Appendix B: Example SOP

Conducting a Routine Filter Inspection

Date Adopted:

Date Revised:

Reason for Revision:

Manager Approval: _____Date: _____

Background

This SOP for conducting a filter inspection is seventh in a series that details operations at the City of Aguaville SWTP. All staff conducting routine filter inspections must follow the procedures and safety precautions contained in this SOP. Filter inspections require a team of at least two licensed water works operators, and at least one must hold a valid Class C Surface Water license. Failure to comply with the requirements of this SOP is grounds for disciplinary action up to and including termination.

Summary of Steps

The following list summarizes the steps of a routine filter inspection:

1. Prepare a filter diagram.
2. Partially drain the filter and measure the filtration rate.
3. Observe the pre-backwash condition of the filter media surface.
4. Look for unusual conditions during a routine filter backwash.
5. Drain the filter.
6. Observe the post-backwash condition of the filter media surface.
7. Make filter bed measurements.
8. Excavate the media to identify unusual filter conditions.
9. Backwash the filter again, re-stratify and return it to service.

Important Safety Precautions

A routine filter inspection requires that an operator climb down into the filter. Operators must take the following precautions during a filter inspection to avoid injury and filter damage:

- At least two operators must be present any time someone enters a filter. One of the operators carefully enters the filter and make the measurements while the

other remains outside the filter to record the data. Class D operators may not enter a filter.

- Filter surfaces are often wet and slippery. Wear slip-resistant shoes when entering.
- Be extra careful when working in the large filters at Plant No.2 where high backwash water flow rates exist. Plant No. 2 filter boxes are designated as "confined spaces" because they are very deep and some of them are partially covered. Consequently, any operator who enters those filters must comply with the following requirements:
    - Get a signed Confined Space Entry Request Form signed by your supervisor prior to entering the filter.
    - Wear a safety harness securely anchored to the filter wall or some other immovable object. The safety rope must be short enough to prevent the operator from becoming submerged in the filter bed, backwash trough, or spent backwash water channel.
- Do not stand or walk in the fiberglass backwash troughs at Plant No. 1 because they can be severely damaged. Use ¼-inch plywood boards to distribute and support weight whenever walking or standing on the filter media submerged in the filter bed, backwash trough, or spent backwash water channel.

Equipment and Supplies

The following equipment, as applicable is needed to implement this procedure:

- Filter probe.
- 1-inch wide tape measure or a 1-inch wide yardstick.
- 2 ft × 2 ft pieces of ¼-inch plywood (4 pieces needed.
- 2 ft × 3 ft piece of ⅜-inch plywood.
- Stopwatch.
- 8 ft to 10 ft length of 2 × 4 plank.
- 1 ft × 1 ft × 2.5 ft (H) plexiglass excavation box.
- 2-inch diameter PVC filter-coring tool if special studies will be conducted following the routine inspection.

Procedure

1—Prepare a Filter Diagram

Make or obtain a diagram that shows the location of filter inlets, outlets, and backwash trough. Although the diagram does not have to be to scale, the diagram should be drawn as large as possible and look like the filter.

2—Partially Drain the Filter and Measure the Filtration Rate

Follow the steps below:

1. Close the filter influent valve completely.
2. Leave the filter effluent valve open.
3. Record the filtered-water flow rate from the filter's flowmeter.
4. Measure and record the amount of time it takes for the water level to fall 6 inches. If possible, make this measurement while the water level is at least 6 inches above the top of the backwash trough. If the water level is not at least 6 inches above the top of the backwash trough, wait until the water level is below the top of the trough to begin the measurement.
5. Leave the filter effluent valve open until the water reaches the surface of the filter media.
6. When the water reaches the surface of the filter media, do the following per the plant:
    - Plant No. 1 does not have filter-to-waste facilities. Leave the filter effluent valve open for three minutes after the water level reaches the surface of the filter media, and then completely close the valve.
    - Plant No. 2 has filter-to-waste facilities. Completely close the filter effluent valve and then open the filter-to-waste valve for eight minutes.
7. Determine and record the wetted surface area of the filter. If the drawdown was measured above the wash water trough, calculate the surface area of the filter. If the drawdown was measured below the top of the trough, determine the total area between the troughs.
8. Calculate the filtration rate using Equation 1.
9. Compare the calculated filtration rate with the filtration rate shown on the filtered water flowmeter.

$$\text{Filtration rate (gpm)} = \frac{\text{drawdown (inches)} \times \text{surface area (ft}^2\text{)} \times \left[\frac{\text{ft}}{\text{12 in}}\right] \times \left[\frac{\text{7.48 gal}}{\text{ft}^3}\right]}{\text{time (minutes)}}$$

$$= \frac{\text{drawdown (inches)} \times \text{surface area (ft}^2\text{)} \times 0.6233}{\text{time (minutes)}}$$

Equation 1: Calculating the filtration rate

3—Observe the Pre-Backwash Condition of the Filter Media Surface

Enter the Filter

Plant No. 1: The lightweight fiberglass backwash troughs at Plant No. 1 will not support an individual's weight. Follow the steps below to enter Filters No. 1–4:

1. Lower the ⅜-inch piece of plywood into the filter and place it directly on the filter media near the wall where the operator will enter. This board will then be used as the support footing for the ladder.
2. Lower the ladder into the filter and center its feet on the piece of plywood.

Plant No. 2: The concrete backwash troughs at Plant No. 2 will support an individual's weight. When inspecting Filters No. 5–8, operators can either use the steps described for Filters No. 1-4 or they can lower a securely positioned ladder directly into the backwash trough as follows:

1. Secure the top of the ladder to the top of the filter or the filter railing using a strong rope or chain.
2. If a safety harness is being used, secure the end of the lanyard to the filter railing at a location where the operator standing outside the filter can reach it.
3. The operator making the measurements must carefully enter the filter. The operator recording the data must remain outside the filter as a safety precaution.
4. Lower the tape measure, the ¼-inch plywood pieces, the straight 2 × 4, and other equipment into the filter.

Filter Media Surface Documentation

Observe the surface of the filter media and/or measure the following conditions:

- **Thickness of the floc mat:** Measure the thickness of the floc mat at several locations throughout the filter.
- **Distribution of floc mat:** Specifically, look for areas where the floc has accumulated to an unusual depth or has not accumulated to the same degree as in the rest of the filter.
- **Mudballs:** Specifically, look for areas where mudballs appear to be accumulating on the surface of the media.
- **Significant media mounds or depressions:** Specifically, look for areas where the depressions or mounds exceed 1½ inches in depth or height.
- **Filter cracks:** Specifically, look for cracks that are more than 6 inches long, more than ¼-inch wide, or more than ½-inch or so deep. Some small cracks may form as the filter dewaters, but larger cracks suggest that the filter media has been coated with an excessive coagulant layer.
- **Separation from filter wall:** Specifically, look for areas where the media has separated from the wall more than ¼ inch, the length of the separation exceeds 6–8 inches, or the separation is more than 1inch deep. Some separation from the filter

wall may occur as the filter dewaters, but separations that exist before the filters dewater suggest that the filter media has been coated with an excessive coagulant layer.

Record the location of any unusual conditions seen on the media surface and describe the conditions in detail on a separate sheet of paper.

After making and recording your observations, remove any equipment taken into the filter. Exit the filter and remove the ladder and the ¼-inch plywood piece if used.

4—Look for Unusual Conditions During a Routine Filter Backwash

Follow the steps below:

1. Open the filter backwash valve slightly and allow the water to rise to 6–8 inches below the bottom of the backwash-water trough.
2. Complete a routine backwash of the filter following the facility's SOP - *Routine Filter Backwash Procedure*. During the backwash cycle, observe the condition of the filter for the following unusual backwash conditions:
   - **Levelness of the backwash trough:** Specifically, look at the top of the backwash water troughs to determine if water flows over some sections of the trough sooner than others.
   - **Trough flooding:** Specifically, look for areas where flooding is occurring in one or more of the troughs.
   - **Media boils and jets**: Specifically, look for areas where the backwash is producing a significantly more vigorous rolling action in the media. Pay particular attention to areas along the filter wall.
   - **Media loss:** Specifically, look for media carryover into the backwash water troughs. Pay close attention to areas where the carryover appears to be localized.
   - **Lack of media agitation:** Specifically, look for areas where the media is moving very little. Again, pay close attention to the areas along the filter wall and in the corners of the filter.

Record the location of any undesirable backwash conditions on the filter diagram, and describe the condition in detail on a separate sheet of paper. Also, record the turbidity of the spent backwash water at the end of the backwash cycle.

5—Drain the Filter

Make sure that the influent and filter backwash are completely closed. Open the filter effluent valve and wait approximately 45 minutes to allow the filter to completely discharge to the clearwell.

At Plant No. 2 which is equipped with filter-to-waste facilities, open the filter-to-waste valve after 15 minutes.

6—Observe the Post-Backwash Surface of the Filter Media

Repeat the filter surface inspection process described in Step 3. Using the filter diagram, record the location of any unusual conditions on the media surface, and describe the condition in detail on a separate sheet of paper.

7—Make Filter Bed Measurements

Follow the steps below:

1. Close the filter effluent valve.
2. Follow the procedures described in Step 3 and all required safety precautions.
3. Carefully lower the filter probe (i.e., do not drop), the straight 2 × 4, the ¼-inch plywood pieces, and other equipment into the filter. Lay the straight 2x4 across the tops of adjacent troughs so that it spans the space between the troughs and provides a reference point for the measurements between the filter troughs.
4. Keeping the probe perpendicular, probe the filter at two-foot intervals. Do not stand or walk directly on the filter media surface. At Plant No. 1, stand on the ¼-inch plywood pieces placed directly on the filter bed. At Plant No. 2 you can either make measurements while standing and walking in the troughs or by using the method described for Plant No. 1. However, if the operator cannot reach the area between the troughs, the Plant No. 1 method must be used.
5. Determine the levelness of the media surface by measuring the distance from the top of the filter trough to the surface of the media.
6. Lower the probe until it just touches the top of the filter media.
7. Record the distance (to the nearest inch or less) directly on the filter diagram.
8. Measure the depth of the media bed to the top of the gravel support layer or, if the filter uses a gravel-less underdrain, to the top of the underdrain.
9. Press the probe down into the media until a change in resistance is felt or until the sound of the probe passing through the media changes. Do not push the probe into the gravel layer. Be extremely careful not to press the probe so far down that it damages the filter underdrain.
10. Record the depth (to the nearest inch or less) directly on the filter diagram.
11. Determine the levelness of the support gravel/underdrain by one of the following methods:
    - Measure the distance from the top of the backwash trough to the surface of the support gravel or gravel-less underdrain.
    - Measure the depth of the media layer and the distance from the media surface to the top of the backwash trough and add the two readings.
12. Record the result directly on the filter diagram.
13. Reduce the interval if significant differences are detected between adjacent measurements for either (1) the distance to the media surface, or (2) the media depth.

14. If the distance or depth between adjacent measurements varies by more than two inches vertically, make an additional set of measurements at the midpoint of the two points.
15. If the distance or depth continues to vary by more than two inches vertically, continue to measure at midpoints until the distance between the measurements is only three inches horizontally.
16. Probe the filter at each site where an undesirable filter backwash or media-surface condition was identified.

8—Excavate the Media to Identify Unusual Filter Conditions

Follow the steps below:

1. Make sure that all filter bed measurements required in Step 7 have been completed.
2. Place the ¼-inch plywood pieces on the filter media about a foot from the area to be excavated.
3. Clean a 3 ft^2 area on the opposite side of the excavation site by scraping off the top ¼-inch of filter media and placing it in a pile on one end of the scraped area.
4. Excavate a 6 to 8-inch diameter hole in the filter bed.
5. Excavate the top 3 to 6 inches of the media bed.
6. If mudballs are present, note their size and shape and the depth of penetration.
7. Place the excavated media in a pile at one end of the scraped area.
8. Excavate the remainder of the upper media layer.
9. If mudballs are present, note their size and shape and the depth of penetration. For example, “pancake-shaped mudballs with a diameter of ½ to ¾ inches have penetrated three inches into the anthracite layer.”
10. Place this layer of excavated media in a pile adjacent to the previous pile.
11. If the filter contains multiple media materials, describe the interface between the layers. For example, “14 inches of clean anthracite is located above a 2-inch layer of intermixed sand and anthracite that contains about 40% sand and 60% anthracite.”
12. If the filter bed contains more than one media layer, continue the excavation by repeating Step 5 until all the layers between the surface of the media and the upper gravel layer have been excavated and described. Stop the excavation as soon as the samples contain more than about 10% gravel; do not excavate the gravel layer.
13. Replace the media after completing the excavation.
14. Return the media to the hole in the opposite order that it was removed.
15. Pack each layer slightly by hand as it is replaced.
16. If there is media left over after filling the excavation hole, spread it around in the general area of the excavation site and the cleared area.

17. Repeat these steps in any area where unusual backwash or media conditions were observed during the media probing.
18. Collect "Core Samples" as described in the facility's SOP *How to Perform Special Filter Studies* if any special studies are to be done on the filter media.
19. Remove the filter probe, tape measure, plywood squares, and any other equipment from the filter.
20. Close the filter to waste valve.
21. During the filter excavation, note and record the following information:

- If mudballs are present, note their size and shape and how far they've penetrated into the media bed.
- If the filter contains more than one media type, note how distinct the interface is between the different media layers or the degree of stratification.
- If the filter contains more than one media type, note how much intermixing of the media layers is present.

During excavation, operators must comply with all of the following precautions to avoid injury and filter damage.

- Do not disturb the gravel support bed when excavating the media at each site.
- Stop the excavation at each site as soon as the operator detects small gravel (1/4 to 1/8-gravel).
- Excavate the upper 75% of the filter bed either by hand or with a small shovel. The lower 25% of the filter bed must be excavated by hand.
- Do not walk or stand directly on the filter media.
- Do not attempt excavation, If the design does not allow the filter to be completely drained below the remaining water level without an excavation box.
- If the excavation cannot be completed because of the presence of subsurface standing water or other conditions that cause the walls of the excavation hole to collapse, it may be useful, or even necessary, to use an excavation box. Do not force the excavation box into the gravel layer.

9—Backwash the Filter Again, Re-Stratify, and Return it to Service

Follow the steps below:

1. Make sure that all of the filter excavation activities required in Step 8 have been completed.
2. Find a place to stand that has good footing and use the lanyard to secure the safety harness to the filter wall or other similar, immovable object.
3. Remove the ladder and the ⅜-inch plywood piece if it was used.
4. Complete a routine filter backwash following the backwash procedure in this example facility's SOP - *Routine Filter Backwash Procedure.*

5. Determine if there are still any of the unusual backwash conditions observed in Step 4. If there are, record their location on the filter diagram.
6. Measure the height of the fluidized or expanded media bed at the maximum backwash flow rate routinely used during the backwash cycle.
7. Lower a Secchi disk into the filter media until a small amount of filter media from the expanded bed begins collecting on the top of the disk.
8. Measure the distance from the top of the filter wall to the surface of the fluidized or expanded media bed.
9. Record the result on the filter diagram.
10. Measure the maximum backwash-water flow rate routinely used to backwash the filters.
11. At the maximum backwash-water flow rate, record the flow rate that is being shown on the backwash-water flowmeter.
12. At the maximum backwash-water flow rate, close the backwash waste drain valve.
13. Measure and record the amount of time that it takes for the water level to rise 6 inches.
14. Open the backwash waste valve.
15. Complete the backwash cycle as described in the facility's SOP - *Routine Filter Backwash Procedure*.
16. Return the filter to service using the procedure described in the facility's SOP - *Routine Filter Backwash Procedure*.
17. Measure the height of the unexpanded filter bed using the same process as described in Step 7.
18. Lower the ladder using the procedures detailed in Step 3.
19. Secure the top of the ladder to the top of the filter or the filter railing using a strong rope or chain.
20. Take the Secchi disk, carefully exit the filter, and remove the ladder and the ⅜-inch plywood piece if it was used.
21. Calculate backwash water flow rate using Equation 2.
22. Calculate the percent bed expansion using Equation 3.

$$Backwash\ rate\ (gpm) = \frac{rise\ (inches) \times surface\ area\ (ft^2) \times \left[\frac{ft}{12\ in}\right] \times \left[\frac{7.48\ gal}{ft^3}\right]}{time\ (minutes)}$$

$$= \frac{rise\ (inches) \times surface\ area\ (ft^2) \times 0.6233}{time\ (minutes)}$$

Equation 2: Calculating the backwash water flow rate

$$\%\ Expansion = \frac{\text{“height” of unexpanded bed (inches)} - \text{“height” of expanded bed (inches)}}{total\ depth\ of\ media\ bed\ (inches)} \times 100$$

Equation 3: Calculating the percent bed expansion

During this step, large volumes of water are used and high-water velocities exist in the backwash troughs and spent backwash water channel. Whenever possible, the evaluation team should collect required data for this step without being in the filter during the backwash cycle. However, if an operator needs to be in the filter during a backwash cycle, the safety precautions described in this SOP very carefully. The operator who records the measurements must remain outside the filter.