General Notes and Corrective Priority
		Filters 1 to 8	Filters 9 to 16	
1.	Troughs – broken supports, non-uniform levels	Yes	Yes	Maldistribution of influent water and backwash flows. This condition cause craters in media, non-uniform backwashing, impaired filtration performance. Occurrence – prevalent Priority – very high
2.	Surface Sweeps – holes and sheared piping	n/a	Yes	Uncontrolled jetting may cause erosion and displacement of media bed and damages troughs which causes impaired filtration performance. Occurrence – prevalent Priority – very high
3.	Air Scour – non-uniform agitation	Yes	n/a	Localized areas of vigorous agitation observed and patterns indicative of underdrain failure. Concurrent air/water rinse not effectively controlled and could contribute to increased underdrain failure risk. Priority – very high
4.	Underdrains – separation of blocks/failure	Yes	Not visible	Condition directly observed in one filter (#5) and indirectly observed (based on media disturbance patterns that align with underdrain joints) in two filters. Appears that the use of air wash is impacting the underdrains. This condition impacts filtration performance and increase risk of catastrophic underdrain failure. Priority – very high
5.	Level/Rate of Flow Control – inability to maintain consistent head and/or rate	Yes	Yes	Widely variable water surface elevation observed among filters with exposed media observed in some filters. Condition contributes to deterioration of filter media condition. Priority – high Note: Plant Manager indicates corrective action is underway according to Plant Manager
6.	Media Condition –media observed to be non-uniform with mounds, caters and fissures	Yes	Yes	Observed severe and widespread non-uniformity believed to be the result of aforementioned issues. Core sampling indicate no discernable anthracite and sand layers. This condition, and the presence of mud balls severely impairs filtration performance. Media separation from walls, craters and fissures may create short-circuit of influent flow. Priority – very high
7.	Remote Valve Actuation – limited functionality	Yes	Yes	Operators report remote actuation required to support automated protocols inoperable, but controller is scheduled to be replaced (by other ongoing work). This condition promotes inconsistency of protocols and requires local actuation of select valves that are relatively inaccessible and could pose a safety hazard. Priority – very high
8.	Backwash Observation – apparently inadequate rapid rinse flow	Yes	Yes	Relatively low rates observed that does not appear to be adequate to effectively wash media could limit the ability to clean the filters. Instrumentation reporting backwash flow rates do not appear to be accurate. Other factors (discussed elsewhere) could potentially contribute to low flows. A thick layer of sludge remaining after backwashing a filter indicated limitations of the system. Priority – very high.

Table 4-1. Key Observations Relating to Condition of Existing Filters				
Observed Condition		General Applicability		Consequence, General Notes and Corrective Priority
		Filters 1 to 8	Filters 9 to 16	
9.	Biological Growth – due to stagnate water	Yes	Yes	For two filters (No's. 1 and 2), there is an apparent obstruction constraining the ability of water to drain out of the filter. Consequently, water has been sitting in the filter for a prolonged period and has turned green from the presumed growth of algae. Priority – very high

Figure 4-1 highlights several typical deficiencies observed in the filter cells. The noted deficiencies are indexed to the descriptions noted in Table 4-1.

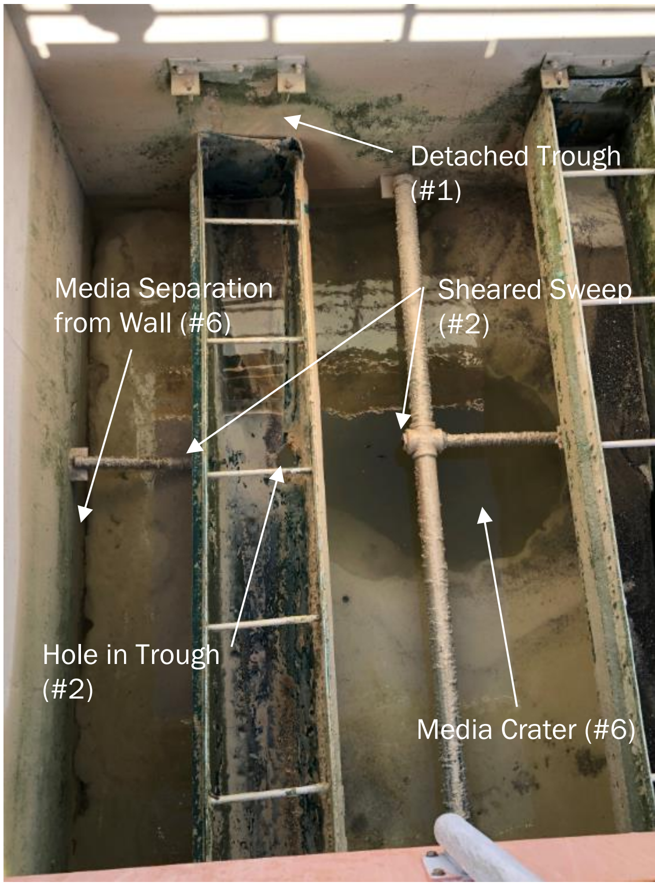


Figure 4-1. Typical Deficiencies Observed (Filter #12) – Sheared Sweep, Detached Trough and Media Crater

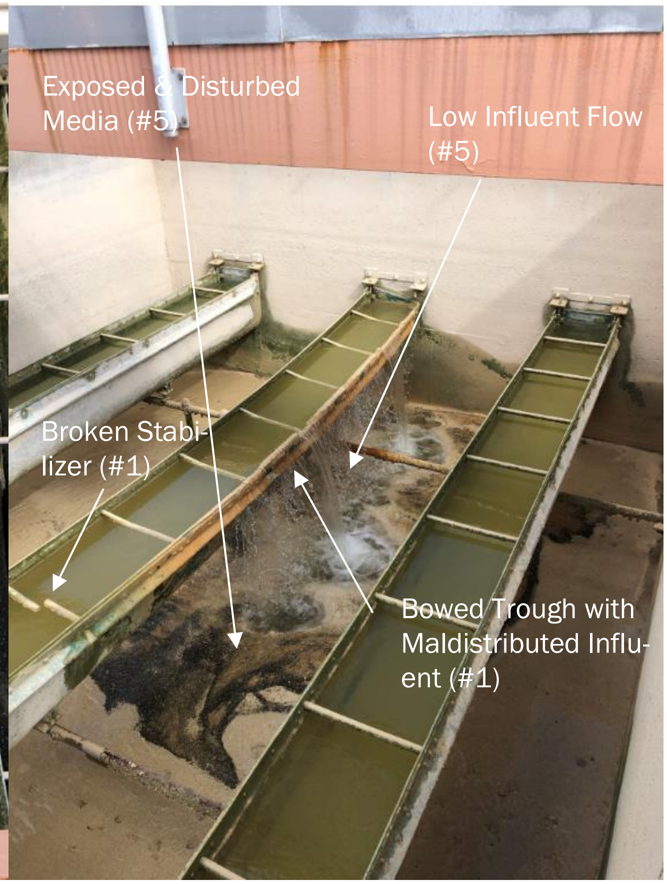


Figure 4-2. Typical Bowed Trough, Mal-distributed Influent, Media Disturbance and Lack of Water Level Control (Filter #10)

4.1.1 Troughs

Various deficiencies were observed in the wash troughs that included inconsistent levels (evidenced by non-uniform water flow over the troughs), and troughs partially detached from supports. In some cases, troughs collapsed and are on top of the media surface on one end while being partially supported on at the opposite end. In these cases, this has resulted in severe maldistribution of influent settled water and the backwash supply resulting in significant disturbance of the filter media. In impacted areas, significant displacement of filter media was observed that is anticipated to result in short circuiting and impaired filtration. Refer to Figure 4-1 and Figure 4-2.

4.1.2 Surface Sweeps

Filters 9 to 16 utilize a surface wash system. The sweeps and associated piping system for surface wash is compromised typically with holes in the piping and in one case, sheared piping. With these conditions, upon activation of the high-pressure water supply to the sweeps, significant jetting action would cause the scouring of media increase the formation of craters and in some cases, damage to impacted troughs. Note that no rotation of the sweeps was observed during visits (operators confirmed that the sweeps are generally inoperable). Besides the detrimental impact of compromised sweeps on media/trough condition, the widespread inoperability also impairs the ability to break up accumulated mudballs for subsequent removal during the rapid rinse phase of backwashing. Consequently, the inoperability of the surface sweep system contributes to an impairment of the ability to adequately clean the filter beds. Refer to Figure 4-3 for an indication of coarse localized agitation during backwashing that results from a failed sweep.

Figure 4-3. Nonuniform Backwash flow Observed (Filter #14)

4.1.3 Air Scour

Filters 1 to 8 use an air scour system since the most recent upgrades in 1996. Backwash sequences inclusive of air scour application was observed for one filter and water surface elevation was lowered for two additional filters to facilitate observation of the media and appurtenances within the filter cells. Observed air scour operation indicated lines of excessive agitation which aligned with known seams in the underdrain providing an indication of potential underdrain failure (discussed below) that provides a short circuit pathway for air to escape. The air is introduced inside the underdrain blocks which subject the blocks to buoyant uplift. Furthermore, the introduction of air did not appear to be gradually controlled which can further increase uplift forces and create a failure of the underdrains

4.1.4 Underdrains

Filters 1 to 8 (South Train) have a Leopold Type S underdrain system that is equipped with an IMS cap for media retention. This was confirmed during a visual inspection of a failed underdrain (in Filter No. 5) that emerged from the media. Filters 9 to 16 reportedly have Leopold clay tiles with a gravel bed for media retention. The actual underdrains used in this train was not confirmed in the field; however, media probing efforts indicated the presence of a supporting gravel layer.

Among Filters 1 to 8, three were inspected and all were found to have an indication of underdrain failure, believed to be at the seams where the underdrain blocks join together.

Of the three filters (1, 3 and 5), Filter No. 5 has been in a known failed condition for years (unspecified) and with the dislocated underdrain emerging from the media bed (refer to Figure 4-4). The apparent failure in the other two underdrains was evident from excessive coarse air bubbling in a line that is aligned with a known failed underdrain seam in in Filter No. 5 and/or cleaner than typical media also aligned with a seam of the underdrain block. The high incidence of failure is indicative of a vulnerability and associated risk for all the filters in this train.

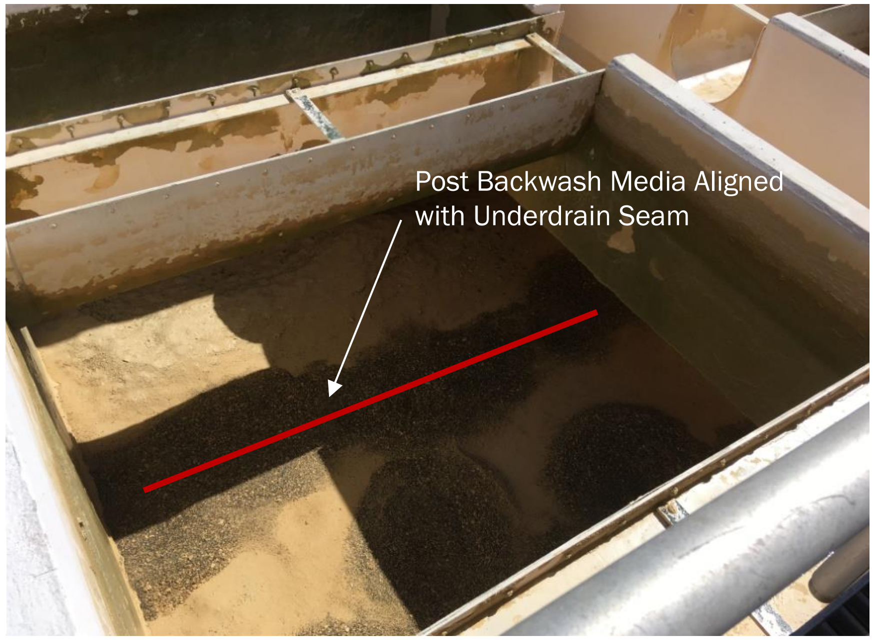


Figure 4-4. Failed Underdrain Emerged Through Media Surface

Figure 4-5. Potential Indicator of Under-drain Failure (Filter No 5)

Among Filters 9 to 16 (North Train), the media in Filter No. 14 was probed to determine differences in depth that could be indicative of irregularities in the gravel support layer. This probing provided an indication that the media supporting gravel was non-uniform in depth and likely compromised. Furthermore, with the noted craters and fissures in the media, it is anticipated that the conditions that created the craters would similarly disrupt the supporting gravel layers.

4.1.5 Rate/Level Control

Automated control of filtration rate/level is currently non-functional. This leads to uncontrolled water surface levels in each filter cell, widely variable flow split among the filters in service, and disturbance of the media in areas impacted by cascading flow over the troughs. The Plant Manager indicated the necessary control system upgrades required to establish automated operation is currently under contract for improvement by a system vendor. Consequently, it is assumed that no further action is required.

4.1.6 Media Condition

The observed condition of the media is very poor. Close inspection of the media indicated no discernable stratification (or separation) of anthracite and sand layers, extensive sludge retention/mudballs, and indicators of loss. Several contributing factors have been identified that impact the observed condition of the media particularly inadequate backwash rate and application of auxiliary washes (air scour and surface wash).

4.1.7 Remote Valve Actuation

The observed inability to remotely activate select valves is reportedly due to previously noted control limitations (Section 4.1.5) that are currently being remedied under a separate contract.

4.1.8 Backwash Observation

Observed filter backwash sequences indicated several previously noted deficiencies including inadequate rapid rinse flow development, breached and inoperable surface wash and air scour systems, and indications of failed underdrains. For Filters 1 to 8, the coordination of air scour and low-rate rinse stages coupled with control limitations could potentially contribute to increased risk of underdrain failure.

Figure 4-6 shows the remnant of a thick sludge cap remaining on the filter media following a complete backwash cycle. Close examination of the washed bed was the presence of mudballs throughout the areas of the bed probed. As shown in the photo, there media was with no delineation of stratified anthracite and sand layers. According to plant operations staff, the inability of the diversion valve (that diverts flow from the GST to the filters for backwashing) to achieve a tight seal is believed to contribute to the deficient backwash flow. Furthermore, reported flow inconsistencies indicated a need to conduct further investigation into the accuracy of backwash flow measurements.

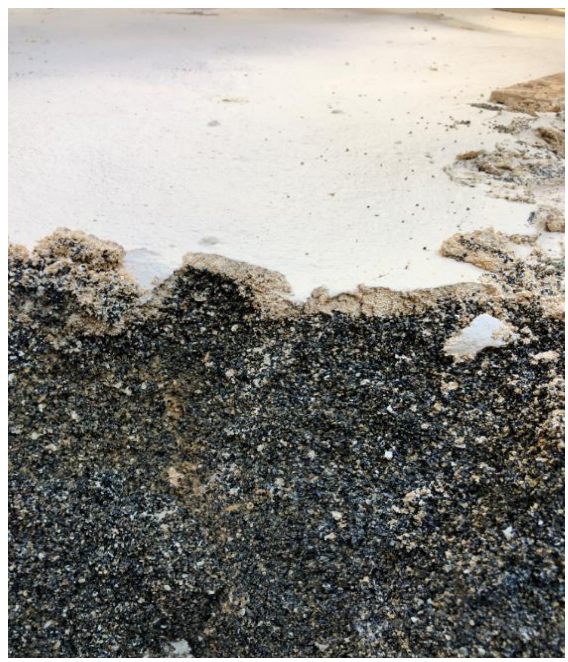


Figure 4-6. Cross-section of Washed Filter Bed

Figures 4-7 and 4-8 depict plan views of both filter trains. The numbers assigned to each filter correspond with the observed conditions listed in Table 4-1. Refer to Appendix B for more details regarding the configuration filters.

1) **Troughs** – broken supports, non-uniform levels
2) **Surface Sweeps** – holes and sheared piping
3) **Air Scour** – non-uniform agitation
4) **Underdrains** – separation of blocks/failure
5) **Level/Rate of Flow Control** – inability to maintain consistent head and/or rate
6) **Media Condition** –media observed to be non-uniform with mounds, caters and fissures
7) **Remote Valve Actuation** – limited functionality
8) **Backwash Observation** – apparently inadequate rapid rinse flow
9) **Biological Growth** – due to stagnate water

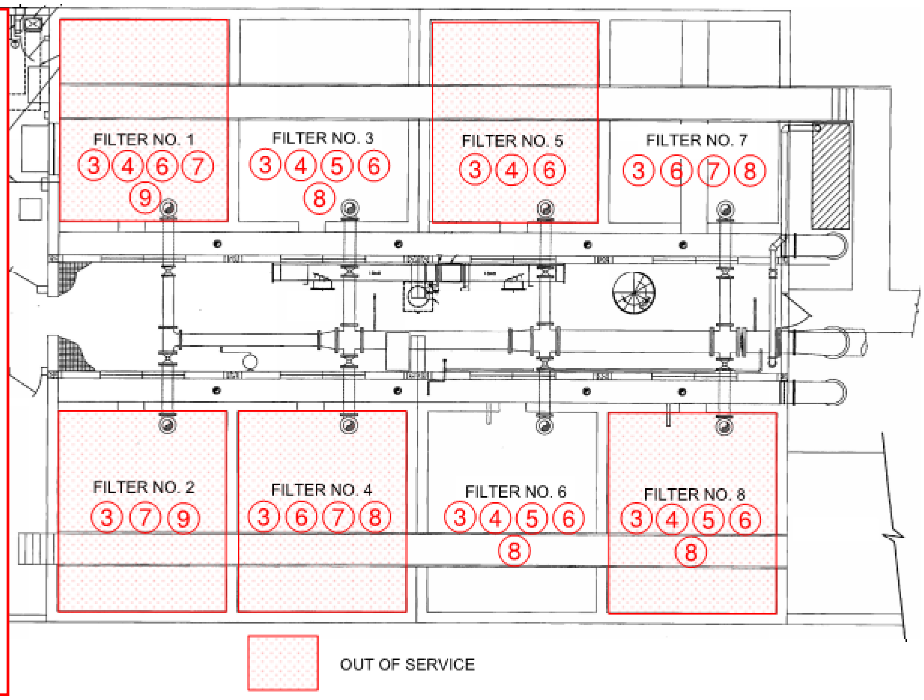


Figure 4-7. Filters 1-8 Inspection and Evaluation Results

1) **Troughs** – broken supports, non-uniform levels
2) **Surface Sweeps** – holes and sheared piping
3) **Air Scour** – non-uniform agitation
4) **Underdrains** – separation of blocks/failure
5) **Level/Rate of Flow Control** – inability to maintain consistent head and/or rate
6) **Media Condition** –media observed to be non-uniform with mounds, caters and fissures
7) **Remote Valve Actuation** – limited functionality
8) **Backwash Observation** – apparently inadequate rapid rinse flow
9) **Biological Growth** – due to stagnate water

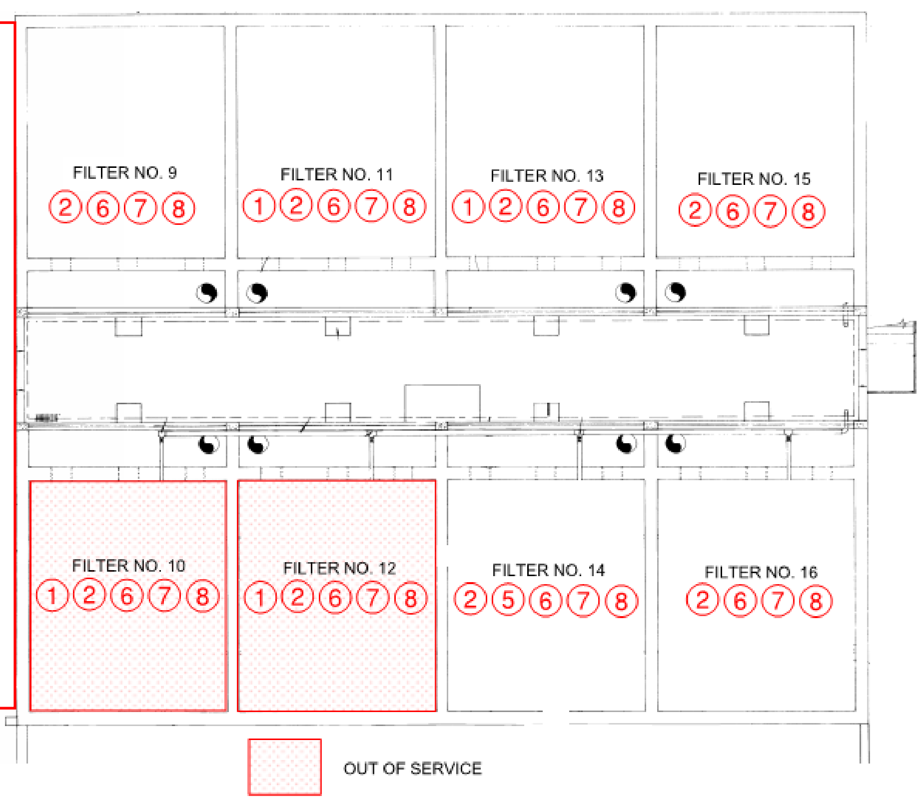


Figure 4-8. Filters 9-16 Inspection and Evaluation Results

4.2 Ancillary Filter Systems

During the site visits and associated inspections, ancillary elements of the filtration system were inspected with the objective of identifying other conditions that could be impacting the filtration system. This section summarized the key findings that require corrective action, or in some cases, further investigation.

4.2.1 Backwash Flow Metering and Control

The visual inspection of the venturi meter and modulating valve arrangement use to control and report backwash flow indicated the unfavorable configuration and placement of the sensor lines and associated instruments that could be conducive to error and potential hazard. Specifically, the following was noted (refer to Figure 4-7 and Figure 4-8):

1. The high- and low-pressure sensor lines terminate at the differential pressure transmitter at a high point that increases the risk of air entrapment with no mechanism in place to purge accumulated gasses. Accumulated air in the sensor lines could introduce significant error in the flow measurements (Figure 4-7)

2. The differential pressure transmitter and associated pressurized terminations is located in the electrical room. This is not a suitable environment for locating equipment of this type due to the potential hazard that could be caused by a water leak inside the electrical room.

Figure 4-9 and Figure 4-10. Arrangement of Venturi Meter and Sensor Lines

4.2.2 Potential Air Binding

A visual inspection of the transfer pumps and visible piping system indicated the absence of air relief valves (ARVs) that would typically be located at the discharge of each pump and/or high points in the piping system. Without appropriate venting of the high points in a piping system, there is an increased risk of air accumulating in those locations that can progressively reduce the capacity of the system as air binding progresses. There were no functional pressure gages in the system that could be used to assess operating conditions within the piping system. High points in the piping system were observed in the discharge header for the transfer pumps as well as the backwash supply piping to the Filters 1 to 8. Refer to Figure 4-9. To the extent that air binding exists, that could contribute to the constraining of backwash flow. While unrelated to the filtration system, the high service pumping system was also noted to lack air relief valves and functional pressure gages.

Figure 4-11. Transfer Pumps and Piping Discharge Missing ARVs

4.2.3 Inconsistent Hydraulic Loading of Filtration Trains

As noted previously, due to the piping configuration interconnecting the existing lime softening units to the two filter trains, settled water is not uniformly distributed to the two filter trains. Differences in overflow elevations between LS No.1 and aligned South Train filters (1 to 8) and the other softening units and the North Train filters (9 to 16) limit the ability to redistribute flow without overflowing the older treatment units. This results in Filters 1 to 8 being hydraulically underloaded while Filters 9 to 16 are overloaded, particularly in light of the condition of the filters.

4.2.4 Filtered Water Turbidity Monitoring

Filtered water turbidimeters are non-functional. When functioning, these instruments may be used to provide an indication of the performance of operator selected filters (note that each filter is not equipped with a turbidimeter). Normal turbidity monitoring practices is to periodically collect grab samples for analysis.

Section 5: Preliminary Recommended Improvements

Preliminary recommendations are provided in this section to guide improvement priorities as well as the development of preliminary engineering and detailed design focus. It is further noted that the focus of the condition assessment was to examine a representative sampling of the filters to characterize needs. Consequently, as part of subsequent preliminary engineering activities, further assessment is recommended to detail the filter specific improvements as well as alternative approaches for restoring an appropriate level of functionality.

5.1 General Improvement Considerations

The following summarizes the general considerations to guide the scope and priorities of recommended improvements to the filtration system:

1. Given the deteriorated condition of the filters and the resulting impact on turbidity removal, priority should be given to expediting the implementation of short lead time components (example media replacement and field repairs) of work in order to enhance performance while long-lead item elements (replacement of underdrains, sweeps, troughs and control improvements) may be deferred to a subsequent phase.
2. Initial prioritized focus should be on rehabilitating Filters 9 to 16 (North Train) since these filters handle most of the flow through the plant.
3. Eleven filters should be targeted for rehabilitation and restoration to full functionality – this should include up to 3 filters (should include Filter 5 to satisfy a Consent Order requirement) from among Filters 1 to 8 and all of Filters 9 to 16. The expectation for the South Train filters is that two of the five filters that are currently out of service units will undergo full rehabilitation and upon completion, the media in the three that are currently operational will be replaced.
4. Filters that are currently out of service should be initially targeted for improvement due to the ability to access each for reconstruction without impacting the current operations. Candidate filters from the prioritized North Train include Filter No. 10 & 12. For the South Train, Filters 1, 2, 4, 5 and 8 are currently out of service.
5. The functionality of the filter control improvements that are currently underway should be independently validated by the Engineer of Record once the improvements are completed and any supplemental capabilities required to achieve desired function incorporated into the proposed improvements.
6. A minimum rapid rinse backwash loading rate of 18 gpm/sf, which corresponds to a flow of 5472 gpm, should be provided. The ability to develop this flow should be verified and if deficient, appropriate improvements implemented to achieve. Minimum improvements required to confirm and/or maximize the capacity of the backwash supply system is summarized below:
    a. Replace the GST Diversion Valve - improve reliability and ensure a tight seal that prevents leakage of backwash flow. This is a critical and urgent priority as failure of the existing valve could adversely impact the operability of the WTP.
    b. Vent Transfer Pumps Discharge Piping – assess and eliminate potential backwash capacity constraint resulting from air binding.
    c. Reconfigure Sensor Lines on Backwash Supply Flow Meter – eliminate potential source of flow metering error, facilitate routine purging, and permit validation of backwash flows.
    d. Install Pressure Gauges on Transfer Pumping Discharge and Downstream Locations - permit assessment of system hydraulics.
7. Written updated backwash protocols should be developed and implemented together with an operator training protocols and procedures for promoting consistency of practice.

5.2 Filter Improvements

Table 5-1 summarizes the preliminary recommended improvements to the existing filtration system. Supplemental considerations are listed below:

1. A minimum of 11 filters should be rehabilitated and restored to full functionality – this should include a minimum of 3 filters from among Filters 1 to 8 and all of Filters 9 to 16. Within the South Train, the three filters currently in service shall have their media replaced following inspection to confirm the integrity of the existing underdrain systems.

2. Filter Media - replace in all filters selected to be rehabilitated inclusive of all eight filters in the North Train and selected filters in the South Train. The media design shall be developed by the EOR once the available backwash flow is established.

3. Surface Wash (North Train Filters) – replace all surface wash sweeps, piping grid, supports and associated system elements.

4. Air Scour System – subject to recommendations to be developed (refer to Section 5.3.1.1)

5. Washwater Troughs – replace all washwater troughs (including supports and appurtenances) in the filters that are currently out of service and assume that approximately 50% of troughs in remaining filters will requirement replacement (subject to filter specific inspection).

6. Filter Underdrains (South Train) – replace existing Leopold Type S underdrains selected for rehabilitation.

7. Filter Underdrains (North Train) – prioritize field repairs with contingent requirement to replace in select filters where field examination indicates a need.

8. Turbidimeters – replace existing meters and configure to permit monitoring of operator selected filters. Integrate Filter Influent Streams – install additional valves and flow control to permit flow from the larger softening units (2 and 3) to be uniformly distributed to all operational filters (i.e. the North and South Trains).

5.3 Preliminary Sequencing of Improvements

This section provides preliminary guidelines for the phased implementation of recommended improvements. Key sequencing considerations gave priority to expediting improvements that can rapidly deliver improved water quality while grouping long lead time elements of the work that may require further engineering considerations and procurement of specialized equipment that must be fabricated to custom requirements. Additionally, given the differences in the configuration, capacity utilization and condition of the filters between the North and South Trains, different approaches are appropriate. Phased implementation considerations are summarized below:

5.3.1 Phase 1 Improvements

1. Assess Phase 2 needs and order equipment to be installed under Phase 1
    a. Excavate a currently offline filter from the South Train for detailed inspection, validating dimensions, assessing options for underdrain replacement and auxiliary surface wash and document final recommendations
        i. Retain use of air scour or alternatively implement surface wash
        ii. Select replacement underdrain system and determine whether to retain IMS cap (or equivalent) on underdrain or utilize graded gravel support
        iii. Select media configuration that can fit within the available space based on aforementioned considerations.
    b. Select and order replacement sweeps for all filters in the North Train (note, delivery and installation will occur in Phase 2)

   c. Order a limited number of replacement troughs to have available in reserve where required to replace troughs that may not be field repaired
   d. Assess hydraulic improvements required to increase maximum backwash flow to within the target range (18 to 20 gpm/sf) and provide recommendations (some ancillary improvements required to assess capacity limitations and appropriate corrective approach)
   e. Upon completion of the ongoing SCADA and controls rehabilitation project, reassess rate of flow control improvements to more effectively manage the distribution of influent flow among the filters and maintain appropriate water levels

2. Initially target Filters 10 and 12 (North Train) which are currently out of service.
   a. Remove the existing media and supporting gravel
   b. Inspect the existing underdrains and assess the feasibility of making field repairs where a need is indicated, and repair is feasible
   c. Probe the underdrain plenum to examine for indications of accumulated media and implement measures to reduce observed accumulation to the extent feasible
   d. Conduct field repairs of existing troughs, reattach/replace supports to achieve level configuration
   e. Replace surface wash piping and reposition or cap existing sweeps (note – all sweeps will be replaced as part of Phase 2 work)
   f. Select, procure, and install suitably graded gravel and media (anthracite and sand) for installation. Target a uniformity coefficient not to exceed 1.4 for media (less than 1.3 preferred if available); media effective size and specific gravity to be determined.

3. Once the work in Filters 10 and 12 is completed and the filters are returned to service, select two additional filters from the North Train for expedited improvement and repeat the steps shown in Section 5.3.1.1

4. Based on the findings from the first four completed filters and the performance achieved, determine whether supplemental improvements are required (e.g. replacement of underdrains) and provide supplemental recommendations to be incorporated in Phase 2. Assuming a need to deviate from the approach used on the first four filters in not indicated, continue rehabilitating the remaining filters in the North Train by taking two filters out of service at a time until all Phase 1 repairs are completed.

5. During the process of implementing repairs, dismantle accessible and representative filter effluent and backwash supply piping to permit inspection of interior condition. This will determine the extent to which scale deposits may be constraining capacity.

6. Implement ancillary improvements aimed at improving hydraulics metering accuracy inclusive of
   a. Installing air relief mechanisms and pressure gages where appropriate in the backwash water supply system
   b. Reconfiguring the sensor lines of the backwash flow meter to reduce the likelihood of trapping air and providing for periodic venting (also relocate the differential pressure transmitter from inside the electrical room)

5.3.2 Phase 2 Improvements

1. Install new surface sweeps in Filters 9 to 16
2. Implement supplemental modifications to Filters 10 to 16 (North Train) based on observations from Phase 1 work, inclusive of replacing select troughs, valves/actuators, instrumentation (level sensors), etc.
3. Select three existing out of service filters of Filter 1 to 8 (South Train) and replace the underdrain, media and auxiliary wash systems with recommended systems identified in Section 5.3.1.1.a.
4. Provide a contingency allowance to provide the flexibility to replace the media in one of the three existing operational filters (selection to be determined).
5. Implement supplemental improvements (example - pumping, piping improvements) required to reliably deliver an adequate rapid rinse backwash flow rate (note, the replacement of the GST diversion valve is assumed to be required and will be implemented in a separate project).
6. Implement supplemental improvements to facilitate reliable water level and rate of flow control in individual filters
7. Replace existing turbidimeters
8. Implement modifications to settled water piping to install appropriate valve and flow control measures to permit influent flow from LS Units No. 2 and 3 to be directed to both the North and South Trains.

Attachment A: Filter Assessment Protocols

FILTER CORE SAMPLING PROCEDURE

Materials and Preliminary Preparation

1. One box of zip-lock bags (bag of 50 +/_ should be adequate)
2. An indelible marker
3. One 4 to 5-ft long pipe with an ID of approx. 1.5 inches. The end of the pipe used to penetrate the media should be beveled (the plant machine shop should have the facilities to o this).
4. Starting from the beveled end of the coring pipe, notch the pipe in a clearly visible manner at the following distances: 1 in, 2 in, 3 in, 6 in, 12 in, 18 in, 24 in, 30 in, and 36 in. The increments 0 – 1 in, 1 – 2 in, 2 – 6in, etc., represent the various cores that will be obtained for each location sampled.
5. Label the zip-lock bags for each location and core lift.
6. One tape measure.
7. Two 500 ml beakers.
8. One 100 ml graduated cylinder.

Coring Procedure

1. Select a filter that is at the end of its normal run cycle.
2. Drain the filter completely of all water.
3. Select representative locations (2 to 3) in the filter to sample.
4. Gently insert the beveled end of the coring pipe into the first location to the first mark (1-inch depth) on the pipe. Insert the pipe while using a circular rotating motion to minimize compaction of the media during insertion.
5. Once the target depth is reached make a twirling circular motion of the pipe while maintaining its vertical position then gently remove the pipe. The intent of the twirling motion is to expand the size of the hole.
6. After withdrawing the core pipe, blow the sample into the appropriately labeled bag.
7. Repeat steps 4, 5 and 6 at three to four locations adjacent to the first core location. The intent is to obtain an adequate sample volume (200 to 400 ml) for subsequent testing.
8. After an adequate volume of sample is obtained for the first core depth, retrieve cores from the subsequent interval (1 to 2 in) by reinserting the pipe in the original holes. Care must be exercised to avoid scraping media from the sides of the hole upon reinsertion of the core pipe. For each core interval, the hole should be expanded in diameter by using the twirling motion described in (5) prior to retrieving the pipe.
9. Repeat steps 4 to 8 for each core interval. Samples may be retrieved from the minimum number of holes needed to obtain the desired volume. Continue retrieving successive cores until insertion of the core pipe becomes difficult. At that point, the supporting gravel layer is reached. Make a note of the media depth at that point.
10. If desired, the above procedures may be repeated for other locations within the filter or other filters (suggest that at least two locations within each of two filters be sampled).
11. Backwash the filter, then repeat core sampling on the clean bed.

Determination of the Mud Deposition Profile

1. For each core interval (i.e. bag) mix sample thoroughly.
2. Measure 50 ml of media from each interval into a graduated cylinder. Gently tamp the cylinder to cause the media to settle.
3. Transfer the 50 ml sample to a 500 ml beaker or similar type of flask. A small amount of tap water may be used to rinse the contents of the graduated cylinder into the flask.
4. Add approx. 100 ml of tap water to the flask. Shake vigorously for at least 30 seconds then decant the washwater into another 500 ml beaker.
5. Repeat step 4 four more times adding the rinse water to the second 500 ml beaker each time. Make a note of the turbidity of the fifth 100 ml rinse water.
6. Mix the combined rinse water in the beaker then measure and record the turbidity. Care must be taken to avoid settling between sampling and turbidity measurement.
7. Repeat steps 2 to 6 for each core interval.
8. Report turbidity as a function of bed depth for each core sample location before and after backwash.
9. Keep “after-backwash” core samples for inspection – do not discard.

Media Characterization Tests

Analyze each core increment of at least one “after-backwash” core sample for the following:

1. uniformity coefficient,
2. effective size, and
3. specific gravity.

This would provide insights into the condition of the existing media and would aid in the interpretation of the mud deposition profile. There would be some analytical costs involved. Radise has local testing capabilities for these parameters.

Components of Typical Filter Performance Evaluation

A basic overview of the key elements of a filter performance evaluation is summarized below. This is a long list and not all steps will necessarily be required. A refinement of specific evaluation protocols may be determined following the project kickoff meeting. Candidate evaluation components include the following:

1. Assess functionality of monitoring and auxiliary systems. Typical components include: turbidity meters; flow meters, surface sweeps, head loss sensors, run time monitors, level switches, controllers, etc.

2. Establish filtered water turbidity profiles. This should be performed for two sequential runs per filter. At the minimum – do this for at least two filters, one considered to be in reasonably good condition, the other considered to be in relatively poor condition. Also collect headloss and filtration loading rate versus time for each filter monitored. This requires that selected filters be equipped with functional instruments that collect/report performance data to the SCADA system data historian.

3. Conduct a comprehensive visual inspection of each filter. The inspection should include, to the extent practical, the following elements:

    a. Inspect the clearwell, filter plenum, wash water (WW) receiving basins for evidence of media accumulation.
        i. Inspection of the clearwell, plenum and readily accessible piping should be limited elements visible without requiring confined space entry.
        ii. Some disassembly will be required by plant maintenance personnel to facilitate visual inspection.
        iii. Maintenance staff may be interviewed to gain additional information that may not be readily apparent from inspection.
    b. Lower water surface to the height of the lowest WW trough (open WW waste valve while keeping all others closed) and check troughs to determine if they are level and of uniform elevation.
    c. Lower water surface slowly and terminate at the moment the media breaks the water surface. Observe media surface for evidence of mounding, craters, etc.
    d. Drain water completely. Enter the filter basin to probe the media (using a rod) to determine spatial variation in bed depth. Seek to detect apparent irregularities in gravel surface elevation.
    e. While the filter is drained, observe the perimeter interface between the media and the filter walls to identify the occurrence and extent of separation of the media from the walls.

f. Measure the clearance between the media surface and the surface sweeps and the bottom of the wash troughs. Also confirm the dimensions and spacing of the wash troughs.
g. While backwashing filters, look for evidence of excessive boiling, media loss or other localized irregularities. Also check uniformity of wash water distribution among the troughs.
h. Take photographs to document observed conditions.

4. Obtain filter core samples from two to three locations per filter. Repeat coring before and following BW. Assess mud deposition profile and media characteristics as a function of bed depth. Refer to separate protocol.

5. Establish the turbidity profile of wash waste (WW) - during the course of a backwash sequence, sample the wash waste stream at 2 min intervals for the entire BW duration.

6. Document pretreatment conditions (polymer use, coagulant, etc), disinfectant type & residual maintained through the filters, pH and settled water turbidity. Also document capacity of auxiliary facilities such as the BW receiving basin, BW pumps, etc., where available.

7. Observe BW protocols utilized by select operators (one or two) and carefully document the following info for each step in the sequence – the sequence, timing/duration and intensity of hydraulic rinse(s), auxiliary wash systems (surface wash, air scour), filter to waste, and rest periods.

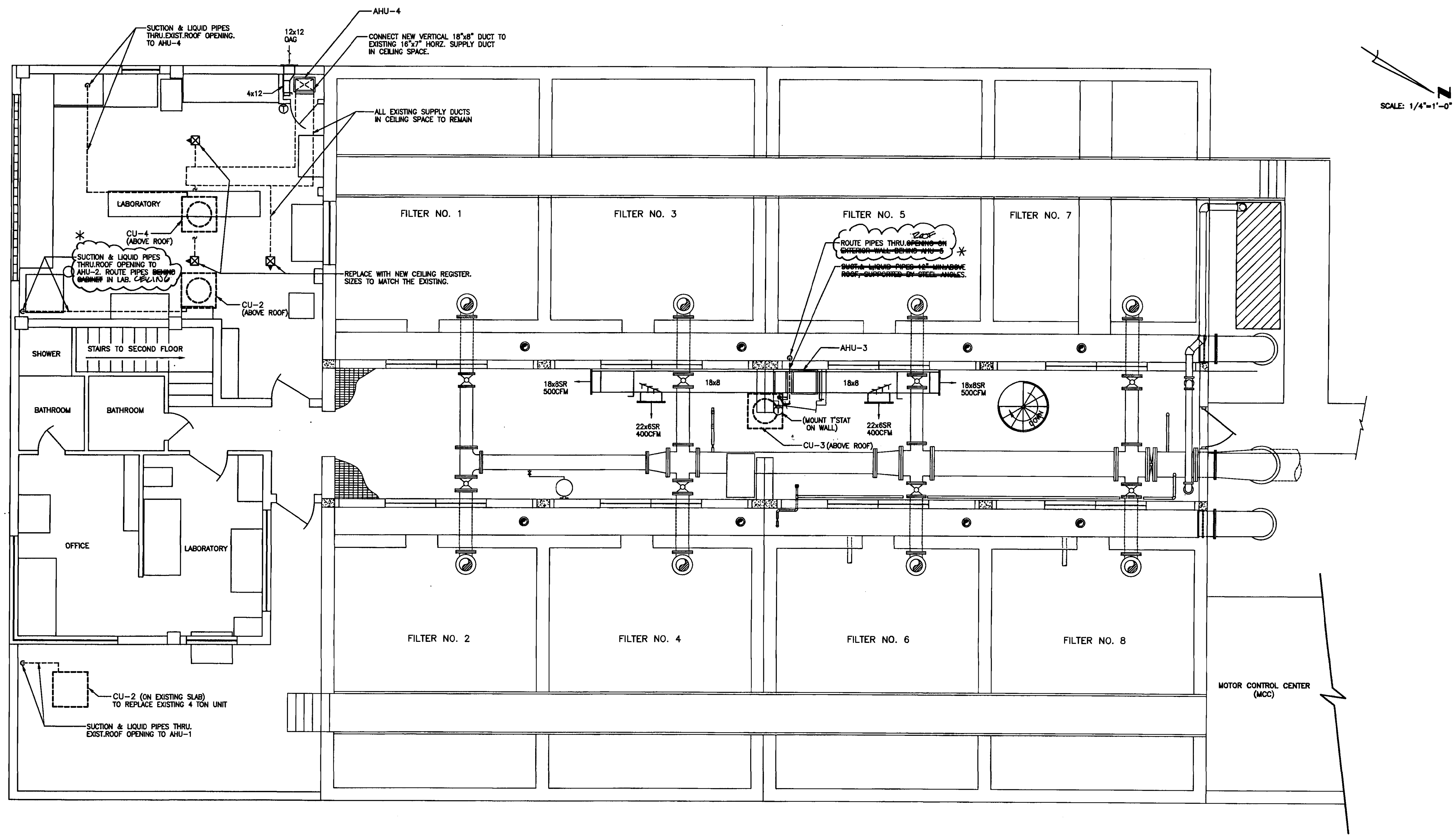
8. Determine conditions that trigger adjustment in BW protocol employed by operations staff and identify episodic conditions that are believed to impair filtration performance.

9. Identify existing written protocols that define normal filter operation, inspection & maintenance practices.

10. Sample and analyze common influent to each filter train and representative filtered water effluent from individual and combined filters (numbers to be determined) for the following parameters:

    a. Total chlorine residual
    b. Total ammonia
    c. Nitrite
    d. Nitrate

Attachment B: Reference Drawings



RECORD DRAWING

*DENOTES FIELD MEASUREMENTS AND GRADES

DATE	INITIAL		DATE	INITIAL	
		IN PROGRESS			REVIEW
2/00	C.M.A.	DRAFTING COMPLETED	2/00	C.H.G.	APPROVED

THE INFORMATION FOR THIS RECORD DRAWING WAS OBTAINED DURING CONSTRUCTION BY THE ENGINEER IN ACCORDANCE WITH THE EXECUTED DOCUMENTS.

NAME OF CONTRACTOR: FLORIDA DESIGN CONTRACTORS

DATE OF CONSTRUCTION: JANUARY 4, 1999 TO DECEMBER 16, 1999

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DRAWN K.P.
CHECKED H.V.L.

BARKER, OSHA & ANDERSON, INC.
PROFESSIONAL ENGINEERS
NORTH PALM BEACH, FLORIDA

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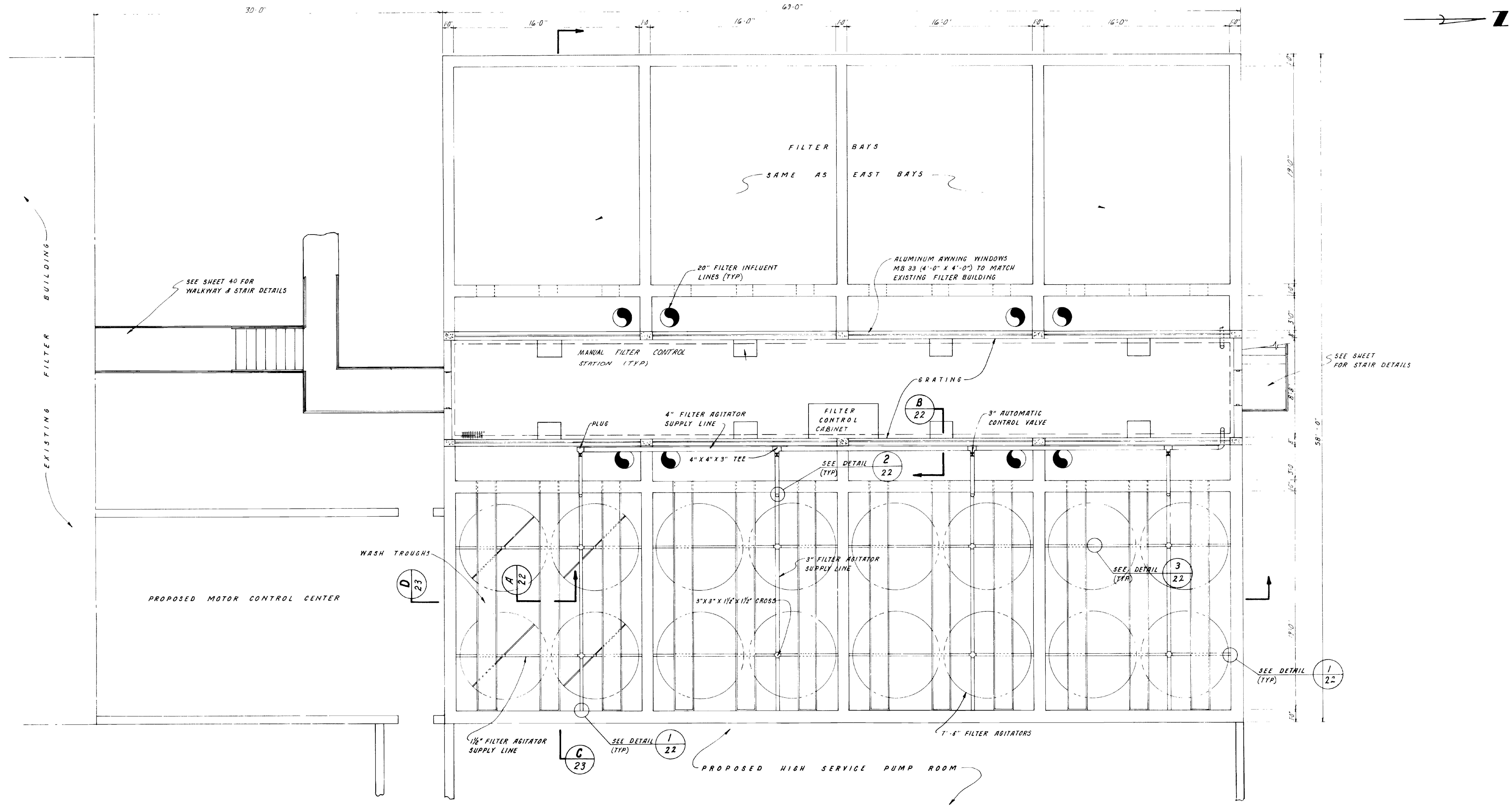
APPROVED [signature] DATE JULY 1998

H.V.A.C. SECOND FLOOR PLAN

IMPROVEMENTS TO WATER TREATMENT PLANT AND REPUMP STATIONS
CONTRACT "B"-WTP OPERATIONS BUILDING
FOR THE
CITY OF RIVIERA BEACH, FLORIDA

PROJECT NO. 97-1004
SCALE 1/4" = 1'-0"
SHEET 10 OF 34 (M-2)
FILE NO. D-2439-117

03-16-2000



PLAN

SCALE 1/4" = 1'-0"

RECORD DRAWING

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Date	Description	By
6-23-80	MINOR DETAILS ADDED FOR CLARIFICATION	
Revision		

Field Book No. Pg.
Design D.S.
Drawn D.S
Checked

BARKER, OSHA & ANDERSON, INC.
CONSULTING ENGINEERS
NORTH PALM BEACH
FLORIDA

Not to be used for Construction until Approved
Approved
Date JUNE, 197[illegible]

FILTER-PLAN

WATER TREATMENT PLANT EXPANSION FOR CITY OF RIVIERA BEACH, FLORIDA

Job No. 79-1001-B
Scale AS SHOWN
Sheet 19 of 51
File No. D-2439-033