Wet Weather Operating Practices for POTWs With Combined Sewers

Technology Transfer Document

New York State
Department of Environmental Conservation

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SUNY MORRISVILLE

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SECTION 1 - INTRODUCTION

New York State requires the development of a Wet Weather Operating Plan for collection systems that include combined sewers. This requirement is one of 13 Best Management Practices (BMPs) that New York includes in the SPDES permit requirements of plants with Combined Sewer Overflows (CSOs). This particular provision has been included in consideration of the Federal CSO policy that mandates maximization of flow to Publicly Owned Treatment Works (POTWs). In addition to the specific requirements for combined sewer systems, the requirement to develop wet weather operating practices may be extended to include those communities with Sanitary Sewer Overflows (SSOs) or which are subject to process upset during wet weather periods. This document provides specific guidance to municipalities in evaluating the operation of their wastewater treatment facilities and formulating Wet Weather Operating Plans. The implementation of these plans will allow communities to improve treatment of sewage during wet weather events and will allow them to demonstrate compliance with the State and Federal BMP requirements.

This manual is divided into three principal sections that will present material on:

- Concepts for Wet Weather Operations at Wastewater Treatment Facilities (Section 2)
- Plant Operations Guidelines (Section 3)
- Case Studies (Section 4)

1.1 NEW YORK AND FEDERAL BMP PROVISIONS

The BMP provisions included within New York and Federal CSO Control Policies have evolved since the mid-1980's. There is significant overlap between the New York and Federal provisions, especially on the more important aspects. Table 1-1 lists the New York provisions and provides a cross-reference to the associated Federal BMP number and the significance to operators of POTWs. It can be seen that the 13 provisions within the State list include all but two of those on the Federal List. Conversely, the State list includes a number of provisions that are not included under the Federal BMP list. Most of these are policy issues pertaining to sewer replacement, new sewer construction or measures that ensure the maximum treatment of waste. One significant difference is that New York requires the development of a specific wet weather operating plan. This technology transfer manual provides communities with guidance to develop these plans.

1.2 FEDERAL POLICY AND GUIDANCE

The Federal CSO Control Policy was enacted on April 18, 1994 after having gone through a rigorous process that considered input from a variety of sources, including the affected communities in the United States. The original basis of the Federal Policy was the EPA National CSO Control Strategy document of 1989, which served as the framework for many state CSO control strategies that were formulated before the final 1994 Federal CSO Control Policy.

The Federal CSO Control Policy established the BMP provision that requires a municipality to maximize its flow to the POTW. As communities enact measures that will bring their discharges into compliance with applicable regulations, their average daily, monthly and instantaneous peak influent flow rates will increase commensurate with the actions taken pursuant to controlling or eliminating CSO discharges. The Policy provides the following commentary on the benefits of this particular BMP provision:

> *In some communities, POTW treatment plants may have primary capacity in excess of their secondary treatment capacity. One effective strategy to abate pollution resulting from CSOs is to maximize the delivery of flows during wet weather to the POTW treatment plant for treatment. Delivering these flows can have two significant water quality benefits: first, increased flows during wet weather to the POTW may enable the permittee to eliminate or minimize overflows to sensitive areas; second, this would maximize the use of available POTW facilities for wet weather flows and would ensure that combined sewer flows receive at least primary treatment prior to discharge.*

A series of technical guidance manuals on CSOs were developed by EPA following issuance of the policy to assist state water quality authorities and permittees to implement the CSO Control Policy. These include:

- *Combined Sewer Overflows - Guidance for Long-Term Control Plan* (EPA 832-B-95-002)

- *Combined Sewer Overflows - Guidance for Nine Minimum Controls* (EPA 832-B-95-003)

- *Combined Sewer Overflows - Guidance for Screening and Ranking Combined Sewer System Discharges* (EPA 832-B-95-004)

- *Combined Sewer Overflows - Guidance for Monitoring and Modeling* (EPA 832-B-95-005) (Revision in draft as of May 1998)

- *Combined Sewer Overflows - Guidance for Financial Capability Assessment* and Schedule Development (EPA 832-B-97-004)

- *Combined Sewer Overflows - Guidance for Funding Options* (EPA 832-B-95-007)

- *Combined Sewer Overflows - Guidance for Permit Writers* (EPA 832-B-95-008)

Chapter 5 of the *Guidance for Nine-Minimum Controls* addresses "Maximization of Flow to the POTW for Treatment" (BMP #4). This chapter presents some of the more meaningful information that would need to be incorporated into New York's Wet Weather Operating Plan. The objective of this BMP measure is to ensure that the POTW minimizes the discharge of untreated CSOs by treating as much of the flow as possible at the POTW. As with all BMP measures, this was intended to be a simple, easy to implement action that would be subsequently expanded upon with more detailed analyses conducted as part of POTW facility planning and development of the CSO Long-Term Control Plan (LTCP). EPA includes six bulleted items as the minimum effort for this BMP measure.

- Capacity determination for major interceptors and pump stations and ensure that the capacity is available via proper maintenance of the collection system.

- Determination of POTW performance during wet weather through a comparison to dry weather performance. Correlate performance and flow.

- Compare design capacity of different components of the POTW with the current flows. Identify areas with excess capacity.

- Determine POTWs capability to operate at incremental increases in wet weather flow and assess the effect on compliance with its discharge permit.

- Assess whether unused facilities at the POTW can be used to store or treat wet weather flows

- Develop cost estimates for planned POTW modifications.

1.3 OVERVIEW OF STATE POLICY AND GUIDANCE

The New York State Department of Environmental Conservation (NYSDEC) has issued 90 SPDES permits to communities with combined sewer overflows. Of those, 75 are communities with treatment plants and CSOs. The remaining 15 communities have CSOs but no wastewater treatment plants since they have collection systems which discharge to other communities' collection and treatment systems. In total the State has approximately 1,300 CSOs. This is about 10 percent of the CSOs in the country. There are permitted CSOs in every NYS DEC region except Region 1 (see the NYSDEC region map in Appendix I). The State? s largest systems with CSOs are located in New York City, Syracuse, Buffalo, and Rochester.

Periodically the NYSDEC publishes a list of surface waters that either cannot be fully used as a resource, or have problems that can damage their environmental integrity. This list is referred to as the Priority Waterbodies List or PWL. The PWL identifies problem information for each identified drainage basin including use impairments, type of pollutants, source of pollutants, and identified needs to resolve the impairment issues. Water quality impacts from CSOs which have been identified in the Priority Waterbodies List include:

- closure of shell fishing (marine waters)
- permanent and temporary bathing beach closures
- standing post-storm advisories
- floating debris or slicks, visual impairment
- depressed DO caused by BOD or nutrients

- solids sedimentation or sludge beds impacting benthic biota and causing sediment oxygen demand

For rivers, CSOs have been identified as contributing 30 percent of the point source flows resulting in impaired usage. For bays and estuaries, CSOs have been identified as contributing 69 percent of the point source flows causing impaired usage.

New York State has placed a priority on abating pollution caused by CSOs for over 30 years. Table 1-2 lists regulatory milestones for CSO abatement in New York State beginning with New York State Department of Health publications from 1967. The current New York CSO Control strategy (New York Technical and Operational Guidance Series 1.6.3) was issued October 1, 1993, approximately six months prior to the Federal CSO Control Policy. The Technical and Operational Guidance Series (TOGS) is a series of documents issued by the New York State Department of Environmental Conservation that provide guidance on how to ensure compliance with regulatory requirements. The CSO Control Strategy was prepared in accordance with the requirements of the "Final National CSO Control Strategy" of August 10, 1989 which was the predecessor of the current Federal CSO Control Policy. Priorities for CSO abatement have been established via the New York Strategy. Communities whose CSO discharges contribute to a precluded, impaired, stressed or threatened use of the receiving water are on the State's Priority Water Bodies list and will require the implementation of both BMP measures as well as additional improvements as determined through preparation of the LTCP.

All CSOs or POTWs serving systems with CSOs will be subject to the BMPs listed in Table 1-1. This will be accomplished by including all applicable BMPs into the plant's SPDES permits. Existing permits will be modified to include the BMPs.

The specific SPDES permit requirement to develop a Wet Weather Operating Plan (BMP #5) is as follows: "The permittee shall maximize treatment during wet weather events. This shall be accomplished by having a wet weather operating plan containing procedures so as to operate unit processes to treat maximum flows while not appreciably diminishing effluent quality or destabilizing treatment upon return to dry weather operation. The wet weather operating plan shall be submitted to the Regional Office for review and approval within __ months after the effective date of this permit." The number of months allowed for plan preparation will be determined by NYSDEC prior to issuance of the permit.

The requirement for including BMP #5 is considered at the time of SPDES permit renewal. If a wet weather operating plan is required, the plan must be submitted for review and approval to the NYSDEC Regional Office. A listing of NYSDEC offices is included in Appendix I. Changes and revisions to the Wet

Weather Operating Plan should be submitted for review and approval to the Regional Office annually. This manual will provide guidance to New York State permit holders in the development of Wet Weather Operating Plans for CSO communities. These plans will meet the requirements of both the Federal and State guidance.

TABLE 1-1

CROSS REFERENCE OF NEW YORK STATE AND FEDERAL BMP PROVISIONS

NEW YORK BMP PROVISION	FEDERAL BMP NO.	SIGNIFICANCE TO POTW OPERATIONS
1. O&M Program for Sewer Systems and CSOs	1	Collection system flow capacity is preserved and sewer cleaning will reduce the influent quantity of heavy solids during wet weather.
2. Maximum Use of System for Storage	2	The total quantity of wet weather flow will increase. The impact on peak influent flow rate to the POTW is conditional on how the storage facilities are operated.
3. Minimize CSO Impacts Through Pretreatment	3	The quantity of industrial waste from batch discharges may be decreased during an event. Post-event industrial wastewater may increase.
4. Maximize Flow to POTW	4	The frequency and duration of high flows will increase at the POTW. Increased O&M will be required to handle this increased flow and load.
5. Wet Weather Operating Plan	NA	Development of this plan will provide operators with a guide to minimize the discharge of pollutants during wet weather and to protect their facility from upset.
6. Eliminate Dry Weather CSO	5	The elimination of dry weather overflows will normally have minor impact on POTWs.
7. Control of Solids and Floatables	6	The solids and floatables controlled or removed through BMP and LTCP measures will increase the load to the POTW. Certain facilities such as grit and screenings removal may have to be expanded to accept this additional load.
8. Combined Sewer Replacement	NA	This is a policy requirement that a municipality must consider the separation of a combined sewer when it needs replacement. This may result in a marginal decrease in POTW flow in most instances.
9. Combined Sewer Extension	NA	When combined sewers are extended they should incorporate separate sanitary and storm sewer pipes to accommodate future separation efforts. Little impact on POTW operations.
10. Connection Prohibition	NA	New connections of sewers to areas with capacity problems are prohibited to preclude surcharging problems from getting worse.
11. Septage and Hauled Waste	NA	This prohibits the discharge of these materials upstream of a CSO, thereby ensuring that the POTW will provide at least partial treatment to these loads during wet weather events.
12. New Development Impact Reduction	NA	No impact on POTW operations is envisioned.
13. Public Notification of CSO discharges	NA	No impact on POTW operations is envisioned.
Additional Federal BMP Measures:		

NEW YORK BMP PROVISION	FEDERAL BMP NO.	SIGNIFICANCE TO POTW OPERATIONS
Pollution Prevention Programs	7	Reducing pollutant loads should improve general POTW performance.
CSO Monitoring	9	No impact on POTW operations is envisioned.

TABLE 1-2

HISTORY OF CSO POLICY IN NEW YORK

YEAR	POLICY
1967	NYSDOH - Technical Bulletin No. 20 "Polluting Discharges from Combined Sewers - Problems and Remedies"
1978 -79	NYSDOH - Combined Sewer Overflow Policy Committee
1981	Statewide 208 Study – "Combined Sewer Overflow/Urban Stormwater Runoff"
1985	DOW TOGS 1.6.3 – "Combined Sewer Overflows"
1989	USEPA – "National CSO Control Strategy"
1993	DOW TOGS 1.6.3 – "Combined Sewer Overflow (CSO) Control Strategy
1994	USEPA "National CSO Control Policy"

SECTION 2 - CONCEPTS FOR WET WEATHER OPERATIONS AT WASTEWATER TREATMENT FACILITIES

2.1 CHARACTERIZING WET WEATHER FLOWS

Wastewater treatment plants serving combined sewer systems are significantly impacted by storm events; but facilities in communities without combined sewer systems can also be plagued with problems at the onset of wet weather. The extent of adverse wet weather impacts at a treatment plant is determined by a complex combination of factors including:

- Age and condition of the sewer system
- Groundwater elevations in the vicinity of sewers
- Sources of inflow such as footing drains, roof leaders, and manhole covers
- Design of interconnections between the storm and sanitary sewer systems
- Storage capacity in the sewer system
- Operation of CSOs or SSOs
- Capacity of each major unit process at the treatment plant

- Operational strategies employed to deal with wet weather

These factors should be addressed in the preparation of a wet weather operating plan for the facility. But before a plan can be developed, information must be gathered to provide the basis for wet weather decision making. The necessary information will come from a characterization of the collection system, flow to the treatment plant, performance of major plant processes under wet weather conditions, and wet weather impacts on effluent quality.

A. **Characterizing the Collection System.** A thorough understanding of the sewer system is essential when developing a wet weather operating plan. The best place to start is to study maps and drawings of the sewer system showing routing, sizes and elevations of the sewer lines. Determine the location and design of control structures including regulators, combined sewer overflow points, sanitary sewer overflow points, and pumping stations. Study the operation and control of existing pumping stations. Determine the age and condition of piping and manholes throughout the system. Determine the major sources of inflow and infiltration including catch basins, roof leaders, sump pumps, footing drains, submerged manhole covers, and deteriorating pipes and manholes. If previous sewer system evaluation studies or infiltration/inflow studies have been conducted, these can be a valuable source of information. A thorough understanding of the collection system will provide the information necessary to identify options for improved wet weather operations.

B. **Characterizing Flows and Pollutant Loadings to the Wastewater Treatment Plant.** A review of historical plant influent flow data can provide important information for evaluating a plant's susceptibility to hydraulic overloads. Flow records normally maintained at treatment plants include the daily average, instantaneous minimum and instantaneous maximum flow for each day. This information provides a good background to assess the overall hydraulic loading condition of each of the plant's treatment processes. It is best to enter the plant flow data in a spreadsheet, database, or commercially available wastewater data management software file to allow easy analysis of flow data. For assessing most plant processes, the following flow information will be sufficient:

- Average dry weather flow
- Maximum 30-day average flow
- Peak daily flow
- Peak hourly flow

The first three flow values above can be determined directly from information normally recorded on plant monthly report forms. Determination of peak hourly flow will require a review of the flow charts recorded during the highest flow periods. Average, maximum 30-day average, and peak day values of BOD_5 and total suspended solids in the plant influent will also be required to assess some unit processes.

Analysis of the flow data will reveal the peaking factors for the plant. Flow peaking factors are expressed as a multiplier of the daily average flow. If, for example, the average daily flow is 1.0 mgd and the maximum 30-day average flow is 1.3 mgd, then the maximum month to daily average peaking factor is 1.3. The peak hour : daily average peaking factor during dry weather flow will range from a factor of about 4 for plants under 1 mgd to about 2 for a 50 mgd plant. During storm events at plants with combined sewer systems, hourly flows can exceed 10 times the average flow, with additional flows being bypassed at combined sewer overflow points.

By keeping records of weather conditions, correlations can be developed between weather events and wastewater flows. This can be helpful in predicting the impacts of upcoming storm events and making preparations for expected weather conditions. The volume of precipitation in a given day (inches of rainfall) is not the only factor which determines the volume of flow received at the plant. Groundwater elevations, stream elevations, ground saturation, and snow melt all contribute to variations in flow received at the plant. With experience, impacts of various combinations of weather conditions and storm events can be predicted and plans developed for the major categories of wet weather events.

C. **Characterizing Effects of Wet Weather Flows on Major Unit Processes and Effluent Quality.** Before a wet weather operating plan can be developed, it is important to understand the impacts of storm events on each major unit process in the plant. This may necessitate some additional sampling and testing beyond that required for normal process control and monitoring. Examples of some of the additional data collection required to characterize process impacts are given below.

Grit Removal - Monitor daily volumes of grit collected. The volume of grit collected can increase tremendously with wet weather flows. The largest grit accumulations are likely to occur during a large storm event following an extended period of dry weather. Grit, which has collected in the sewer system during low flow, will be washed to the plant. Grit volumes can be estimated by determining the volume of the container normally used for grit collection, then estimating the percent full each day (or number of containers filled each day).

Screenings Removal - Monitor daily volumes of screenings collected. While not as highly variable as grit volumes, screenings volumes will also increase with high flows as accumulated screenings are washed out of the sewer system. Screenings volumes can also be estimated on a daily basis by determining the volume of the container normally used for screenings collection, then estimating the percent full each day (or number of containers filled each day).

Primary Sedimentation - Monitor primary influent and primary effluent BOD_5 and TSS. Many plants regularly monitor plant influent BOD_5 and TSS, but do not sample primary effluent for these parameters. Primary influent and effluent monitoring will determine the percent removal of BOD_5 and TSS under varying flow conditions and allow an assessment of the flow rate at which primary settling is adversely impacted. Primary sludge blanket depths, and volume of primary sludge pumped should also be recorded during high flow periods.

Aeration Tanks - Mixed liquor suspended solids concentrations should be monitored at multiple locations in the aeration tanks to determine the impact on activated sludge system solids inventory. Dissolved oxygen in the aeration tanks should be measured to confirm adequate aeration.

Final Settling - Monitor final settling tank effluent BOD_5 and TSS. Sludge blanket levels in the final settling tanks and SVI of the secondary sludge should also be recorded. If ammonia and phosphorus removal are required, these parameters should also be monitored.

Disinfection System - Coliform levels should be checked on the downstream side of the disinfection system.

The additional sampling and testing suggested above could become a significant burden on the plant staff in terms of both time and finances. The suggested tests need not be performed on a continuous basis. The actual number of samples required will vary depending upon plant size, configuration and weather patterns, but sufficient sampling is required only to show performance variations under various flow conditions. If, for example, previous testing has documented primary clarifier effluent BOD_5 and TSS removals up to a flow rate of 2.5 mgd, it may not be necessary to conduct any more tests at flows of 2.5 mgd or less.

Further testing would only be conducted when flows exceed 2.5 mgd in a effort to document the impact of higher flows on clarifier performance.

The type of sample required will also vary depending upon plant size and configuration. When sampling locations such as primary effluent and secondary clarifier effluent for BOD_5 and TSS removal, it is best to use the same sampling procedure that is used for the plant influent and effluent. If, for example, the plant influent sample is a 24-hour flow-weighted composite, it would be best to use a 24-hour flow-weighted composite for the primary effluent sample. At larger facilities, where more sampling equipment is available this may be practical. If, however, facilities and personnel are not available to perform the ideal sampling, simple grab samples taken during multiple storm events can provide the desired indications of process performance.

Sampling outside of the normal required discharge permit monitoring regimen may also raise concerns over which test results must be reported to regulatory authorities. The additional testing recommended above would be conducted primarily during wet weather. Additional effluent samples collected only during high flow events could incorrectly skew effluent values to the high side, potentially resulting in a false indication of a permit violation. One way around this problem is to use rapid test methods which can save time and money, but are not approved for permit monitoring. These tests would be usable for process control purposes, but would not be considered valid for permit monitoring. One example of this would be to perform rapid COD tests using a COD test apparatus, such as the Hach digestion unit and the DR 2010 spectrophotometer. A series of BOD and COD tests can be run on split samples to establish a BOD:COD ratio. Once the ratio is determined, COD tests can be performed for process control to estimate BOD values. Other rapid kit tests can be used to determine ammonia and phosphorus levels. Mixed liquor suspended solids concentrations can be estimated quickly using a centrifuge test in lieu of a complete filtering and drying procedure.

2.2 GENERAL PLANT OPERATIONS RECOMMENDATIONS

Section 3 will describe specific recommendations for maximizing wet weather capacity of individual plant processes. This section presents general recommendations applicable to many different processes and plant configurations.

A. **Use of Unused Equipment and Tankage.** Placing unused equipment and tankage in service during wet weather events can provide several benefits including:

- Increasing hydraulic capacity
- Improving treatment capacity
- Preventing mechanical overloads of process equipment
- Providing temporary storage for biological solids to prevent washout
- Storing a storm's "first flush" for later treatment

Often, equipment which is not needed during dry weather periods is not easily placed in service on short notice when high flows arrive. Gates that receive infrequent use may be inoperable. Equipment which is in need of repair may not be usable. By maintaining equipment in ready condition at all times, performance improvements can be achieved when wet weather arrives by making full use of available processes.

In some cases, it may be best to use tanks for something other than their originally intended purpose. An empty tank from any process might be used to store biological solids temporarily or to retain a first flush of incoming wastewater if the necessary piping connections are available.

B. **Controlled Bypassing of Processes.** Once a process has reached its maximum hydraulic capacity, sending additional flow to the unit could result in decreased performance, or even result in damage to facilities. Controlled bypassing of process components once their limits have been reached can improve performance during wet weather events and after the event is over. A bar screen channel may back up during a storm and overflow. Opening a bypass gate to prevent overflowing may prevent damage caused by the errant flow and allow the bar screen to continue treating a portion of the flow. Clarifiers and aeration tanks will experience excessive solids loss at some limiting flow rate. If bypassing capabilities exist, a bypass should be considered. Through sampling and testing described in Section 2.1 and process assessments described in Section 3. The proper flow rates at which to begin bypassing can be determined.

C. **Minor Modifications to Increase Flexibility.** In some cases minor plant modifications will enhance capability to handle wet weather flows. Gates which require excessive time and effort to exercise throughout the year and to open during a storm event, can be fitted with electric operators. Addition of electric operators on key valves can also make rapid mode changes practical during storm events. Tanks which are difficult to clean out after temporary storm use can be sloped with a new layer of grout on the floor, and provided with additional hose connections or a permanently installed flushing system. Minor piping modifications or gate additions may allow activated sludge process mode changes discussed in Section 3. When developing a wet weather operating plan, minor capital improvements which will benefit wet weather operations should be identified and incorporated in the plan recommendations.

D. **Reducing Plant Recycle Flows During Wet Weather.** Some plant recycle flows such as digester supernatant, belt press filtrate, tertiary filter backwash or gravity thickener overflow can be high in BOD and solids. These flows are generally returned to the head end of the plant or the secondary process stream. During high flows, when treatment capacity may be impaired, recycle flows may not receive sufficient treatment and may impact plant effluent quality. Consideration should be given to eliminating recycle flows by temporarily halting sludge dewatering or other solids handling processes during peak wet weather flows.

2.3 FLOW SPLITTING RECOMMENDATIONS

Uneven flow splitting is a common problem at wastewater treatment plants. Equal distribution of flow to multiple process units allows full use of each unit. When one unit receives more flow than other similar units, process performance will suffer prematurely. At some plants flow splits are fairly even at low or normal flow rates. Slight variations in feed rate between two identical units may not be noticed, because performance is satisfactory at average flows. At high flows, however, the difference between flow rates received by adjacent units may become more noticeable. One clarifier may begin producing high effluent TSS before the others if it receives a higher flow.

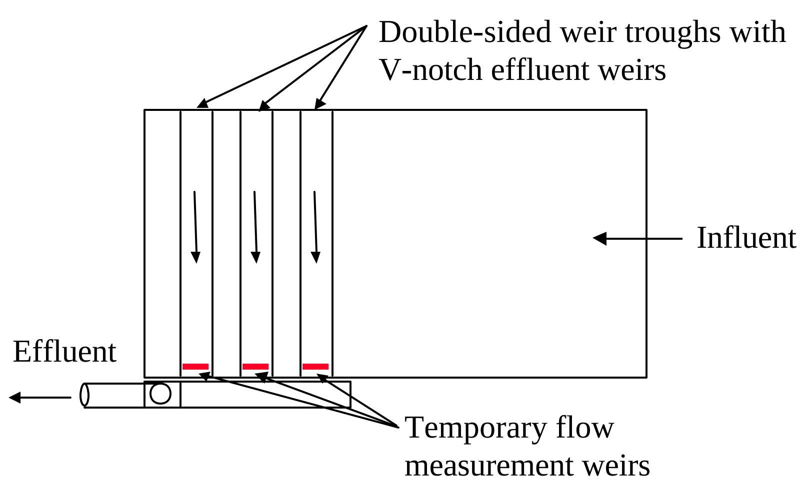
The best solution to good flow splitting is good design of flow splitting devices. Equal flow splits between identical process units can be achieved through use of identical weirs arranged symmetrically around a center feed pipe in a distribution structure. For existing facilities with poor flow distribution, however, new distribution structures may not be feasible. An evaluation of existing flow distribution and installation of low cost enhancements to improve flow splitting can improve performance during wet weather periods.

It is first necessary to evaluate the performance of existing flow splitting devices. Visual observation of flows at tank inlet areas and over weirs can provide an indication of unequal flow distribution. Excessive turbulence in one tank, or excessive solids carryover from one tank is indicative of higher flow. Laboratory analysis showing unequal solids distribution between tanks can also indicate uneven flow splits. If any of these observations suggest a flow distribution problem, further checking should be initiated to confirm the extent of the problem. Flow distribution can be checked by comparing depths of flow over weirs.

In splitter boxes with multiple weirs, depth of flow should be equal over all weirs. Weirs can be leveled and adjusted to identical elevations to improve distribution. The location and depth of the feed pipe can impact performance of a distribution box. Weirs of equal length and elevation may not create an even split if the feed pipe arrangement causes turbulence or currents that produce unequal liquid depths across the box. The negative effects of asymmetrical feed arrangements in splitter boxes can be mitigated by strategic baffle installation.

Primary and secondary clarifiers typically utilize long v-notch effluent weirs. In circular clarifiers the weirs usually line a single or double-sided weir trough near the tank perimeter. In rectangular tanks the v-notch weirs commonly line multiple lateral troughs or serpentine weir troughs near the effluent end of the tank. If these long weirs are not level throughout their entire length, excess flow will pass over the lower portions of the weir. Weirs should be checked and leveled as necessary. It is difficult to use depth over long v-notch weirs to make flow comparisons between multiple tanks. Very small depth variations can represent significant flow differences in these tanks. If depth of flow over clarifier effluent weirs is measurably different, a large difference in flow is indicated, and corrections to the flow split feeding the tanks should be investigated. If there is no measurable difference in depth over the effluent weirs, but unequal flow split is suspected, flow can be estimated through placement of temporary measurement weirs. Temporary weirs constructed of plywood can be inserted in channels at locations such as those shown in Figures 2-1 and 2-2 to estimate flow splits between tanks. Formulas for estimating flow rates over weirs are given in Appendix F.

Figure 2-2: Temporary Flow Measurement Weirs Placement - Rectangular Weirs



If flow rates at the effluent ends of tanks indicate poor distribution, the flow splitting mechanism upstream of the tanks must be investigated. Flow through submerged pipe or port openings covered by gates can be throttled by adjusting the gates. Flow splits in asymmetrical open channels can be adjusted by inserting diverter baffles. These methods will not produce consistent flow splits at all plant flow rates. However, testing at various flow rates can produce a record of gate or baffle settings required for each flow rate.

2.4 DYE TESTING AND BAFFLE INSTALLATION FOR IMPROVED CLARIFIER PERFORMANCE

Secondary clarifiers are a critical element affecting the performance of a plant during wet weather. They are the last line of defense before effluent leaves the plant. They capture and return sludge which keeps the activated sludge process viable. If high flows cause uncontrolled solids loss from the secondary clarifiers, the discharge permit may be violated and activated sludge process performance may suffer even after the wet weather subsides.

Numerous studies have demonstrated that density currents in clarifiers can cause less than optimal clarifier performance. These currents, traveling at higher velocity than the surrounding fluid, can carry solids through the tanks and over the effluent weirs. In center-feed circular clarifiers, density currents tend to travel outward across the top of the sludge blanket, up the outside wall of the tank, and over the effluent weir. In rectangular settling tanks, currents have been shown to travel at various elevations in the tank, producing the same tendency to carry excessive solids in the regions of higher velocity.

Methods have been developed to confirm the existence of density currents through use of dye testing and to interrupt these velocity currents through installation of density current baffles.

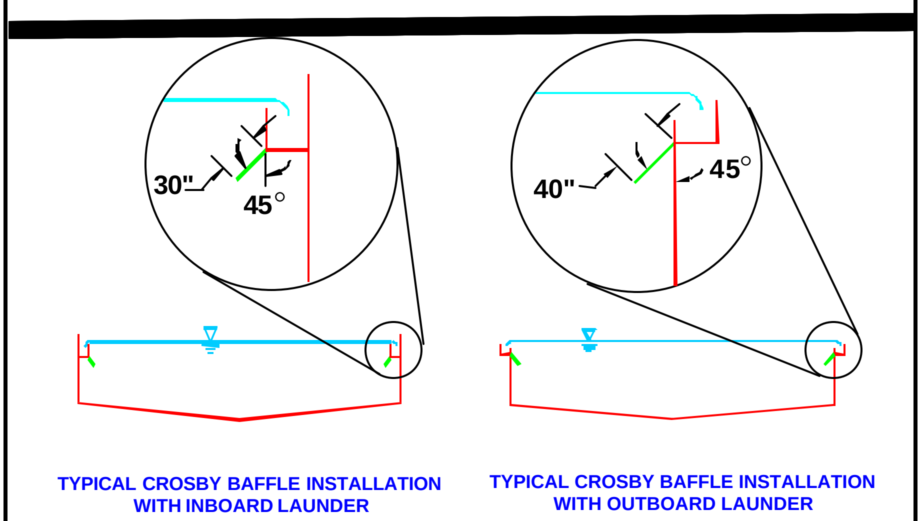
Two dye tests, a slug test and a continuous feed test, are normally performed to assess the need for baffle addition in clarifiers. The slug test is performed by dumping a slug of dye at a point upstream of the clarifier where the dye will be well mixed with the clarifier influent. Samples are taken periodically at the clarifier effluent weir and measured for dye concentration. The time at which the peak dye concentration reaches the clarifier effluent weir is an indication of the travel time through the clarifier. The actual hydraulic detention time in the clarifier is calculated as the area under the curve when effluent dye concentration is plotted versus time.

The continuous feed test is performed by feeding a continuous stream of dye at a constant rate to the influent end of the clarifier at a well-mixed location. Core samples of the clarifier contents are collected and tested periodically for dye concentration. The test results reveal a dye profile which shows the location of density currents in the clarifier. Based on the observed current locations, baffle locations may be selected to interrupt and disperse the density currents. A complete dye testing procedure for the slug test and continuous feed test is presented in Appendix C.

Peripheral density current baffles, referred to as Crosby baffles, have become standard additions to circular clarifiers. They are typically placed at a 45- to 60-degree angle on the clarifier wall as shown on Figure 2-3. The purpose of these baffles is to deflect solids-carrying currents back toward the tank interior, away from the effluent weir. The benefits of this type of baffle have been sufficiently demonstrated that in most cases dye testing is not necessary to determine recommended baffle replacement.

Baffles can also be very beneficial to performance in rectangular clarifiers. Mid tank baffles will help disperse density currents at various locations as determined through dye testing. Multiple baffles have been found to be more effective than a single baffle. Further discussion of baffle placement, materials and construction can be found in Section 3.6.

Figure 2-3: Density Current Baffles For Circular Clarifiers



2.5 DEVELOPING A WET WEATHER OPERATING PLAN

The best management practices included in the discharge permits of POTWs in New York State that have combined sewer overflows require the plant staff to have in place a wet weather operating plan. This plan is intended to provide operators with a guide to minimize the discharge of pollutants during wet weather and to protect their facilities from upset.

A. **Key Elements.** Every wet weather operating plan should contain the following key elements:

- **Goals of the Plan.** The goals section will define the overall objectives of the wet weather operating plan with respect to protecting water quality and plant performance.

- **Critical Components.** The plan should list the critical components of the collection and treatment system that significantly impact wet weather performance. For each critical component, specific objectives should be defined.

- **Operating Guidelines.** For each critical component, the plan will contain step by step guidance for operation, maintenance, and management procedures to be followed before, during and after a wet weather event.

- **List of Contacts.** The plan should contain a list of important contacts that may be of assistance during wet weather events.

1. **Goals of the Plan**. The goals of the plan should define the water quality objectives of the collection and treatment system. For most systems with combined sewer overflows, operating decisions made during wet weather events can affect how much flow is treated at the wastewater treatment plant and how much flow is bypassed through CSOs. Difficult decisions must be made rapidly. These decisions may affect water quality in the receiving water at the CSOs, water quality in the receiving water at the plant, and performance of the plant during and after the wet weather event. Well defined goals for receiving water quality will help guide the development of operating guidelines for the plant and help guide decision making during wet weather events. It may be necessary to obtain advice from the State regulatory agency in setting water quality priorities.

2. **Critical Components.** The critical components are processes in the collection system (such as CSO regulators or pumping stations) or the treatment plant (such as bar screens or aeration tanks) which can significantly affect treatment of wet weather flow (or can be significantly affected by wet

weather flow). The list of critical components is unique to each facility. One plant's critical component may not be critical at another facility. The Wet Weather Operating Plan is not intended as a substitute for the plant's operation and maintenance manual. Components that have no bearing on wet weather operations will not be listed. As an example, a collection system may include multiple wastewater pumping stations, but not all stations may be listed as critical components. Unlisted stations might serve a new portion of the sewer system that has no combined sewers and little I/I. Though regular operation and maintenance procedures are essential at any pumping station, no special procedures may be needed at these stations during wet weather.

Any major unit process in the collection system or the wastewater treatment plant that is handling wet weather flows should be included on the list of critical components. Even if the process does not normally present special problems during wet weather it should be included on the list if it is handling wet weather flows. In addition, auxiliary processes that are impacted by wet weather flows should be included. If, for example, special provisions for sludge handling must be made during wet weather, a sludge thickening, stabilization or dewatering processes might be included on the list of critical components.

3. **Operating Guidelines**. Operating Guidelines should be developed for each critical component identified in the collection system and treatment plant. For each component, tasks should be listed for completion before, during and after a wet weather event. Task descriptions should be brief and specific. The wet weather operating plan is intended to serve as a quick reference during a wet weather event. This is not the place for a detailed description of the theory behind a treatment process. The descriptions must be specific enough, however, to describe exactly what needs to be accomplished. For example, "Check water level in influent channel" may not be specific enough. But, "Check water level in influent channel. Open feed gate to second bar screen if water level is above 3-foot mark on staff gauge" provides specific direction based upon a required observation.

4. **List of Contacts**. Develop a list of contacts who can provide advice or assistance during a wet weather event. The list should include supervisors and other involved public officials, equipment representatives and service organizations, local and state regulatory agencies, utilities, and emergency contacts such as fire department, police department and ambulance.

B. **Plan Development.** The operation and maintenance staff who actually run the facility should develop the wet weather operating plan. If outside assistance is obtained for plan development, the plant staff should have a significant role in providing input, guidance, and review of the operating plan. The key steps in plan development are as follows:

- Identify personnel to be involved and form development team
- Break down plant and collection system into physical areas
- Break down areas into unit processes
- By unit process, list wet weather O&M procedures to be followed before, during, and after each wet weather event
- Review and refine list of procedures
- Evaluate and continue to revise procedures (continuous process improvement)

At a large facility, the development team may include a large number of people with diverse roles at the plant. At a small plant, the development team may include the entire plant staff. Each of the steps in the development process can be initiated effectively through a brainstorming meeting with ideas contributed by all present. The detailed procedures can then be further developed in smaller work groups.

The completed Wet Weather Operating Plan should not be considered a final document. The plan should be subject to revision whenever operating experiences at the plant demonstrate improved or additional procedures to be included. The plan should be kept in a three-ring notebook that can be easily modified as new revisions are developed. Even after the initial plan is developed, investigate some of the suggestions made in this manual, and other ideas that are developed at your plant. Test and compare various procedures to find new ways to treat more flow more efficiently at your facility. Never stop looking for new ways to make your plant provide better, more efficient performance and further reduce untreated overflows.

SECTION 3 - OPERATIONS GUIDELINES

3.1 COLLECTION SYSTEM RECOMMENDATIONS

State and federal guidelines for CSO controls require that:

- Collection systems be properly operated and maintained
- Use of the collection system for storage is maximized
- Flow to the POTW is maximized
- Dry weather overflows are eliminated

These four guidelines necessitate implementation of a plan for collection system operation and maintenance. The following sections discuss key elements of combined sewer system O&M

A. **Maximizing Sewer System Storage.** Trunk, interceptor and other main components of sanitary and combined sewer systems are generally filled to a small fraction of their total capacity during dry weather. When wet weather occurs this unused capacity begins to fill with stormwater flow. In some systems, combined sewer overflows may begin or treatment capacity at the POTW may be adversely impacted before some of the large capacity sewers in the system are flowing full. This unutilized volume within the sewer piping offers an opportunity to store additional flow, which can reduce volume of overflows and reduce peak flow rates reaching the POTW. Additional storage capacity may be available in manholes, pumping stations, and regulator structures. The system must be carefully assessed to determine the potential for utilizing additional storage.

A good sewer map showing pipe sizes and invert elevations is invaluable for system assessment. Use the following steps to evaluate potential for additional system storage.

- Study sewer map to identify large diameter sewers with potential for storage
- Inspect manholes and regulators during wet weather to determine whether identified pipes are flowing full
- Identify methods to control water levels in the identified pipes
- Confirm that increased water levels will not cause overflows at new locations or sewer system backups into residences or buildings

A simple method to take advantage of unused system storage capacity is to throttle the influent sluice gate at the POTW. Other methods include raising overflow elevations at regulator points as discussed in the next paragraph, modifying pump station operations (see Section 3.2), or constructing removable dams at key locations in the system. When utilizing any of these methods, follow-up inspections during wet weather events are critical to avoid unwanted consequences. Through diligent inspections and recordkeeping, a plan can be developed outlining the steps to take (such as gate throttling or insertion of temporary weir boards) at various flow rates and under various wet weather scenarios.

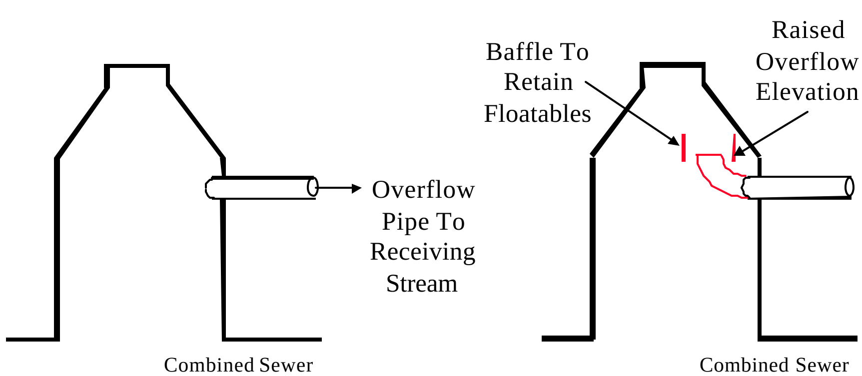
B. **Recommendations for Overflow Points.** Combined sewer overflow points employ many different methods of regulating overflows so that normal dry weather flow passes to the wastewater treatment plant and overflows only occur during wet weather. Regular inspections, proper maintenance and in some cases minor modifications to overflow regulators will minimize occurrences of unnecessary overflows. Figures 3-1, 3-2, and 3-3 show CSO regulators and potential minor modifications to increase system storage and decrease overflow volume. Strategies shown include raising overflow weir levels, installing extensions to raise overflow outlet pipe elevation, installing flap gates to prevent backflow from receiving streams and installation of baffles to maximize capture of floatables.

Figure 3-1: Backflow Prevention Devices

Flap gate

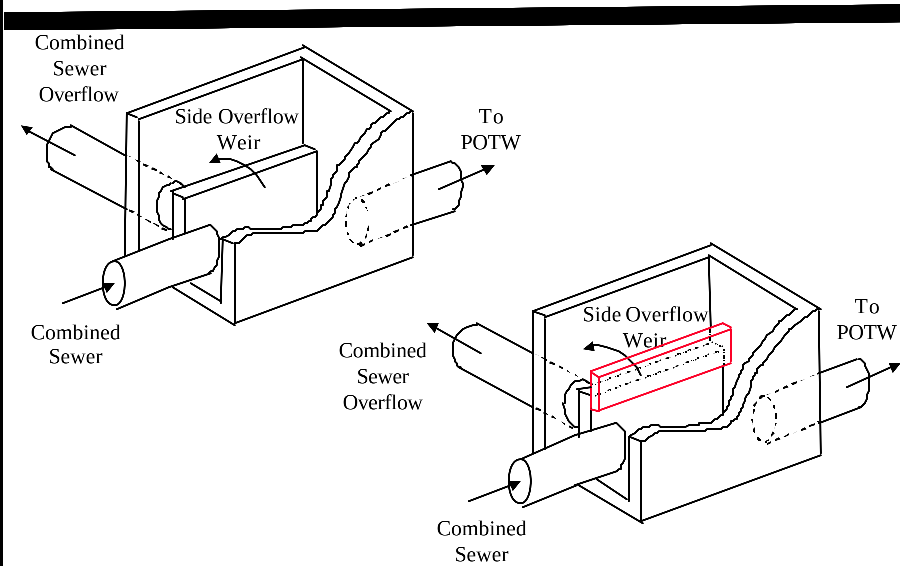
Tideflex valves

Figure 3-2: Minor Modifications to CSO Overflow Points



Regulator chambers can be locations where grit and other debris tend to collect. This can result in improper operation of the regulator, unnecessary loss of solids to the receiving water, and decreased carrying capacity. Periodic cleaning can minimize these impacts. Frequency of cleaning should be determined based

Figure 3-3: Minor Modifications to CSO Overflow Points



upon observations from regulator inspections.

Some overflow locations have the potential for flow from the receiving water to enter the sewer system during times of high receiving water elevation. This can cause large increases in flow to the POTW and rob the system of valuable carrying and storage capacity. Consider adding flap gates or tide gates at the discharge end of the overflow pipe to avoid backflow.

C. **Collection System Cleaning and Maintenance.** A wet weather operating plan should include requirements for collection system cleaning and maintenance. Good collection system O&M will have the following benefits:

- Maximize sewer flow capacity
- Maximize sewer storage capacity

- Avoid excessive buildup of grit and solids that decrease sewer capacity, decrease flow to the POTW and increase overflow volumes.

- Decrease the volume of grit and solids carried to the POTW in the first flush of a storm event.

- Identify minor problems in the system to repair before they become major problems

- Identify correctable sources of inflow and infiltration.

Maximum use of storage and transmission capacity is dependent upon sewers that are clean and free from obstructions. Grease buildup, root intrusion, grit deposition, clogging by debris and damaged pipe all result in reduced capacity. All of these problems can be minimized through implementation of a regular program of inspection, cleaning and repair.

TV inspection is an effective method of identifying damaged pipe and sources of infiltration. For sewer systems which have not been inspected in the last 10 years or where pipe damage or significant infiltration is suspected, a program of TV inspection is recommended. Prior to TV inspection, the sewer should be thoroughly cleaned, so that all interior portions of the system including pipe, joints and manholes are clearly visible. TV inspections should be recorded on videotape with narration included on the tape identifying the pipe location and defects observed including cracking, faulty joints and sources of infiltration. By reviewing the videotapes, an assessment can be made of the condition of the sewer and the need for repairs.

Required cleaning frequency can vary greatly depending upon the condition of pipes, flow velocities and quantity of grit, grease and debris entering the system. Based upon experience with each sewer system, a regular cleaning schedule should be developed. Special attention should be given to segments of the collection system that are utilized for storage or provide the flow path between CSO points and the POTW.

D. **I/I Reduction Measures.** Combined sewer systems have a major source of inflow through the catch basins and storm drains connected to the system. Separation of sanitary and storm sewer systems is an obvious approach to minimizing wet weather flows to POTWs, but for many communities complete separation of the sewer systems in not economically feasible. Significant benefits may be realized, however, by taking steps to reduce infiltration and inflow in portions of the collection system. Identification and removal of infiltration and inflow sources can eliminate some of the wet weather flow entering the system, freeing up capacity for combined sewer flows which cannot be eliminated, and reducing the volume of overflows during wet weather.

Methods of investigation that can be used in an infiltration/inflow study include:

- TV inspection of the sewer system
- Smoke testing
- House-to-house surveys
- Installation of temporary flow monitoring devices in the sewer system

Routine inspections of the system may also identify sources of I/I. Leaking pipe joints and manholes identified through TV or other means of inspection should be considered for replacement or rehabilitation. In areas where storm and sanitary sewers are not combined, property owners should be asked to disconnect sump pumps, roof drains and footing drains from the sanitary sewer system. In areas where manhole covers become flooded and submerged, sealed manhole covers or cover inserts can eliminate large volumes of inflow. In storm sewers, flow restricting devices can be installed in catch basins to slow the rate of entry of stormwater into the sewer system.

3.2 PUMPING STATION RECOMMENDATIONS

Operation and maintenance of pumping stations impact both storage and transmission in the collection system. Failure of a pumping station can result in combined sewer overflows, flooding of basements, and property damage. Required maintenance at pump stations includes regular maintenance of pumps and accessories as well as periodic cleaning of wet wells to remove grit, scum and debris. Where emergency generators are provided, generators should be exercised weekly and properly maintained. Automatic transfer switches for transferring power from emergency generators or backup utility power feeds should be tested and exercised periodically. To be sure that all equipment is ready for service when wet weather arrives, provide regular maintenance of all equipment in accordance with the manufacturer's recommendations.

Pump stations and their control systems can be utilized to provide additional sewer system storage during wet weather. If the inlet sewer to the pumping station is not normally submerged and has available storage capacity, pump controls can be adjusted to allow the wet well level to rise above the feed pipe elevation, resulting in storage in the collection system.

3.3 PRELIMINARY TREATMENT RECOMMENDATIONS

A. **Screening**. Bar screens are normally the first preliminary treatment units at the wastewater treatment plant. Screens may also be located at pumping stations and CSO points. Bar screens remove material that could clog or damage other downstream equipment in the plant. During wet weather, bar screens may be loaded to their hydraulic limits. Under these conditions, excessive screenings quantities can overload the screens causing various problems including:

- Overflowing screen feed channels
- Activation of upstream combined sewer overflows
- Passage of some screenings through the screens due to localized high velocity through the bars
- Activation of bypass channels around screening units
- Overflowing screenings containers

During average flow periods, observed quantities of screenings typically average about 1 cubic foot of screenings per million gallons of flow treated for screens with 2-inch openings, to 3 cubic feet per million gallons treated with 1-inch screens. These quantities can increase dramatically during the first flush of a wet weather event, when material that has collected in the sewers is suddenly washed to the screens. The following paragraphs describe recommendations to minimize the adverse impacts of high flows and large screenings loads during wet weather.

1. **Place All Units in Service.** The velocity of the wastewater approaching a bar screen should normally be in the range of 1 to 3 feet per second. The screen channel will remain cleaner (less grit will settle in the channel) if the velocity is in the range of 2 to 3 feet per second. At plants that have multiple bar screens, it may be necessary to take units in and out of service to maintain the desired approach velocity. For example all units could be placed in service during normal wet weather seasons and when storms are forecast during dry weather seasons.

2. **Set Controls for Continuous Operation During Wet Weather.** The most commonly used control scheme for mechanical bar screens is periodic operation using a programmable time clock. A level sensor in the channel will override the time clock and run the screen continuously when high flows and clogging of the bar screen raise the water elevation in the channel to a pre-set level. When wet weather is anticipated, the controls should be set for continuous operation. This will avoid waiting for a high level alarm condition to initiate continuous operation. It will help avoid washing screenings through the bars due to localized high velocity caused by a clogged screen.

3. **Periodically Clean Out Channels.** Even with proper operation and the proper number of units in service for velocity control, grit and other solids may settle in the bar screen channels. Periodic cleaning of the channel will maintain peak hydraulic capacity of the channel. It will also avoid sudden washing of the collected solids to the bar screen during wet weather flows, which could adversely impact operation of the screen.

4. **Prepare Screening Containers.** During wet weather, the volume of screenings collected can increase dramatically. Prepare for wet weather events by having screenings containers empty. If existing containers overflow during wet weather, increase emptying frequency and consider purchasing larger or additional containers.

B. **Grinding and Comminution**. Many smaller plants utilize grinders or comminutors in place of mechanical bar screens. As with bar screens, the high volume of large solids carried with the first flush of a storm event can overload a grinder or comminutor with solids. This can result in channel overflows and activation of upstream CSOs. Recommendations to maximize treatment during wet weather include placing all units in service and periodically cleaning upstream channels. In addition it is important to keep comminutor and grinder cutting surfaces sharpened, and perform regular preventive maintenance on the units so that they are available when needed.

C. **Grit Removal.** High flows in a combined sewer system can inundate a treatment plant with grit. Grit settles and builds up at locations throughout the collection system where velocity is low. When velocity increases during a storm event, collected grit is washed to the plant. The highest volumes of grit will be received at the plant when high flows occur after a long period without wet weather. The excess grit arriving at the plant during wet weather can cause many problems including:

- Overloading and shutting down grit removal facilities
- Excessive grit carrying through grit removal facilities to downstream processes
- Grit blocking channels and pipes at the treatment plant
- Overflowing grit receiving containers

Principal methods of grit removal include:

- Aerated grit chambers
- Detritus chambers
- Velocity controlled grit channels

- Vortex-type chambers
- Cyclone degritting of primary sludge

All of these grit removal processes can be impacted by high wet-weather-induced grit loadings.

Quantities of grit received at wastewater treatment plants vary greatly from one community to another. Important factors which influence grit quantities include whether the sewer system is combined or sanitary (with combined sewers sand and grit from roadways will enter the system), whether soils are sandy and can be washed into the sewer system through open pipe joints, and whether garbage grinders are used in local households. Reported volumes of grit collected in aerated grit chambers range from 0.5 to 27 cubic feet of grit per million gallons of wastewater treated, with a typical value of 2. This wide range demonstrates the variability of grit volumes that can be encountered. Several recommendations for handling wet weather grit loadings are presented below.

1. **Clean Sewers and Catch Basins Regularly.** A program for periodic sewer cleaning should be a part of the wet weather operations plan (see Section 3.1). Catch basins in storm sewer systems are designed to trap grit and stones in their bottom sump. After the sumps are full, additional grit entering the catch basin will wash down the sewer. Periodic sewer and catch basin cleaning can greatly reduce the volume of grit received at the plant during wet weather.

2. **Place All Units in Service.** Most of the grit removal methods mentioned above accomplish grit removal by controlling wastewater velocity. When too much flow enters a grit chamber, the velocity may be too high, causing grit to wash through the chamber. Placing additional units in service will allow the desired velocity to be maintained at a higher flow rate. Additional units will also place a lower grit loading on the grit collection devices which remove grit from the grit chamber. Velocity control and grit removal devices are discussed in greater detail in the following paragraphs.

3. **Control the Velocity.** The method of velocity control varies greatly between grit removal systems. In an aerated grit chamber, air from a coarse bubble diffuser creates a spiraling flow pattern with sufficient velocity to carry organics through the chamber while allowing grit to settle. As flow increases, horizontal velocity through the chamber increases, and it may be necessary to turn down the air volume to minimize grit wash-through. As flow continues to increase, air to the chamber can be turned off entirely. The proper level of air flow can be judged by observing the quantity of organics removed with the grit. If too many organics are removed, air flow can be increased.

In mechanically controlled vortex type grit chambers (such as a Pista-Grit unit), paddle speed and paddle blade angle can be adjusted to control velocity in the chamber. In both mechanical and non-mechanical vortex units, velocity adjustments can be made through placement of baffles in the chamber. This approach should be discussed with the individual equipment manufacturer before making any baffle adjustments.

Another type of grit removal common in older facilities is the velocity controlled grit channel. These are simply long rectangular channels with proportional weirs at the outlet end. These weirs are designed to maintain a velocity of approximately 1 ft/sec in the channel at all times. If the channel velocities are too high during wet weather, and if additional channel depth is available, it may be possible to redesign the proportional weir to produce lower velocity by increasing the depth of flow.

Detritus-type grit chambers are also used in many older facilities. These grit chambers are shallow square or circular chambers designed to settle grit along with some organic material. The mixture is then sent to a grit washing device to remove the collected organics. Many detritus type units have a set of guide vanes that distribute flow across the inlet end of the chamber. At high flows, flow distribution across the inlet may be uneven. The guide vanes may be adjusted during high flow periods to provide a more even flow distribution.

4. **Remove Grit Continuously.** Whether a plant uses aerated grit chambers, detritus tanks, vortex chambers or various other grit removal processes, grit must be removed from the grit chambers, in some cases washed, and deposited in a container for transport. Some of the methods used to remove grit from the grit chamber include:

- Chain and flight scrapers
- Chain and bucket scrapers
- Collector screws
- Recessed impeller grit handling pumps
- Air lift pumps

These removal devices may discharge to a cyclone degritter or a screw-type classifier which then discharges to the grit collection container.

Typical controls for grit removal devices operate the systems on a time clock. As an example, consider a velocity controlled grit channel with a grit screw at the bottom of the chamber which moves grit to a submerged hopper at the influent end of the chamber. A recessed impeller pump removes grit from the hopper through a pipe connecting the hopper to the pump. The pump discharges the collected grit through a cyclone degritter, which then discharges to a screw-type grit washer, which finally discharges to a grit container. This system could be set up to operate the grit chamber bottom screw, the grit pumps and the grit washing screw every four hours for a period of one-half hour. At normal flow this could be adequate to remove all grit received without allowing any excessive grit buildup in the channel. If, however, a sudden storm deposits a first flush of grit into channel during a period when the grit removal system is off, numerous problems could result. The grit collector screw could be buried under a pile of grit that is too heavy to allow the motor to start the screw, causing it to shut down due to motor overload. The grit hopper could be filled with grit of sufficient depth that the pump suction line is plugged and cannot remove any grit. This scenario could be avoided by placing the entire grit removal system in continuous operation when wet weather is expected. Though there may still be grit loadings high enough that collectors in operation can be overloaded, they have a much greater chance of maintaining operation through the entire wet weather event if they are in operation and the chamber is empty of grit when the first flush arrives. This recommendation applies for all of the grit removal systems described above.

At some plants, grit is not removed before the primary clarifiers. Grit settles out in the primary clarifiers and is removed with the primary sludge. Primary sludge is then pumped to a cyclone degritter where the grit is removed. Usually the degritted primary sludge then flows to a gravity thickener for thickening. With this type of grit removal, continuous operation is also recommended during wet weather. In addition, the primary sludge blanket in the clarifier should be monitored closely and kept low in anticipation of wet weather. Cyclone degritting of primary sludge is most effective when the sludge concentration in the cyclone feed is 1 percent solids or less. If the primary sludge blanket gets too thick, grit removal efficiency at the cyclone will decrease.

5. **Prepare Grit Containers.** During wet weather, the volume of grit collected can increase dramatically. Prepare for wet weather events by having grit containers empty. If existing containers overflow during wet weather, increase emptying frequency and consider purchasing larger or additional containers.

3.4 PRIMARY TREATMENT RECOMMENDATIONS

Primary clarification separates settleable solids from the influent wastewater. Performance of primary clarifiers is highly dependent on the flow rate through the clarifier. The primary clarification process can be adversely impacted by wet weather flows in the following ways:

- High solids loading in the first flush, causing high sludge blanket levels
- Scouring of solids from the sludge blanket, resulting in excessive solids in the primary effluent
- Reduction in overall removal efficiency of BOD and TSS
- Excess grit and screenings loadings to primary clarifiers due to overloaded preliminary treatment processes
- Flooded scum removal and storage boxes

Standard criteria adopted by many states set the standards shown in Table 3-1 for primary clarifier design:

TABLE 3-1

PRIMARY CLARIFIER DESIGN STANDARDS

Minimum side water depth	10 feet
Surface overflow rate at design average flow (not receiving waste activated sludge)	1,000 gpd/ft^2
Surface overflow rate at design peak hourly flow (not receiving waste activated sludge)	1,500 ? 3,000 gpd/ft^2
Surface overflow rate, design peak hourly flow (receiving waste activated sludge)	1,200 gpd/ft^2

When the above overflow rates are exceeded, removal efficiency will decrease significantly. If sludge blanket depths are high, removals may suffer at even lower overflow rates. Several recommendations for improving primary clarifier performance during wet weather are presented below.

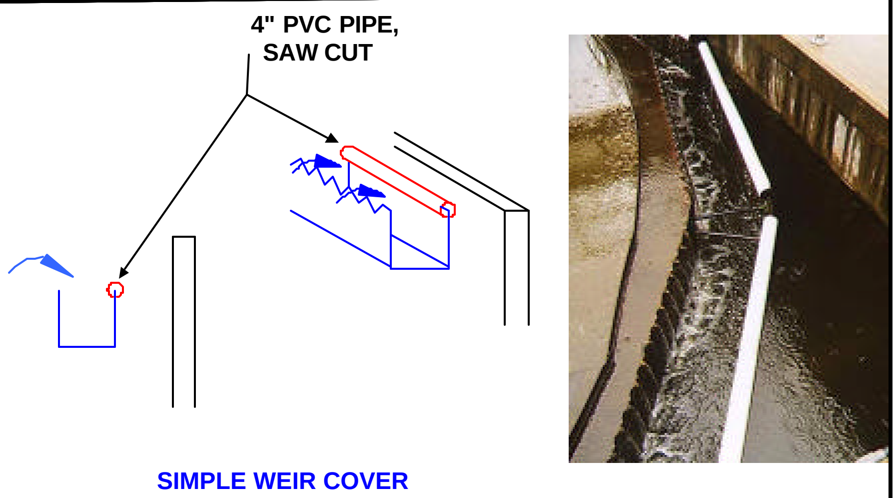
1. **Place All Primary Clarifiers in Service.** If all clarifiers are not needed under normal flow conditions, unused clarifiers can be placed in service during wet weather. The additional clarifier area will reduce the surface overflow rate, which will enhance removal efficiency. If operators are present at the time the first flush arrives at the plant, an empty tank can also be used to catch the excess solids received with the flush. The tank can then be placed in normal operation or isolated if the quantity of solids received would create a washout with continued flow. If the tanks is isolated and removed from service, solids should be removed from the tank as quickly as possible to allow it to be returned to service.

2. **Improve Flow Splitting to the Tank.** Unequal flow distribution to all primary clarifiers can result in some tanks performing well while others operate at reduced efficiency. See the flow splitting recommendations in Section 2 for suggested corrective action.

3. **Improve Tanks Hydraulics Through Baffle Addition.** Density currents can form and impact performance of primary clarifiers as well as secondary clarifiers. Though secondary clarifiers are generally the focus for dye testing and baffle additions, baffles can be added to primary clarifiers to improve performance. See the discussion in Sections 2.4 and 3.6 regarding dye testing and baffle installation.

4. **Improve Tanks Hydraulics Through Weir Modifications.** Recommended weir loading rates for primary clarifiers are in the range of 10,000 to 40,000 gallons/ft/day, with a typical weir loading rate of 20,000 gallons/ft/day. If weir loading rates exceed these recommended values, the velocity of currents approaching the weirs may be such that excessive solids are carried over the weir. Weirs can be lengthened by placing additional lateral weir troughs in rectangular primary clarifiers. Weir lengths are normally sufficient with one peripheral effluent weir in circular primary clarifiers. Problems have been observed with solids carryover on the outer weir of double-sided effluent weir troughs in circular primary clarifiers. This often occurs when the v-notch spacing on the outer weir is the same as the v-notch spacing on the inner weir. The approach velocity can be decreased on the outer weir by blocking off alternating v-notches with plywood or other material. Alternately, the outer weir can be blocked off entirely as shown in Figure 3-4.

Figure 3-4: Clarifier Weir Block



5. **Discontinue Secondary Sludge Feed to Primary Clarifiers.** The recommended design overflow rates given above indicate that the hydraulic capacity of a primary clarifier is greatly reduced if secondary sludge is fed to the primaries for resettling along with the primary sludge. During periods of high flow caused by wet weather, primary clarifier capacity can be enhanced if secondary sludge is not sent to the primaries. Depending upon the duration of the wet weather event, an alternate method of handling secondary sludge may be required. In fact if the solids inventory in the secondary treatment system is at its maximum, it may be preferable to discontinue sending secondary sludge to the primary clarifiers. If the high flows are of short duration and secondary sludge can be kept within the system by means discussed in Sections 3.5 and 3.6, then temporarily discontinuing secondary sludge wasting should be considered. If high flows continue for extended periods other methods of handling secondary sludge should be considered. If any other empty tanks are available, secondary sludge could be stored temporarily in the spare tank. In some cases, secondary sludge can be sent directly to sludge handling processes without co-settling in the primary clarifiers.

6. **Implement Chemically Enhanced Primary Treatment.** Several plants have shown successful results with chemically enhanced primary settling. Through addition of various chemical coagulants, TSS removals in primary clarifiers have been shown to improve from the normal range of 50 to 70 percent up to 80 to 90 percent removals. BOD removal efficiency has been shown to

improve from the normal range of 25 to 40 percent up to 50 to 80 percent. Possible coagulants include ferric chloride, ferric sulfate, alum, polyaluminum chloride, and cationic or anionic polymers. Several plants have had success with a combination of ferric chloride and anionic polymer. At the Point Loma WWTP plant in San Diego, BOD and TSS removals of 60 percent and 85 percent, respectively have been achieved at twice the normal design overflow rates, using a combination of ferric chloride an anionic polymer. Required doses should be determined through jar testing, and full scale trials should be conducted to verify performance. Addition of microsand and polymers to primary clarifiers has been shown to be effective in increasing hydraulic capacity while maintaining excellent solids removal performance.

3.5 BIOLOGICAL SECONDARY TREATMENT RECOMMENDATIONS

A. **Activated Sludge.** Successful treatment with the activated sludge process depends on maintaining a healthy population of organisms in suspension in the aeration tanks. Because it is a suspended growth process, the organisms are very susceptible to washing out of the aeration tanks when high flows occur. As flow to the aeration tanks increases, the rate at which solids are transferred to the secondary clarifiers also increases. Solids are settled out in the secondary clarifiers and returned to the aeration tanks by the return sludge pumps. As long as the hydraulic and solids handling capacities of the secondary clarifiers are not exceeded, the essential organisms can be returned to the aeration tanks and the process can continue to function. When clarifier capacities are exceeded, however, biological solids loss may be difficult to control and process performance may be jeopardized -- not only during the wet weather event, but also for the days or weeks that it may take to recover the lost biomass.

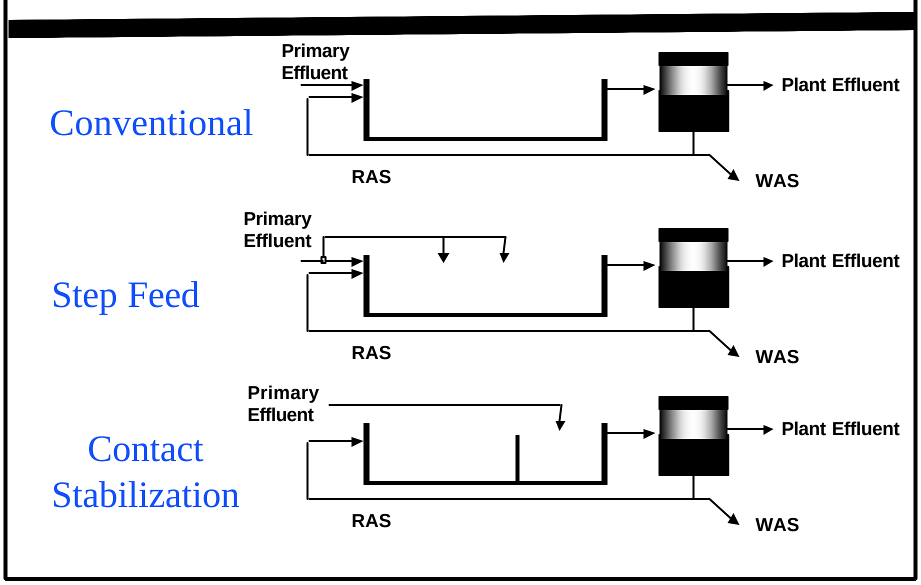
Potential impacts of wet weather events on the activated sludge process include:

- Loss of biomass from the aeration tanks and secondary clarifiers
- Overloading of the aeration system resulting from high BOD loadings caused by solids washout from the sewer system and solids washout from the primary clarifiers
- Electrical overload of mechanical surface aerators caused by high water levels
- Decreased BOD removal efficiency due to shortened hydraulic retention time in the aeration tanks

The following recommendations for the activated sludge process are focused on preventing loss of biological solid from the system during wet weather events.

1. **Modify Mode of Operation.** The activated sludge process can be operated in various modes. Three basic modes that will be discussed here are conventional, step feed and contact stabilization. These are illustrated in Figure 3-5. The conventional mode mixes the full flow of primary effluent with the return activated sludge flow at the head end of the aeration tanks. Step feed mode feeds primary effluent into the aeration tank at multiple points along the length of the tank. Contact stabilization mode mixes primary effluent with return sludge in the last one-half to one-third of the aeration tank volume. One of the most significant problems plaguing activated sludge operations during wet weather events is washout of biomass from the system. This will occur when the solids loading to the secondary clarifier exceeds the clarifier's solids handling capacity.

Figure 3-5: Activated Sludge Modes



We can compare three activated sludge systems: one operated in conventional mode, one in step feed mode, and one in contact stabilization mode. For our comparison each of the three systems has the same total aeration tank volume, the same primary effluent flow rate, and the same total mass of biological solids in the aeration tanks. In this example the conventional activated sludge system would have the highest MLSS concentration leaving the aeration tank, the step feed system would have the second highest concentration leaving the aeration tanks, and the contact stabilization system would have the lowest MLSS concentration leaving the aeration tanks. Since the flow rates are the same for all three systems, the solids loading rates to the secondary clarifiers are significantly lower for the step feed and contact stabilization systems than for the conventional system. This means that the step feed and contact stabilization modes have the potential to handle higher hydraulic loadings than the conventional mode, without suffering a significant solids loss. Although there may be a lower BOD removal efficiency in the step and contact modes than in conventional mode, during extreme wet weather at many plants we are most concerned about keeping solids in the system. The alternatives may be running in contact stabilization mode at lower BOD removal efficiency or losing all of our solids in conventional mode.

For plants that are designed with the flexibility to operate in these various modes, mode changes should be considered if solids loss during high flow periods is a problem.

2. **Adjust Return Sludge Pumping Rate.** The decision whether to turn the return sludge pumping rate up or down can be confusing at times. It is dependent on many factors including sludge settling characteristics, dynamics of the solids inventory which is constantly moving between the clarifiers and aeration tanks, and the rate at which solids are entering the clarifiers.

In general, the return sludge pumping rate should be increased under any of the following conditions:

- Low solids in the aeration tanks, high blanket in clarifier
- Increasing clarifier sludge blanket level, clarifier solids loading rate is below the clarifier's solids handling capacity
- Solids loss is occurring, and some aeration is shut down for solids storage

In general, the return sludge pumping rate may be decreased under any of the following conditions:

- Low clarifier blanket and additional solids storage is desired in clarifier
- Low or mid-level clarifier blanket with clarifier solids loading rate approaching its upper limit

3. **Maintain Low MLSS.** Many plants store solids in the activated sludge system, for a variety of reasons. Often this happens due to limitations of the solids handling systems at the plant. Plants that use sludge drying beds for dewatering, for example, may not be able to dewater sludge for a significant length of time during the winter months. This forces the operators to store as much solids in the aeration tanks and clarifiers as possible. This also results in a much higher MLSS concentration than is necessary for proper treatment. If a wet weather event occurs while solids inventory in the activated sludge system is high, a significant quantity of solids can be washed out of the system to the receiving water.

The activated sludge process should not be used for excess solids storage. This practice not only contributes to potential for solids washout, but also compounds the problem by creating an older, poorer settling sludge that is even more susceptible to washout. If solids handling or other processes are limiting the ability to waste secondary sludge from the system, alternate methods of handling secondary sludge should be investigated. Temporary hauling of thickened sludge to another facility would be a possible alternative.

4. **Control Filamentous Growth.** Filamentous growth in activated sludge systems can seriously degrade sludge settleability and increase potential for solids washout during wet weather flows. In order to correct a filamentous growth problem one should attempt to identify the filament and determine the conditions contributing to its growth. Possible conditions that promote filamentous growth include low DO, nutrient imbalance, and long MCRT. Controls include correction of the condition promoting filamentous growth, or if this is not feasible, chlorinating the return sludge flow. Several good references are available on identification and control of filamentous growth.

5. **Conserve Biomass.** In the event that other measures described above have been exhausted and significant loss of solids from the system is imminent, aeration system control can be utilized to keep solids in the aeration tanks and avoid losing them in the secondary effluent. If aeration can be independently controlled in zones of the aeration tanks, aerators near the effluent end of the tank can be turned off, allowing solids to begin accumulating in that portion of the aeration tank and decreasing the solids loading to the clarifiers. If the condition continues, aerators further upstream in the aeration tanks can be turned off to provide additional solids storage. While this is not a solution that can provide adequate treatment for extended periods of time, it can be the best alternative in some situations. The choice is clear between sacrificing some BOD removal for a period of a few hours or even a whole day, and losing BOD removal

efficiency for a few weeks due to severe solids washout. Many plants successfully utilize controlled aeration shutdown during extreme wet weather flows while maintaining acceptable BOD removals.

B. **Fixed Film.** Fixed film processes including trickling filters and rotating biological contactors have an inherent advantage over suspended growth processes when it comes to wet weather ? their biomass is not as easily washed out of the plant. Nonetheless, fixed film processes are impacted by the occurrence of high flows, and some steps can be taken to improve performance during wet weather. Some of the impacts of wet weather on fixed film processes include:

- Lower hydraulic detention time in the fixed film reactor can decrease BOD removal efficiency
- High hydraulic loading on trickling filters can rotate distributor arms too fast
- High hydraulic loading rates can cause sloughing of biomass in extreme cases
- Uneven flow distribution accentuated by high flows

The following are recommendations to improve fixed film performance during wet weather operations:

1. Reduce or stop trickling filter or RBC recirculation flows. Recirculation around trickling filters is generally practiced to provide adequate wetting of the media. In some RBC installations, recirculation of secondary sludge is practiced to encourage development of some suspended growth. Generally during periods of high wet weather flows recirculation is not necessary and can be discontinued until flows have returned to normal.

2. Adjust trickling filter distributor arm speed. During high wet weather flows, trickling filter arms that are hydraulically motivated may turn at excessive speeds. The distributor arms can be slowed by installing nozzles on the distributor arms that discharge in the opposite direction of the other nozzles. The nozzles can be provided with caps, which can be used to shut them off and return the arms to normal speed when normal flows return.

3. Place trickling filters in parallel operation. At many trickling filter installations, two trickling filters are operated in series. During wet weather flows, design hydraulic loading rates for the filters may be exceeded. If the piping and pumping configuration allows, the filters can be converted to parallel operation during high flows, thereby reducing the hydraulic loading rate by half.

3.6 SECONDARY CLARIFICATION RECOMMENDATIONS

Secondary clarifiers provide a critical treatment step that determines to a large extent the final effluent quality. As discussed in Section 3.5A, wet weather can cause solids to wash out of the secondary clarifiers, which can have a long-term negative effect on the activated sludge process. Sludge settling characteristics are a big factor in determining how much flow a secondary clarifier can accept. When poor sludge settling characteristics are observed due to filamentous growth or other problems, operational adjustments should be made to improve settling characteristics.

Standard criteria adopted by many states set the standards shown on Table 3-2 for secondary clarifier design:

TABLE 3-2

SECONDARY CLARIFIER DESIGN STANDARDS

Minimum side water depth	10 feet (fixed film) 12 feet (suspended growth)
Surface overflow rate at peak hourly flow (conventional activated sludge)	1,200 gpd/ft^2
Surface overflow rate at peak hourly flow (single-stage nitrification)	1,000 gpd/ft^2
Surface overflow rate at peak hourly flow (with chemical addition for P removal)	900 gpd/ft^2
Surface overflow rate at design peak hourly flow (fixed film)	1,200 gpd/ft^2
Solids loading rate, peak day (conventional activated sludge)	50 lb/d/ft^2
Solids loading rate, peak day (single-stage nitrification)	35 lb/d/ft^2

When the above overflow rates, or solids loading rates are exceeded, removal efficiency will decrease significantly. If sludge blanket depths are high, removals may suffer at even lower overflow rates. Several recommendations for improving secondary clarifier performance during wet weather are presented below.

1. **Place All Secondary Clarifiers in Service.** If all clarifiers are not needed under normal flow conditions, unused clarifiers can be placed in service during wet weather. The additional clarifier area will reduce the surface overflow rate and solids loading rate, which will enhance removal efficiency.

2. **Improve Flow Splitting to the Tank.** Unequal flow distribution to secondary clarifiers can result in some tanks performing well while others operate at reduced efficiency. See the flow splitting recommendations in Section 2 for suggestions on corrective action.

3. **Improve Tanks Hydraulics Through Baffle Addition.** Density currents can form and impact performance of secondary clarifiers. Through dye testing and baffle additions, density currents can be deflected to improve clarifier performance. See the discussion in Section 2.3 regarding dye testing and baffle installation.

In circular secondary clarifiers, peripheral density current baffles known as Crosby baffles have become standard equipment. These baffles are shown in Figure 2-3. These baffles have been sufficiently proven that dye testing is not normally required before baffle installation. Crosby baffles have been constructed of plywood, steel, fiberglass and other materials. Several manufacturers sell standard designs manufactured in fiberglass, but baffles may be constructed of sheets of virtually any rigid water-resistant material. Cylindrical mid-tank baffles have been installed in circular clarifiers, but they are more difficult to support than peripheral baffles and are not widely used.

In rectangular secondary clarifiers, many plants have installed mid-tank baffles to disrupt density currents. The location of currents in rectangular clarifiers is difficult to predict, therefore dye testing is recommended before placing baffles. A dye testing procedure is presented in Appendix C. Results of continuous feed dye tests as depicted in Figures 3-6 and 3-7 can be used to determine locations of currents and select baffle locations. Baffles for rectangular tanks have been fabricated of many different materials including pressure treated lumber, fiberglass, or even used belt filter press belts cut into strips. Successful baffle placements from previous installations and a wooden baffle design are shown in Figures 3-8 and 3-9.

Figure 3-6: Continuous Feed Dye Test Plot

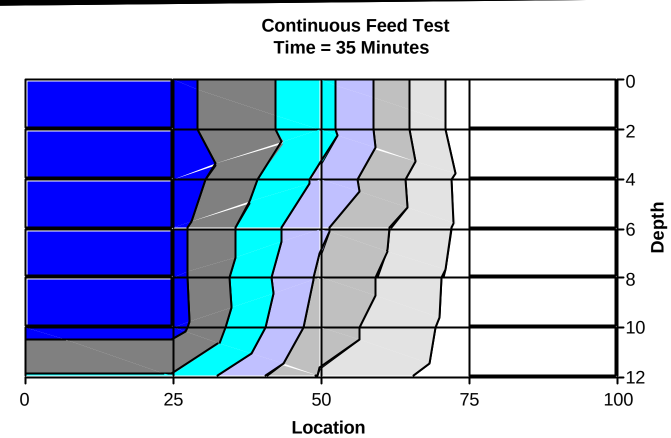
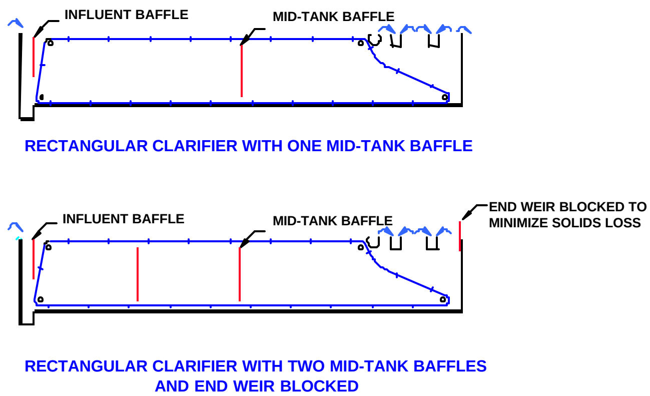


Figure 3-8: Density Current Baffles For Rectangular Clarifiers



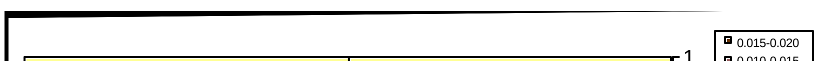
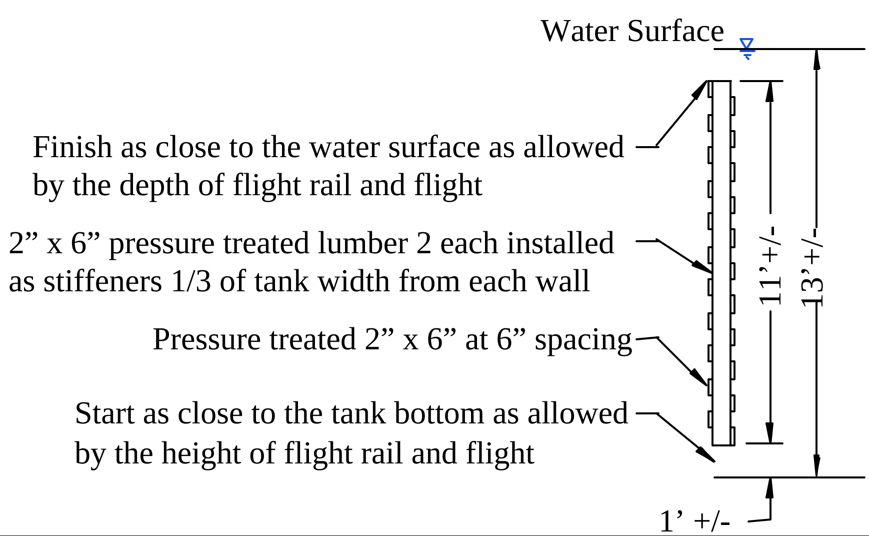


Figure 3-9: Typical Wooden Density Current Baffle Detail For Rectangular Clarifiers



4. **Improve Tanks Hydraulics Through Weir Modifications.** Recommended weir loading rates for secondary clarifiers are in the range of 20,000 to 30,000 gallons/ft/day in large clarifiers, and 10,000 to 20,000 gallons/ft/day in small clarifiers. If weir loading rates exceed these recommended values, the velocity of currents approaching the weirs may be such that excessive solids are carried over the weir. Placing additional lateral weir troughs in rectangular clarifiers can lengthen weirs. Weir lengths are normally sufficient with one peripheral effluent weir in circular clarifiers. Problems have been observed with solids carryover on the outer weir of double-sided effluent weir troughs in circular clarifiers. This often occurs when the v-notch spacing on the outer weir is the same as the v-notch spacing on the inner weir. The approach velocity can be decreased on the outer weir by blocking off alternating v-notches with plywood or other material. Alternately, the outer weir can be blocked off entirely as shown in Figure 3-4.

5. **Add Chemicals to Enhance Settling.** Some plants have improved secondary settling during wet weather through polymer addition. Chemical coagulants used for phosphorus removal including ferric chloride, ferric sulfate, or alum can also be added with polymers, but in some cases chemical doses required for phosphorus removal may cause poorer settling.

3.7 FILTRATION RECOMMENDATIONS

Sand filters are used at plants requiring low effluent suspended solids concentrations or low effluent phosphorus. Potential impacts of wet weather flows on sand tertiary filters include:

- Washing of excessive solids from secondary clarifiers resulting in premature blinding of filter media
- Hydraulic overloading of filters resulting in excessive headloss

Recommendations for maximizing filter performance during wet weather include:

- Place all filters in service
- Backwash before the high flows arrive to be sure that all filters are available at peak capacity
- Reduce backwash time during high flow periods
- Reduce secondary clarifier blankets before high flows to minimize excessive secondary solids carryover

Standard design practice is to provide a filtration rate of 5 gpm/ft^2 at peak hourly flow with one filter out of service. Many filters can be operated at higher flow rates, with maximum flow limited principally by headloss through the media. During wet weather, flow through the filters can be maximized up to the point where the limits of available head are reached.

3.8 DISINFECTION RECOMMENDATIONS

Chlorination is commonly used as a means of effluent disinfection. Ultraviolet disinfection is rapidly gaining in popularity. Both disinfection methods rely on required exposure times to adequately disinfect secondary effluent. During periods of extreme wet weather, there may be insufficient exposure time in the chlorine contact tank or the ultraviolet disinfection chamber to adequately disinfect the effluent. In addition, excessive solids in secondary effluent resulting from high flows can hinder either disinfection method. In spite of the potential for reduced effectiveness, it is preferable to send as much flow through the disinfection units as possible to achieve some degree of disinfection. Recommendations for maximizing chlorine disinfection efficiency during high flows include:

- Experiment with chlorine dosage at high flows. Adequate kills may be achievable at detention times of less than 15 minutes with the proper chlorine dose.

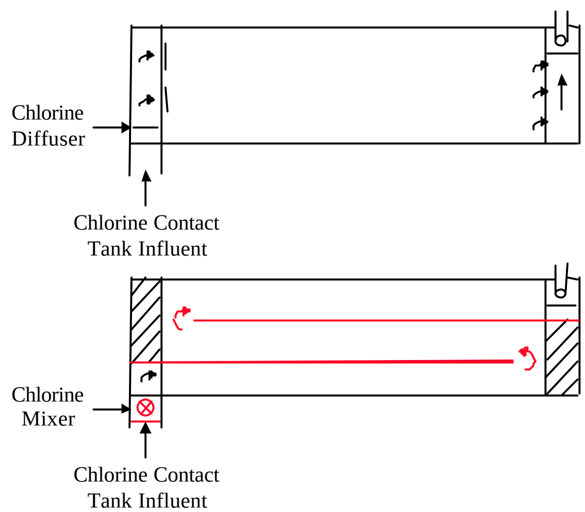
- Optimize chlorine mixing. Poor mixing or diffuser placement can greatly reduce chlorination effectiveness.

- Increase length-to-width ratio of chlorine contact tank. To avoid short-circuiting and effectively utilize chlorine contact tank volume, length-to-width ratios of 10:1 to as high as 40:1 are recommended. Chlorine contact tanks that fall short of this recommendation can sometimes be modified with the addition of longitudinal baffles as shown in Figure 3-10. This creates a near plug flow regime with less opportunity to short circuit.

Recommendations for maximizing ultraviolet disinfection efficiency during high flows include:

- Place all units in service. Make sure that all ballasts and lamps are operational.
- Clean lamp sleeves before wet weather arrives.

Figure 3-10: Chlorine Contact Tank Modifications to Improve Disinfection



3.9 SOLIDS HANDLING RECOMMENDATIONS

Although solids handling processes do not receive wet weather wastewater flows, they can be impacted by wet weather operations. Solids handling processes can also impact treatment efficiency during wet weather, and modifications to solids processing procedures may be necessary during wet weather. Solids handling impacts of wet weather include:

- Excess solids entering plant with first flush
- Poor treatment efficiency of solids handling recycle streams (such as digester supernatant or belt press filtrate) during wet weather flows
- Inability to achieve adequate drying on drying beds during wet weather

Solids handling recommendations to reduce wet weather impacts include:

- Reduce quantity of solids stored prior to wet weather. Inability to waste solids during wet weather due to insufficient solids storage capacity often results in solids loss from secondary clarifiers. If capacity can be made available in digesters, sludge holding tanks, gravity thickeners, sludge drying beds or other potential solids storage locations, sludge can be wasted from the main process areas as needed during wet weather. Available solids storage will also create potential for reducing solids recycles during wet weather. If digester levels are reduced, production of digester supernatant can be minimized during wet weather.

- Make arrangements for alternate methods of solids disposal. If wet or winter weather prevents solids removal from the facility, resulting in excessive solids in aeration tanks and clarifiers, alternative methods of solids disposal should be investigated. Paying for additional solids hauling costs for a period during the winter can avoid excess solids accumulation when the snow melt and high spring flows arrive at the plant.

SECTION 4 - CASE STUDIES

4.1 WASHINGTON COUNTY SEWER DISTRICT #2 WWTP

In March 1996, NYSDEC and Washington County began a joint project related to improving wet weather operations at the Washington County Sewer District #2 WWTP. The goal of the project was to investigate methods to increase the amount of wet weather flow that can be treated by the secondary process. The secondary treatment process is currently limited to 5.0 mgd during wet weather events.

The project tested three options to increase the wet weather flow capacity:

1. Running the activated sludge in the contact stabilization mode rather than conventional plug flow.

2. Evaluating the secondary clarifiers to determine if short circuiting was occurring within the clarifier. From the results, recommend future modifications to improve the secondary clarifier performance.

3. Evaluating the primary clarifiers to determine if short circuiting was occurring within the clarifier. Based on the testing, install and test a modification to improve the clarifier performance.

The project demonstrated the following:

1. The contact stabilization mode could treat a higher level of flow than the plug flow mode. In addition, it also minimized sludge blanket buildup in the secondary clarifier. The plug flow mode failed at a flow rate of 7.0 mgd and was close to losing the blanket at a 6.5 mgd flow rate. The contact stabilization mode treated a flow of 7.5 mgd, effluent quality was still within permit and the sludge blanket did not increase significantly.

2. The secondary clarifier did exhibit some short circuiting, thus reducing its clarification effectiveness. A baffle concept to address the short circuiting was developed for potential future use.

3. The primary clarifier also exhibited short circuiting. A seven foot high solid, mid-tank baffle, recommended by DEC was installed. The baffle, constructed at a cost of lest than $50, consisted of a used belt press belt supported by a wooden frame. Testing, after installation, showed the baffle did not improve the clarifier performance. The baffle was modified to an open configuration (6-inch openings were cut into the baffle every 6 inches). The open baffle improved hydraulic characteristics and reduced effluent suspended solids by 10 percent.

The Washington County Sewer District #2 WWTP is a 2.28 mgd design plant. The preliminary treatment includes a coarse bar rack, influent pumping using three screw pumps (normally only one pump is needed), mechanical bar screening followed by two aerated grit tanks. After preliminary treatment, the flow is measured using a Parshall flume. The next step is primary treatment using two rectangular clarifiers. Secondary treatment is accomplished using two, two pass conventional activated sludge tanks. The aeration tanks can be run in series or parallel. In the series arrangement, the plant can run one tank as sludge stabilization and the other tank as a contact tank. The capability also exists for stepping the return sludge. The aeration tanks are followed by clarification with two circular center feed, peripheral takeoff clarifiers. The effluent is discharged into the Hudson River. Solids handling at the plant includes one rotary drum thickener, two anaerobic digesters and two sludge belt presses.

The Washington County WWTP averages a dry weather flow of 2.1 mgd. During wet weather conditions, the flows can exceed 15 mgd. The grit chamber is throttled to treat 7.5 mgd with the remaining flow bypassed around the plant. The 7.5 mgd that passes through the grit chamber then receives primary treatment. After primary treatment the flow is throttled again, restricting the flow to the secondary treatment process to 5.0 mgd. The remaining flow is bypassed around the secondary process.

<u>TABLE 4-1</u>

MAJOR TREATMENT UNIT SUMMARY

	PRIMARY CLARIFIER	AERATION TANK	SECONDARY CLARIFIER
Number	2 tanks, 2 bays/tank	2 tanks, 2 passes/tank	2 tanks
Dimensions	Each bay is 12' x 72 x 8.5'	Each pass is 18' x 68' x 14.75'	55' diameter 12.15' swd
Dry Weather Unit Loading	WOR - 6,250 g/ft/d SOR - 578 g/sq ft/d	DT - 6.5 hours	WOR - 5,882 g/ft/d SOR - 421 g/sq ft/d
Wet Weather Unit Loading	WOR - 23,438 g/ft/d SOR - 2,170 g/sq ft/d	DT - 2.6 hours	WOR - 14,706 g/ft/d SOR - 1,053 g/sq ft/d

Wet weather problems at the Washington County WWTP include:

1. Surcharging of the collection system followed by CSO diversions.
2. Secondary treatment limited to 5.0 mgd.
3. No septage received during wet weather events (loss of revenue).
4. No sludge processing or dewatering during wet weather events.
5. Primary tanks limited to 7.5 mgd.

The project goal was to investigate methods to increase the amount of flow that can be sent to the secondary treatment process during wet weather events (the process is currently limited to 5.0 mgd). To try and meet the project goal, we evaluated the following methods:

1. Compare maximum secondary hydraulic flow at different sludge volume index (SVI) values.

2. Compare maximum secondary hydraulic flow using two different activated sludge modes - a conventional plug flow scheme and the contact stabilization mode.

3. Conduct dye testing of the secondary clarifiers to determine the hydraulic characteristics and identify any short circuiting currents within the clarifiers. Recommend modifications to improve clarifier performance.

4. Conduct dye testing of the primary clarifiers to determine the hydraulic characteristics and identify any short circuiting currents within the clarifiers. Recommend modifications to improve clarifier performance.

For the first two items, the approach was very simple. For item #1, the activated sludge process would be run at a constant mlss but different sludge volume index values. For item #2, the activated sludge process would be tested under two different operating conditions - running parallel, conventional plug flow and running series in a contact stabilization mode. To simulate wet weather flow conditions, we took one secondary clarifier off line to create the necessary high flow condition. The clarifier sludge blanket and effluent turbidity were sampled regularly to minimize any effluent quality problems. The goal was to push as much flow as possible through the clarifiers without experiencing permit violations (effluent TSS greater than 30 mg/l).

For the last two items, we used Rhodamine WT dye to evaluate the clarifiers. The two tests performed included the dye slug test and the dye tracer test. For the dye slug test, concentrated dye was added upstream of the clarifier distribution box. This introduction point provided for proper mixing prior to introduction into the final clarifier. Samples were taken and analyzed from the clarifier effluent at regular intervals. From this test we get two important pieces of information:

1. The time to peak (time to highest dye reading) - this indicates how quickly the major short circuiting current reaches the effluent weir.

2. The half area - This is the time when half the amount of dye has left the clarifier. This value is considered to be the best estimation of the actual operating detention time in the clarifier.

For the dye tracer test, a dye solution was pumped continuously during the test. The dye tracer test consists of collecting vertical core samples at locations along the length of the clarifier at designated times while the dye is being added. The core sample is discretely bled off at one or two foot intervals for analysis. The times to collect the samples and the locations are determined by the results of the dye slug test. The results are then plotted on a clarifier schematic to indicate the path of the short circuiting current. A narrow intense band of high dye readings indicate a severe short circuiting current within the clarifier.

Item #1, the Sludge Volume Index (SVI) was not performed. The problem was that the sludge volume index could not be easily changed. Over several months, the SVI stayed within a narrow range 180 - 220 ml/gram. We elected not to introduce chlorine to control the filament growth and abundance.

For item #2, we were able to run six different, controlled clarifier stress tests. In all six tests, the entire plant flow was directed to the #2 clarifier. The first three tests were done with the activated sludge process running in the conventional, plug flow mode. The final three tests were done with the activated sludge process in the contact stabilization mode. The data from the stress tests are summarized in Table 4-2.

TABLE 4-2

STRESS TEST SUMMARY

DATE	MLSS	SVI	FLOW TO CLAR. #2	RSF	SOLIDS LOAD	TURBIDITY RANGE	BLANKET START/END	COMMENT
Conventional, Plug Flow								
7/19	1890	196	2.90	0.43	11.1	2.1 - 3.6	5.5' - 7.0'	
7/24	1830	224	3.25	0.43	11.8	1.5 - 2.7	5.0' - 9.0'	Max BLT 10.5'
7/29	2333	227	3.48	0.40	15.9	1.1 - 69.2	5.0' - 11.5'	BLT Loss
Contact Stabilization								
9/20	2285	166	2.1	0.43	10.1	1.1 - 2.6	5.0' - 1.0'	
10/1	1364	140	3.2	0.47	8.8	1.6 - 19.0	3.0' - 4.0'	TSS <12 mg/l
10/10	1840	130	3.7	0.31	12.9	2.4 - 14.7	6.0' - 5.5'	TSS <5 mg/l

The stress test conditions differ in two ways:

1. **MLSS Concentrations.** The average MLSS concentration to the clarifiers is lower in the three contact stabilization tests. The reason for this is that the contact stabilization mode stores solids in the sludge stabilization tank during high flow conditions. This lowered the solids loading to the secondary clarifiers. The pounds of solids in the activated sludge system is the same because more solids are carried in the sludge stabilization tank.

2. SVI values are lower in the contact stabilization mode. At this facility, it appears the contact stabilization created an environment that discouraged the growth of the low organic loading filaments observed in the plug flow mode.

Under plug flow, all three tests showed a significant rise in the clarifier blanket. The clarifier failed, due to blanket loss, at a flow rate of 3.48 (simulated flow of 7 mgd). The clarifier blanket increased to within 1.5 feet of the effluent weirs at the 3.25 mgd flow rate (simulated flow of 6.5 mgd). However, in all three plug flow tests, the turbidity indicated a consistent degree of clarification until blanket loss occurred.

The stress tests indicate that more flow can be put through the system under the contact stabilization mode. Even at a flow rate of 3.7 mgd (simulated flow of 7.4 mgd), the blanket did not increase from its initial value. However, with the faster settling sludge and lower MLSS concentration, the effluent turbidity did increase significantly at the higher flow rates. Effluent grab samples showed the effluent TSS did not exceed 15 mg/l which is well below the 30 mg/l effluent limit.

The secondary clarifier dye tests show the effect of the short circuiting occurring within the clarifier. Analytical results show the peak dye reading occurred at 100 minutes. The half area calculation indicated an actual detention time of 125 minutes, which is 50% of the theoretical detention time at the testing flow rate of 2.5 mgd.

The secondary clarifier dye tracer results confirmed the presence of short circuiting within the clarifier. The dye traveled in a narrow 4- to 5-foot band near the bottom of the clarifier bottom. The 30-minute tracer showed the current rising up the end wall and being drawn to the effluent. Obviously a large part of the clarifier volume is not being used for settling.

The primary clarifier dye slug test also indicated short circuiting was occurring within the clarifier. To reduce the short circuiting within the primary clarifier, we installed a 7-foot solid mid-tank baffle in primary clarifier #2. The baffle consisted of a belt press belt attached to a wooden frame. The solid baffle was modified to an open baffle design by cutting out sections of the belt and retesting. The dye slug and effluent suspended solids results are summarized in Table 4-3 below.

TABLE 4-3

PRIMARY CLARIFIER PERFORMANCE SUMMARY

	BEFORE MODIFICATION		SOLID BAFFLE IN CLAR. #2		OPEN BAFFLE IN CLAR. #2	
PARAMETER	CLAR. #1	CLAR. #2	CLAR. #1	CLAR. #2	CLAR. #1	CLAR. #2
Time to peak	30 min	40 min	55 min	65 min	35 min	80 min
Operating DT	65 min	75 min	77 min	87 min	76 min	101 min
Theoretical DT	156 min	156 min	105 min	105 min	138 min	138 min
Effluent TSS	83.6	71.2	45.6	43.0	66.0	49.4
% TSS Imp.		+14.8%		+5.7%		+25%

The test results indicate that the solid baffle installed in primary clarifier #2 did not reduce short circuiting. The difference in effluent suspended solids in clarifier #2 actually decreased from 14.8% lower to 5.7% lower.

The open baffle significantly reduced the short circuiting. The time to peak increased from a ten minute difference to a 45-minute difference - this is a better settling condition. The effluent suspended solids showed a 25% improvement for the baffled clarifier (49.4 mg/l) compared to the unbaffled clarifier (66 mg/l). The overall improvement in suspended solids was 10% for a $50 baffle.

The Washington County Sewer District #2 WWTP has consistently and reliably met permit limits at flows over the design limit of 2.28 mgd.

The goal of the project was to investigate methods to increase the flow capacity of the secondary treatment process during wet weather events. Based on the testing and modifications done by plant personnel, the following recommendations are offered:

1. Running the activated sludge process in the contact stabilization mode will reduce the chance of blanket loss during wet weather flow conditions. In contact stabilization mode, solids are stored in the stabilization tank, reducing the solids level in the contact tank and lowering the solids loading to the final clarifiers. In this mode, the plant demonstrated that it could treat a flow rate up to 7.5 mgd and still stay within permit limits. Running in the contact stabilization mode appears to increase effluent suspended solids, but effluent quality is still well below permit limits. Running contact stabilization at the Washington County SD#2 WWTP does present a problem:

Using the contact stabilization mode requires the plant to run both aeration tanks in series. This study has demonstrated that the treatment plant can run just one aeration tank and still meet permit limits (cold weather performance must still be evaluated). The facility has been running just one aeration tank since June 1997. By running one aeration tank, the operators do not have the option of running in the contact stabilization mode. However, the plant operators now have the option of using the off-line tank to store storm flows.

2. The study identified a short circuiting current within the secondary clarifier. In addition, a strong end wall effect was observed in the dye tracer results. It was not within the scope of the project to install baffles within the secondary clarifier. The facility may, in the future, explore baffling the clarifier to increase the operating detention time. To direct the current and solids away from the effluent weirs, the plant staff felt the following baffle configuration would provide the most benefit:

Installing a Crosby perimeter baffle, 2 feet below the effluent weir. This baffle is an angled piece of plywood, fiberglass or other material, attached to the clarifier end wall. The angle should be at least 60 degrees to allow solids to slide back off the baffle.

3. The solid baffle installed in primary clarifier #2 did not improve the clarifier hydraulic performance or the effluent suspended solids. The solid baffle was modified in November 1997 to an open design (6-inch baffle segments with a 6-inch spacing). Testing shows that the open baffle design performed much better. The short circuiting was reduced significantly - the time to peak was 80 minutes compared to 35 minutes in the unbaffled clarifier. More importantly, the effluent suspended solids improved by 10% compared to the baseline condition.

4.2 KINGSTON, NY WASTEWATER TREATMENT PLANT

The City of Kingston WWTP is a 6.8 mgd design secondary treatment plant. The original primary treatment facility was built in the 1930s and has been upgraded periodically. The last upgrade two years ago expanded the secondary treatment capacity with the addition of a third aeration tank, full floor coverage ceramic diffusers in all aeration tanks, and a fourth final clarifier. At that time, there were also pump motor and motor control upgrades and other miscellaneous items. The facility is manned from 6:00 a.m. to 5:00 p.m., Monday through Friday, by a staff of 10. Weekend coverage is skeletal. An evening “walk through” is conducted.

The combined sewer system includes 11 sewer overflows, limiting the flow to the plant to roughly 11 mgd. The average monthly flow has averaged 5 mgd for the period of June 1996 to August 1997. The range of monthly average flow is a low of 3.9 mgd in July 1996 to a high of 6.379 in July 1996. Instantaneous maximum flows at the plant are around 11.6 mgd.

Influent sewage is screened, degritted, and screened again prior to primary treatment in rectangular primary clarifiers. Primary effluent flows to the settled sewage wet well. From the wet well, it is pumped up and gravity flows through secondary treatment. The settled sewage pumping capacity is 11.4 mgd. Secondary treatment is accomplished by the activated sludge process running in plug flow mode followed by rectangular final clarifiers. Secondary effluent is disinfected with ultraviolet. Primary sludge is continuously pumped to a gravity thickener and waste activated sludge is pumped to a dissolved air floatation thickener. Thickened sludges are fed to the first stage anaerobic digester. Digested sludge from the second stage is dewatered on a belt filter press and the cake is landfilled.

Wet weather poses several problems at the plant. During high flow, grit removal efficiencies decrease leading to higher inorganic content in the primary sludge. Lower VSS and reduced TSS in the sludge effect the gravity thickener and anaerobic digester operations. To a lesser degree, pump plugging leads to more maintenance. Primary tank influent gates are raised or removed to prevent primary channel flow back up and spill over. This leads to solids and grit carry over into the secondary system.

Flows can rise very quickly, leaving little time for changes at the plant. On one occasion, the flow increased from 2.5 to 11 mgd in 20 minutes.

Solids carryover from the secondary clarifiers is not as big a problem as it is at many plants. This is due in part to maintaining sludge quality to avoid bulky sludges, no sludge blanket is carried, and final tanks have had mid tank baffles installed. The newest final clarifier has no mid tank baffle, but an end wall Crosby baffle was installed during the study. Solids loss leads to increased maintenance of the UV bulbs.

The scope of the project included clarifier modifications, weir configurations, and process control adjustments. Dye studies showed that clarifiers with mid tank baffles perform better than unbaffled clarifiers. Addition of an end wall Crosby baffle on the clarifier without mid tank baffles did not improve clarifier performance. The plant operators plan to baffle this tank in the future. An inexpensive and easy weir modification is to close off one or both sides of an effluent launder. This can be especially useful when dealing with solids loss over one side of a launder and not the other (an end wall weir for example). This was accomplished at Kingston by clamping strips of plywood to the launder to close off the v-notch weir.

Chlorination of the RAS to control filamentous growth and use of an anoxic zone in the aeration tank are key components of the process control strategy at the plant. The plant is required to nitrify to meet a UOD limit. Denitrification in the final clarifier is a problem at many activated sludge plants. Solids are lifted from the sludge blanket into suspension by nitrogen gas bubbles and can be carried over the weir into the effluent. This rising sludge condition is commonly referred to as "ashing" or "clumping." Increasing return sludge flow (RSF) to minimize denitrification in the final clarifier was not effective, and as the RSF increased, so did the solids and hydraulic loading to the unit. The aeration tank has a 15-foot tall baffle wall across it, 31 feet from the effluent weir. The wall has two openings near the bottom to pass flow, as well as the flow over the wall. The tank has full floor coverage ceramic diffusers. The area between the baffle wall and the effluent weir was made into an anoxic zone by turning down the air. Once a week, the air is turned on full to resuspend solids that may have settled. "Clumping" is evident in this zone in all three aeration tanks. The anoxic zone in the aeration tank provides for denitrification there, rather than in the final clarifiers. The operator sees less solids loss when denitrification is limited in the final clarifiers. To this point, after two summers of anoxic zone operation, no problems with the aeration system plugging have occurred.

Physical layout of the aeration tanks allows for operation in plug or step feed modes. Each aeration tank could be run in a contact stabilization or reaeration mode for the purpose of protecting solids from hydraulic surges. In addition, piping allows all RAS to be returned to one aeration tank. This would allow for a contact stabilization mode to be run with one tank receiving only RAS and the other two only primary effluent. This type of mode operation was tried once and was effective for that storm and situation. Since the plant is not manned around the clock, mode changes are limited to storms that occur during working hours. During the summer when flows are low and the ground is dry, the characteristic of the wet weather event like a thunderstorm is a fast peak with a short duration, as short as several hours. Fall and spring characteristics are a fast peak with a duration of several to four days. The operator feels the mode change is effective for the summer, but not for the fall and spring events.

A dye study on the primary clarifiers showed that flows are well distributed, and actual detention times are very close to the theoretical detention time for that flow.

The final clarifiers with mid-tank baffling perform better than the clarifier without mid tank baffles. Addition of an end wall Crosby baffle did not improve clarifier operation.

4.3 VILLAGE OF GRANVILLE, NY WASTEWATER TREATMENT PLANT

The Village of Granville is located in Washington County, NY. The Village of Granville WWTP is a fixed film facility consisting of a bar screen, effluent flow measurement, grit chamber, three Imhoff tanks, one covered high rate trickling filter with stone media, two secondary settling tanks, one chlorine contact tank, and four sludge drying beds. The design and flow to the facility is 650,000 gallons per day.

The unit process at the Village of Granville Wastewater Treatment Plant are described in the table below. The facility was originally constructed in 1937 and consisted of Imhoff tanks and sludge drying beds. In 1972 the facility was upgraded to provide secondary treatment with the addition of the grit chamber, trickling filter, secondary settling tanks, chlorine contact chamber, enclosed sludge drying beds, and associated piping and pumps.

The collection system was originally constructed in 1937 with additions and minor rehabilitation done in 1969. The surrounding terrain is dominated by slate beds and there are many slate quarries in the area. The slate and rock makes digging very difficult, resulting in many homeowners piping sump pumps directly into the collection system.

The Village of Granville WWTP consists of the following units shown in Table 4-4.

Due to a very old and deteriorating collection system, along with a combined collection system the wastewater treatment facility flows during snow melt and rain events, rise from a dry weather flow of 300,000 gpd to over 3,000,000 gpd. This flow increase can be very quick and continued through a week in duration. The operator has very little opportunity to respond and few tools to respond with. There are no CSOs; consequently, the treatment plant receives all the flow that is collected. At times, the high flow causes overflowing treatment units and plant flooding. The biggest impacts are seen in the trickling filter arm speed and extreme sloughing of biomass, along with degraded effluent quality for some time after the wet weather event.

TABLE 4-4

GRANVILLE PROCESS SUMMARY

UNIT	QUANTITY	SIZE
Worthington comminutor	1	5 HP
Bypass chamber and bar screen	1	Manually cleaned bar screen
Parshall flume and flow reading transmitter	1	6 inch throat, 1.5 mgd
Grit chamber	1	6 ft x 8 ft x 2 ft deep
Imhoff tanks	3	14 ft x 44.5 ft x 19.0 side water depth
Trickling filter recirculation pumps	2	15 HP (variable speed)
Trickling filter, high rate, stone media	1	60.0 ft diameter x 6.0 ft deep
Secondary settling tanks	2	12.0 ft x 35.0 ft x 8.5 ft deep
Chlorine contact tank	1	17.0 ft x 18.0 ft x 6.0 ft deep
Imhoff tank sludge pump	1	5 HP
Secondary settling tank sludge pump	2	5 HP
Sludge drying beds (enclosed)	4	36.0 ft x 40.0 ft
Sludge drying beds underdrain sump pump	1	2 HP

The scope of the *"Wet Weather Operating Project"* (WWOP) at the Village of Granville WWTP was to identify operational problems during wet weather flow and optimize plant operations during these events. There were four items that the operators wanted to address during the WWOP project.

The first item addressed was to improve trickling filter performance during high flow conditions. High flows to the trickling filter caused the arm speed to increase from two revolutions per minute to over seven revolutions per minute. The high arm speed and excessive flow rate resulted in extreme sloughing of the biomass. The operator was also very concerned with premature failure of the center bearing of the trickling filter arms due to the high arm speed. To address this problem two retro nozzles were installed on each trickling filter arm. The retro-nozzles were successful in lowering the arm speed to less than three revolutions per minute during peak flows (over 2.0 mgd). This helped in reducing excess sloughing and the lost biomass during high flow conditions.

The second item that was identified was maximizing the Imhoff tank operation. All flow, regardless how high, has to pass through the Imhoff tanks. This decreased the efficiency and caused poor Imhoff tank effluent quality during times of high flows. The operator had always drawn sludge off the Imhoff tanks about two to three times per year. The timing of sludge drawoff was determined to be important in Imhoff tank effluent quality. The operator now tries to withdraw sludge as late in the season as possible (into

December) to keep sludge levels in the Imhoff tanks at a minimum during snow thaw and spring rain events. This has led to better Imhoff tank effluent quality during high spring flows.

Another item that the operator was very interested in, was improving suspended solids removals in the secondary clarifiers, not only during wet weather flow conditions, but also during dry weather flow conditions. A great deal time was spent dye testing and evaluating the secondary clarifiers. Base line data was collected and secondary clarifier baffles were designed and installed. The first baffle was solid at the top with staggered 2 x 8's used at the bottom. The baffle was installed at the one-third point in the tank. The clarifiers were then re-dye tested. The result was very little improvement (6 percent in effluent TSS).

A second baffle was designed, built and installed at the two-thirds point of clarifier #1. The second baffle was solid from top to bottom, leaving about 14 inches for the bottom flights and stopping just below the top flights. The clarifier was then re-dye tested and effluent TSS were re-analyzed. The result was a 19 percent decrease in secondary clarifier effluent suspended solids. These results were observed at various flow rates, between 300,000 to 1,318,000 gallons per day (design = 650,000 gpd).

The operator could not measure flow during high flow periods due to the flow recorder and totalizer reading only to 1.5 mgd. However, the 6-inch Parshall flume, was useable at much higher flows. By sticking the flume with a ruler, the operator could measurer the head and calculate flows well above 3.0 mgd. This helped in determining when to start diverting flow around the trickling filter.

The operator has been extremely pleased with the secondary clarifier baffles in decreasing effluent TSS concentrations. The baffles have improved effluent suspended solids during wet weather as well as dry weather flow. The installation of the retro-nozzles on the trickling filter arms helped to minimize biomass sloughing and trickling filter arm speed. The instantaneous flow measurement gives the operator an excellent tool in controlling flow to, and around, the trickling filter during high flow conditions. When the flow reaches 2.0 mgd the bypass valve is opened which diverts about half the flow directly to the secondary clarifiers. The remaining half goes to the trickling filter. Due to the dilution of the wastewater during these times, the plant still is able to meet effluent limits. The improved Imhoff tank sludge pumping schedule has resulted in not having as much sludge in the tanks at the least opportune time of snow melt and spring rains.