4. APPROACH FOR COMPLIANCE

4.1 Compliance Approach for Turbidity Requirements

While many systems already meet or will meet turbidity requirements prior to compliance deadlines, some systems will need to evaluate their treatment plants to determine what changes, if any, are needed to comply with the requirements. Utilities which determine they may have difficulty complying with the turbidity requirements of the IESWTR should first evaluate the system and begin to optimize plant performance. Section 4.2 outlines the Agency's suggested approach for utilities to evaluate their systems, and identifies key areas which systems should evaluate.

Although it is anticipated that compliance with the IESWTR will generally be possible through adjustments to existing treatment processes, additional treatment processes or other treatment technologies or enhancements may be required in some cases. It is not anticipated that systems will need to make major capital improvements, but those systems considering capital improvements in order to meet requirements of the IESWTR should conduct an optimization activity similar to the Composite Correction Program to assess the real need of construction. Section 4.3 briefly outlines many of the process enhancements that, in the opinion of the Agency and other water professionals, are the most likely to be employed by systems, if optimization alone does not permit a system to comply with turbidity requirements.

4.2 System Evaluation & Plant Optimization

A thorough treatment plant evaluation and improvement program is the best way to ensure pathogen-free drinking water. With an emphasis on improved performance at minimal cost, optimization is an economical alternative for compliance with the turbidity requirements. Currently, two programs serve as excellent resources for systems wishing to follow a systematic and proven approach to optimizing water treatment plant performance. These are:

- **Composite Correction Program**

  The Composite Correction Program (CCP) is a systematic action oriented approach that federal or state regulators, consultants, or utility personnel can implement to improve performance of existing water treatment plants. The Comprehensive Performance Evaluation phase of the CCP is described in greater detail in Chapter 6. The Agency has developed a guidance manual that may be obtained by calling the EPA Safe Drinking Water Hotline at 1-800-426-4791.

- **Partnership for Safe Water**

  The Partnership is a voluntary cooperative effort between the EPA, AWWA and other drinking water organizations, and over 186 surface water utilities representing 245 water treatment plants throughout the United States. The goal of this common sense cooperation is to provide a new measure of safety to millions of Americans by implementing prevention programs where legislation or regulation does not exist. The preventative measures are based around optimizing treatment plant performance and thus increasing protection against microbial contamination in America's drinking water supply. Information regarding the Partnership is found at AWWA's website http://www.awwa.org/partner1.htm or may be obtained by calling (303) 347-6169.

Systems are strongly encouraged to utilize one of the above noted programs if intending to optimize plant performance.

While systems should consider the above noted programs, this section provides information utilities may find useful in evaluating their system and optimizing their plant's performance. It is important to remember that the items listed in this chapter may or may not apply to all systems. Optimizing water treatment plants is a site-specific endeavor. As such, this section does not seek to serve as a recipe for how to optimize water treatment for lowered turbidity. It does however highlight the areas which, in the experience of the Agency and other water professionals, most often can be improved to optimize water treatment at PWSs. The items discussed in this section are addressed in greater detail in the Composite Correction Program and the Partnership for Safe Water.

4.2.1 Coagulation/Rapid Mixing

Coagulation is the process by which small particles are combined to form larger aggregates and is an essential component in water treatment operations. Evaluation and optimization of the Coagulation/Rapid Mixing step of the water treatment process includes a variety of aspects. Optimal coagulant dosages are critical to filter performance. Maintaining the proper control of these chemicals can mean the difference between an optimized surface plant and a poorly run surface plant. Inadequate mixing of chemicals or their addition at inappropriate points within the treatment plant can limit performance. The following issues may be evaluated as they may improve the performance of this step in the treatment process.

Chemicals

An evaluation of the chemicals used in the treatment process can identify the appropriateness of the coagulation chemicals being used. A thorough understanding of coagulation chemistry is necessary, and changes to coagulation chemicals should not be made without careful consideration. The following aspects relating to coagulation chemicals may be considered by systems:

- Operating procedures should not call for the shutting off of coagulant chemical addition when raw water is less than 1 NTU.
- Are chemicals being dosed properly, paying special attention to pH? Is dose selection based on frequent jar testing or other testing methods such as streaming current monitoring, zeta potential, or pilot filters? Relying exclusively on past practice is not good practice.
- Do Standard Operating Procedures exist for coagulation controls? Systems should develop SOPs, and establish a testing method that is suited to the plant and personnel.
- Are the correct chemicals being utilized? Is the best coagulant being used for the situation? Changing coagulant chemicals or adding coagulant aids may improve the settleability of the flocculated water and in turn optimize performance. Coagulants may also be changed seasonally.
- Do operators have the ability to respond to varying water quality by adjusting coagulation controls to ensure optimum performance? Systems should provide operators with such learning opportunities so that they can react to various conditions with understanding and confidence.
- Are solutions used promptly? Most solutions should be utilized within 48 hours of their formulation. Are chemicals utilized before manufacturer recommended expiration or use-by dates?
- Is pH a consideration? Measurement of pH is a key aspect in coagulation chemistry. Do not dilute coagulant solutions to pH levels higher than 3.3 for alum and 2.2 for iron salts. Manufacturers instructions should be followed when diluting polymers.
- Are chemicals being added in the correct order? The order of chemicals is very important, as certain chemicals interfere with others. Jar tests should be utilized to develop optimal sequences.
- Is the chemical feed system operating properly? Operators should consider checking the accuracy of systems at least once daily or once per shift.

Feed Systems

Feed systems are another important aspect of the coagulation step in typical treatment processes. These systems are responsible for delivering coagulants into the system at rates necessary for optimal performance. The following aspects should be evaluated regarding feed systems.

- Is redundancy a consideration? Redundancy may be built into the feed systems so that proper feeding of chemicals can be maintained in the event of failure or malfunction of primary systems.
- Is the feed system large enough? Feed systems should be sized so that chemical dosages can be changed to meet varying conditions.
- Are chemical pumping equipment and piping checked on a regular basis? Maintenance of these systems should be a priority and incorporated into routine maintenance performed at the system.
- Is a diaphragm pump utilized? A continuous pump allows coagulants to be added in such a way as to avoid pulsed flow patterns.

Satisfactory Dispersal/Application Points

Finally, proper coagulation and mixing also depends on satisfactory dispersal of coagulation chemicals and appropriate application points. Coagulants should be adequately dispersed so that optimal coagulation may occur. A sufficient number of feed points should exist such that chemicals have the opportunity to mix completely. Utilities should evaluate the following items:

- Is adequate dispersion taking place? If chemicals are added at a hydraulic pump, ensure that the chemicals are distributed across the width of the flow stream and at the location where turbulence is greatest. The rapidity of coagulation necessitates even dispersal as soon as possible.
- Are coagulants being added at the proper points? Metal salts should be introduced at the point of maximum energy input. Low molecular weight cationic polymers can be fed with metal salts at the rapid mix or to second stage mixing following the metal salt. High molecular weight nonionic/anionic floc/filter aids should be introduced to the process stream at a point of gentle mixing.
- Is rapid mixing equipment checked frequently? Systems should check the condition of equipment, and ensure that baffling provides for adequate, even-flow.

4.2.2 Flocculation

Flocculation is the next step in most treatment plants (in-line filtration plants being the exception). It is a time-dependent process that directly affects clarification efficiency by providing multiple opportunities for particles suspended in water to collide through gentle and prolonged agitation. The process takes place in a basin equipped with a mixer that provides agitation. This agitation should be thorough enough to encourage interparticle contact but gentle enough to prevent disintegration of existing flocculated particles. Effective flocculation is important for the successful operation of the sedimentation process. Several issues regarding flocculation should be evaluated by utilities to ensure optimal operation of flocculation basins.

Flocculation Mixing and Time

Proper flocculation requires long, gentle mixing. Mixing energy should be high enough to bring coagulated particles constantly into contact with each other, but not so high as to break up those particles already flocculated. Utilities should consider evaluating:

- How many stages are present in the flocculation system? Three to four are appropriate to create plug flow conditions and allow desired floc formation.
- Is the mixing adequate to form desired floc particles? Tapered mixing is most appropriate. “G” values should be variable through the various stages from 70 sec^{-1} to 15 sec^{-1}.
- Are mechanical mixers functioning properly? Are flocculator paddles rotating at the correct rates?
- If flow is split between two flocculators, are they mixing at the same speed and “G” value? If the flocculators have different characteristics, dosages may be proper for one, but not both.

Flocculator Inlets and Outlets

If water passes through the flocculation basin in much less time than the volumetric residence time, the influent stream has short circuited. Inlet and outlet turbulence is oftentimes the major source of destructive energy in flocculation basins that contributes to short circuiting. Utilities should evaluate the following:

- Do basin outlet conditions prevent the breakup of formed floc particles? Basin outlets should avoid floc breakup. Port velocities should be <0.5 fps. The velocity gradient at any point from the flocculation basin to the sedimentation basin should be less than the velocity gradient in the last flocculation stage.
- Do inlet conditions prevent the breakup of formed floc particles? Inlet diffusers improve the uniformity of the distribution of incoming water. Secondary entry baffles across inlets to basins impart headloss for uniform water entry.
- What size are the conduits between the rapid mix basin and the flocculation basin? Larger connecting conduits help reduce turbulence which can upset floc.

Flocculator Basin Circulation

Baffles are used in flocculator basins to direct the movement of water through the basin. Baffling near the basin inlet and outlets improves basin circulation and achieves more uniform circulation. A system may think about the following items when evaluating flocculation.

- Is current baffling adequate? Can baffling be added to improve performance or does existing baffling require repair? Serpentine baffling is better than over/under. Baffling should allow headloss through opening to prevent short-circuiting and to allow plug flow conditions.
- Induced velocity in floc chambers should vary from 2 fps in first stage to 0.25 fps in the last stage. Velocity through openings in the baffle should be slightly less than the induced velocities.

4.2.3 Sedimentation

Sedimentation is the next step in conventional filtration plants (direct filtration plants omit this step). The purpose of sedimentation is to enhance the filtration process by removing particulates. Sedimentation requires that water flow through the basin at a slow enough velocity to permit particles to settle to the bottom before the water exits the basin. Utilities should consider the following items when evaluating sedimentation basins.

- Is sludge collection and removal adequate? Inadequate sludge collection and removal can cause particles to become re-suspended in water or upset circulation. Systems should disrupt the sludge blanket as little as possible. Sludge draw-off rates can effect the sludge blanket. Sludge draw off procedures should be checked periodically, making sure sludge levels are low; and sludge should be wasted if necessary. Sludge pumping lines should be inspected routinely to ensure that they are not becoming plugged. These lines should also be flushed occasionally to prevent the buildup of solids.
- Do basin outlet conditions prevent the breakup of formed floc particles? Settling basin inlets are often responsible for creating turbulence that can break up floc. Improperly designed outlets are also often responsible for the break-up of floc. Finger launders (small troughs with V–notch weir openings that collect water uniformly over a large area of the basin) can be used to decrease the chance of short-circuiting.
- Is the floc the correct size and density? Poorly formed floc is characterized by small or loosely held particles that do not settle properly and are carried out of the settling basin. This is the result of inadequate rapid mixing, improper coagulant dosages, or improper flocculation. Systems should look to previous steps in the treatment train to solve this problem.
- Is the basin subject to short circuiting? If the basin is not properly designed, water bypasses the normal flow path through the basin and reaches the outlet in less time than the normal detention time. The major cause of short-circuiting is poor influent baffling. If the influent enters the basin and hits a solid baffle, strong currents will result. A perforated baffle can successfully distribute inlet water without causing strong currents. Tube or plate settlers

also improve efficiency, especially if flows have increased beyond original design conditions. Tube settlers can result in twice the basin's original settling capacity.

- Are basins located outside and subject to windy conditions? Wind can create currents in open basins that can cause short-circuiting or disturbances to the floc. If wind poses a problem, barriers lessen the effect and keep debris out of the unit.
- Are basins subject to algal growth? A problem that occurs in open, outdoor basins is the growth of algae and slime on the basin walls.
- In solids contact clarifiers, is the sludge blanket maintained properly? Operators should be able to measure the sludge depth and percent solids to ensure the sludge blanket is within the manufacturer's recommendations.

4.2.4 Filtration

Filtration is the last step in the particle removal process. Improperly designed, operated, or maintained filters can contribute to poor water quality and sub-optimal performance. There are a host of items which systems will need to evaluate regarding filters that may be contributing to poor performance. Many of the items listed below are detailed in Chapter 5, Individual Filter Self-Assessment.

Design of Filter Beds

It is important to verify that the filters are constructed and maintained according to design specifications. Utilities should consider the following items when evaluating the design of filter beds.

- Media – Is the correct media being used? Issues such as size, uniformity coefficient, and depth need to be evaluated.
- Underdrains – Are underdrains adequate or have they been damaged or disturbed?

Filter Rate and Rate Control

The rate of filtration and rate control is another important aspect of filters that should be evaluated. Without proper control, surges may occur which would force suspended particles through the filter media.

- Are surges in flow an issue of concern? Systems should avoid sudden changes to filter rate. Systems should minimize plant flow rate changes, throttle filter control valves slowly, and bring a filter on-line when one is being backwashed).
- Is the plant operating at the appropriate flow rate? At some plants (typically smaller systems), the flow is operated at a level that hydraulically overloads unit processes. Operating at lower flow rates over longer periods of time prevents overloading and increases plant performance.

- At what flows are the filters rated? Make sure not to exceed flow rates on remaining in-service filters when taking filters off-line or out of service for backwash.

Filter Backwashing

Filter backwashing has been identified as a critical step in the filtration process. Many of the operating problems associated with filters are a result of inadequate backwashing. Utilities should consider the following items when evaluating filter backwash practices.

- Is the rate of filter backwash appropriate for the filter? Filters can be either underwashed or overwashed. Utilities need to determine the appropriate flow that will clean the filter and prevent mudballs, but will not upset the filter media to the extent that the underdrain is damaged or filter media is lost. (20-50 percent bed expansion is typical)
- Are criteria set for initiating backwash? Systems should establish criteria such as time, headloss, turbidity, or particle counts for initiating backwash procedures.
- How are filters brought back on-line? Media should be allowed to settle after backwashing before bringing filters back on-line. Filters should be brought back on line slowly. Several filters should not be brought on line at the same time. Filters should not be brought back on-line without backwashing first.
- When a filter is backwashed, is more water diverted to the remaining filters, causing them to be overloaded during backwash? During the backwash, flow going to the remaining filters may need to be cut back to ensure the filters are not overloaded or "bumped" with a hydraulic surge causing particle pass through.

4.3 Process Enhancements/Technologies

As noted at the beginning of this chapter, some systems may need to provide additional treatment processes or make enhancements to existing processes to meet the requirements of the IESWTR. **The Agency stresses that utilities need to first fully evaluate their systems, specifically utilizing either the CCP or Partnership for Safe Water programs, prior to installing new treatment or equipment. EPA believes that most systems will be able to meet requirements through process optimization.**

EPA expects that systems might use a combination of equipment modifications and process enhancements or treatment processes to meet requirements if process optimization alone does not bring the system into compliance. The Agency developed a *Cost and Technology Document for the Interim Enhanced Surface Water Treatment Rule*, which discusses these treatment processes/enhancements. Treatment process enhancements fall into the following categories:

- Chemical Modifications

- Coagulant Improvements
- Rapid Mixing Improvements
- Flocculation Improvements
- Settling Improvements
- Filtration Improvements
- Hydraulic Improvements
- Laboratory Modifications
- Process Control Modifications

By no means is this list exhaustive or do the process enhancements which fall under each category represent the only modifications available to systems. They represent enhancements that, in the opinion of the Agency and other water professionals, are the most likely to be employed by systems. For further information regarding these enhancements, the reader is directed to the *Cost and Technology Document for the Interim Enhanced Surface Water Treatment Rule*, dated July 28, 1998, which was developed in support of the Regulatory Impact Analysis (RIA) for the IESWTR.

Certain technologies, especially those involving large financial expenditures, should only be implemented with appropriate engineering guidance, and should consider factors such as the quality and type of source water, turbidity of source water, economies of scale and potential economic impact on the community being served, and treatment and waste disposal requirements. An engineering study should be conducted, if needed, to select a technically feasible and cost-effective method to meet the unique needs of each system for improved filter effluent quality to comply with the IESWTR. Some situations may require more extensive water quality analyses or bench and/or pilot scale testing. The engineering study may include preliminary designs and estimated capital, operating and maintenance costs for full-scale treatment.

4.4 References

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