Green City, Clean Waters

Facility Concept Plan For the Southeast Water Pollution Control Plant

Consent Order & Agreement

Deliverable IV - b

City of Philadelphia Combined Sewer Overflow Long Term Control Plan Update

Submitted to

The Commonwealth of Pennsylvania

Department of Environmental Protection

By The Philadelphia Water Department

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1. Introduction

In August 2008, the Philadelphia Water Department (Water Department) entered into a Consent Order and Agreement (COA) with the Pennsylvania Department of Environmental Protection (PADEP) which specifies the process for development of an update to the Water Department's Long Term Control Plan commitments as originally included in National Pollutant Discharge Elimination System (NPDES)permit of 2007. On September 1, 2009, a Long Term Control Plan Update (LTCPU) was submitted to PADEP and on June 1, 2011, the Water Department entered into a COA with the PADEP which enforces the implementation of the LTCPU and its supplements. Pursuant to Paragraph 3.a.iv, pertaining to Compliance Requirement Deliverables, a Facility Concept Plan for each of the three Water Pollution Control Plants (WPCPs) must be submitted within 24 months of the agreement date. Appendix G of the COA requires the Facility Concept Plans to describe the specific engineering and construction activities proposed to increase the maximum wet weather flow into each water pollution control plant facility and thereby increase the capture rate of combined sewage. The Facility Concept Plans will provide design and construction performance standards for the five-year, ten-year and fifteen year milestone periods with the completion deadline at the end of a twenty year period.

The Water Departments 's implementation approach to the 2009 LTCPU has been developed to integrate the management of Philadelphia's watersheds into a larger context such that the program is designed to provide multiple benefits beyond the reduction of combined sewer overflows (CSOs), so that every dollar spent provides a maximum return in benefits to the public and the environment. In a similar approach, the Facility Concept Plans look beyond infrastructure improvements and consider modifications to facility operations as well as collection system optimization to address wet weather flow delivery to the treatment plants.

2. Goals of Facility Concept Plans

The stated goal and commitment of the *Green City, Clean Waters* program for CSOs is to reduce water quality impact due to CSOs on the receiving waters through: green stormwater infrastructure, stream corridor restoration and preservation, and wet weather treatment plant upgrades. The Facility Concept Plans provide details of the City's treatment plant upgrade strategy to achieve CSO reduction ofapproximately 1.75 billion gallons annually through:

- Wastewater plant capacity increases,
- Collector system modifications to increase wet weather capture and transmission of wet weather flows,
- Potential operational changes of the existing wastewater plants to ensure sustained treatment capacity,
- Continued study and investigation of strategies and technologies for implementation at the treatment plants to achieve CSO reductions.

All treatment plant and collector system modifications discussed in this Facility Concept Plan will be completed within the 20 year timeframe as stated in the LTCPU. The Facility Concept Plans represent the current best plans and approach for work to be performed by the Water Department necessary to meet CSO reductions. In addition, the Water Department is committed to continuing research and studying new technologies and improvements to the collection system and treatment plants to increase CSO capture and wet weather treatment. Additional projects may be constructed if studiesconclusivelyshow operational advantages.

This Facility Concept Plan is the basis for the development of a comprehensive Wet Weather Facility Plan, which will provide details includingschedule, cost and anticipated performance for each project presented in this plan. The Wet Weather Facility Plan will be a dynamicdocument, revisited regularly to evaluate if regulations, technologies, community needs or other criteria require a change to the plan. This ensures the Water Departmentis responsive to the commitment to increase CSO capture in the drainage district and at the treatment plant in the years ahead.

3. SE WPCP Permit Modifications

As per Appendix G of the 2011 COA, the performance standards of the Facility Concept Plan will become permit requirements by being incorporated into future versions of the NPDES permit for each treatment plant.Under the 2009 LTCPU, as described on page 10-52, the Water Department committed to a 50 million gallon/day increase in peak instantaneous flow through process and hydraulic improvements at the Southeast WPCP (SE WPCP). A replacement of the bar rack systemwill allow for the treatment of additional wet weather flow, which will be reflected in future modifications to the NPDES permit as presented in Table 1.

Table 1: Current and Future SE WPCP PermittedCapacity

	2007-2012 NPDES Permit	Future (2031)
Facility Design Flow Rate (Q)	112 MGD	112 MGD
NPDES Maximum Daily Flow	168 MGD	168 MGD
NPDES Peak InstantaneousFlow	224 MGD	274 MGD

To treat the maximum flow rates delivered to the plant, several plant upgrades have been proposed and the planning process has been initiated.

4. Implementation Approach for the SE WPCP Drainage District

The Water Department is taking a comprehensive approach to achieving increased peak wet weather capacity and reduced CSO volume. The Water Department has prioritized work performed on the Northeast WPCP drainage district since the improvements to this single district will allow the City to meet the majority of the city-wide wet weather targets that are derived from traditional infrastructure improvements (i.e. not derived from Green Stormwater Infrastructure). In addition, the City has the capacity to treat NPDES peak instantaneous flow of 274 MGD at the SE WPCP through the treatment of an additional 50 MGD, and will meet an operational commitment to treat a peak wet weather flow of 280 MGD.

In the LTCPU, seven improvements for plant modifications were considered for the SE WPCP to increase CSO capture through increased wet weather flow of 280 MGD at the facility. These projects were presented in Table 8-3 of the LTCPU. Table 2 presents the LTCPU improvement options along with their status resulting from planning studies and analysis performed to date.

Table 2: Current status of LTCPU Improvement projects for the Southeast WPCP

2009 LTCPU Improvement	2009 LTCPU Improvement Description	2013 Project Status
1	Provide facilities for phosphorus addition to wastewater	Completed
2,3	Resolve capacity limitation associated with having one coarse bar rack out of service and hydraulic bottleneck at existing influent pump station	**Under construction**
4	Replace existing primary clarifier effluent launders with new launders running parallel to flow to increase hydraulic capacity	**Not required** to achieve 280MGD
5	Provide two gravity thickeners to perform offline sludge thickening and improve performance of the primary clarifiers	**Not required** to achieve 280MGD
6	Provide an additional 71-MGD effluent pump at the effluent pumping station	**Not required** to achieve 280MGD
8	Resolve hydraulic limitation between primary clarifiers and the aeration basin	**Under Study,Not required** to achieve 280MGD

The original concept presented in the 2009 LTCPU was to achieve the annual average of 145 MG of CSO reduction by increasing the peak flow rate at the SE WPCP to 330 MGD. This was to be

achieved through improvements to the headworks and increased treatment capacity at an estimated cost in excess of $100 million. Since that time, study and investigations into collection system improvements have determined that modifications to the collection system can achieve the targetedaverage annual overflow reduction volume of 145 million gallons in a cost effective approach, while maintaining a peak wet weather flow of 280 MGD at the SE WPCP. The in-depth study for this work is discussed in more detail within Section 4.4.

The implementation approach for the Southeast WPCP is the replacement of the bar racks (LTCPU Improvement 2,3). LTCPU Improvements 4 through 8 are not required to achieve 280 MGD of peak wet weather flow, but were meant to obtain a treatment capacity of 330 MGD. In addition, the Water Department decided to initiate a study to address potential issues concerning Improvement 8.

4.1 SE WPCP Facility Improvements

4.1.1 Completed SE WPCP Facility Improvements

To increase operational reliability for meeting the increased wet weather capacity at all times, the following capital project has been completed:

Provide facilities for phosphorus addition to wastewater

The Water Department has installed and currently operates a phosphoric acid feed system.

4.1.2 Future SE WPCP Facility Improvements

To ensure unit operation redundancy for meeting the increased wet weather capacity at all times, the following future capital project has been identified:

Replace Influent Pump Station Coarse Bar Rack System

The influent pumping station coarse bar racks have been identified as a limitation to increased flow capacity. A detailed design for a replacement bar rack system (2009 LTCPU Improvement 2), rated above 274 MGD, was completed; a construction contract was awarded and Notice to Proceed given in November 2012. This project is presently under construction.

In addition to the improvements to the Coarse Bar Rack System, studies to identify facility improvements at the SE WPCP are discussed in Section 4.4.2.

4.2 Collection System Improvementsin the SE WPCP Drainage District

Studies to identify collection system improvementsin the SE Drainage District are underway and discussed in Section 4.4.1.

4.3 Operational Improvementsat the SE WPCP

At this time, no operational improvements at the SE WPCP are planned.

4.4 Continuing Studies for the SE WPCP Drainage District

Implementation of the selected alternatives in the LTCPU for the SE WPCP Drainage District was intended to include a reduction in average annual CSO volume of approximately 145 million gallons through capital improvements. The original concept was to achieve this overflow reduction by increasing the peak flow rate through the plant by 50 million gallons per day, to a peak treatment capacity of 330 MGD. Initial investigations performed by the Water Department indicated that the peak treatment capacity might be achieved through plant headworks improvements, including an increase in pumping capacity (2001 Stress Test). However, subsequent engineering analyses indicate that to achieve these increases in pumping rates would require lowering the elevation of the influent pumping station, necessitating the construction of an entirely new pumping and screening facility at an estimated cost well in excess of $100 million.

During the continuing analyses conducted for the implementation of the *Green City, Clean Waters* plan, and the concurrent investigations performed in preparation of the Facility Concept Plan for the SE WPCP, new insights evolved into the nature of and the opportunities for controlling sewer overflows in the Southeast drainage district. Results of those efforts suggest a more efficient and cost effective approach to achieving the proposed overflow reduction of 145 million gallons, without the need to alter the pumping station at the plant influent.

4.4.1 Collection System Studies for the SE Drainage District

Balancing CSO Regulator Wet Weather Treatment Capacities

The *Green City, Clean Waters* plan for CSO control relies upon land based stormwater management practices. Those practices are intended to control stormwater runoff near the source through infiltration, evapotranspiration, decentralized storage, and slow release to the combined sewer system, for conveyance to treatment facilities. For the slow release of stormwater detained in green stormwater infrastructure to be effective in reducing overflow volume and duration, there must be sufficient treatment capacity at the regulator to admit the cumulative slowly released stormwater flows that have been achieved by all management practices in the entire sewershed. This requires that regulator treatment capacities in wet weather should be balanced sufficiently, on a unit drainage area basis, among all the regulators located within each of the three WPCP drainage areas, to allow for the balanced treatment of slow releases from all management practices in all of the sewersheds contributing to the interceptor systems.

In the course of developing the City's approach to using green stormwater infrastructure to control sewer overflows, hydrologic and hydraulic modeling-based analyses revealed that the wastewater treatment plants provide a unit area treatment rate for combined sewage flows in wet weather equal to 0.05 cubic feet per acre of impervious cover that directly drains to the collection system. Further, the *Green City, Clean Waters* plan firmly established the seminal concept that the efficient implementation of green stormwater infrastructure as an overflow control does not lend itself to special targeting of different levels of implementation in different sewersheds. The only realistic and practical approach to implementing green stormwater

infrastructure within the combined-sewered areas of the City is to treat all areas equally in seeking opportunities for that implementation. As a result, the Water Department's combined sewer system-wide design standard for all green stormwater management facilities located in the public right of way, that incorporate storage and slow-release, is set at 0.05 cubic feet per second (or less) per acre of tributary impervious area draining directly to the control facility. Therefore, the balancing of the wet weather treatment rates provided by the treatment plants equally across the collection system for all regulating chambers, to the extent technically and economically feasible, is a fundamental design assumption underlying the successful implementation of the City's green CSO control plan.

Several issues and potential advantages were identified in the course of performing the analyses in the Southeast Drainage District to bring a system-wide balance to the capacity of the combined sewer regulators, and to match that net capacity to the transmission capacities of the interceptors and the peak treatment rate of the plants. It became evident while conducting the hydrologic and hydraulic modeling work that without lowering the wet well bottom elevation of the influent pumps, increasing the peak pumping capacity from 280MGD to 330 MGD was effective only for a limited number of hours when interceptor flows above 280MGD can be delivered to the SE WPCP during a typical year. That is, without lowering the wet well, the number of hours in a year that a hydraulic gradient develops sufficient head to carry flows to the plant in excess of 280MGD is limited.

The modeling efforts further revealed that modifications to collection system hydraulic control elements along the Lower Delaware Low Level and the Oregon Avenue interceptors can lead to an increase in the average annual duration that peak wet weather flows are delivered to the SE WPCP. These analyses suggest that an average annual CSO reduction of 145 million gallons is possible through collection system modifications. These modifications involve the alteration of regulating structures and some trunk sewer hydraulic control elements, designed to increase wet weather flow delivery to the interceptors and ultimately to the plant. However, as discussed above, collection system performance improvement projects need to achieve the desired results in a balanced manner. Greatly increasing the capture of wet weather flows at only a few regulators comes at the expense of reducing the treatment capacity at other regulators below a minimum level needed to maintain the effectiveness of green stormwater management controls.

The Water Department's hydrologic and hydraulic modeling team performed analyses for a broad range of interceptor and trunk sewer improvement alternatives designed to increase wet weather flow delivery to the SE WPCP in a balanced manner. Modifications considered include:

- Regulator orifice enlargement
- Regulator connector pipe enlargement / replacement
- Raising existing regulator overflow weir elevations
- Regulator overflow weir elevations raised through chamber reconstruction and/or weir expansion

These regulator modifications fall into two primary categories: increasing regulator orifice and connector pipe capacities, and increasing overflow weir elevations.

Improvements to regulator orifice sizes can range from simple modification to existing structures, to complete reconstruction of regulating chambers. Enlargement of dry weather outlet pipes (i.e., pipes connecting the trunk sewers to the interceptor sewers) generally requires replacement of existing conduits with pipes of increased diameter. In some cases construction of an additional parallel pipe from the regulating chamber to the interceptor may be preferable.

Improvements to increase regulator overflow weir elevations can involve the simple addition of stop logs or "bricks and mortar" techniques to raise the dams and achieve increases in treatment capacity through increasing the hydraulic gradient between the regulating chamber and the interceptor. These types of modifications must be accomplished without reduction in storm flood relief capacity. If an increase in a weir elevation is not feasible without compromising the stormwater outlet capacity, some degree of reconstruction of the regulating chamber may be needed to achieve significant increases in overflow weir elevation while providing necessary flood protection through increasing the length of the weir.

For the Southeast Drainage District Collection System Improvement Concepts, numerous combinations of regulator chamber modifications were evaluated to seek optimum combinations that can achieve a minimum average annual overflow reduction volume of 145 million gallons in a balanced manner. Examples include rebuilding regulating chambers with increased overflow weir elevations and increased weir lengths to meet flood protection requirements; increasing orifice sizes increasing connector pipe sizes; adding stop logs or "bricks and mortar" improvements to raise weir elevations and others. As the Water Department moves forward from this proof of concept in the completed Concept Plan to a comprehensive Wet Weather Facility Plan for the SE WPCP, in preparation for the submission of Part 2 NPDES permit applications, the specific collection system modification projects will be identified and the overflow reduction benefits will be firmly established. The Department is committed to achieving at least 145 million gallons of average annual overflow reduction through this process.

4.4.2 Facility Improvement Studies for the SE Drainage District

In an effort to address potential operational limitations of increasing the SE WPCP wet weather capacity by 50 MGD, the Water Department initiated additional hydraulic investigations. The following capital improvement study has been identified below:

Aeration Basin Hydraulic Limitation Study

The LTCPU Improvement 8 looks to resolve a hydraulic limitation between the primary clarifiers and the aeration basin. Operational history of the SE WPCP indicates the aeration basin influent weirs (splitter boxes) may not distribute flow evenly to the aeration basins near the peak wet weather capacity. The Water Department is currently performing Computational Fluid Dynamic (CFD) modeling of the primary clarifier effluent channel, aeration basin influent, distribution conduits, and effluent weirs, calibrated with a survey of hydraulic elevations and plant structures. The results of the investigation will be used to identify any source of flow restriction(s). Following study completion, design alternatives analysis will be modeled or operational changes will be initiated, if necessary.

5. Design and Implementation Schedule

The design and implementation schedule below (Table 3) presents the design and construction performance standards for the proposed capital project in terms of percent complete for the five-year, ten-year, and fifteen-year milestone periods for the SE WPCP and collection system expansion. Specific detail for each of the currently proposed capital projects in terms of percent complete for the five-year, ten-year, fifteen-year and twenty-year milestone periods for the SE WPCP is included within Table 4 below.

Table 3: Design and Implementation Schedule for SE WPCP Drainage District

Southeast WPCP and Drainage District Upgrades	2016	2021	2026	2031
Design Schedule	0%	0%	100%	
Construction Schedule	0%	0%	0%	100%

Table 4: Anticipated Design and Implementation Schedule for Identified SE WPCP Drainage District Projects

Southeast WPCP and Drainage District Upgrades	Construction Completion Schedule			
	2016	2021	2026	2031
Facility Improvements				
Replace Influent Pump Station Coarse Bar Rack System	100%			
Pending Results of Studies	--	--	--	--
Collection System Improvements				
Pending Results of Studies	--	--	--	--
Operational Improvements				
None Identified to Date	--	--	--	--

The Water Departmentwill submit a comprehensive Wet Weather Facility Plan prior to the next milestone date of 2016, which will provide details includingschedule, cost and anticipated performance for the sewershed modifications and the influent bar rack replacement presented in this plan. The Wet Weather Facility Plan will also provide an update on any studies and new concepts being developed by the Water Department to increase flow and CSO capturein the SE WPCP and Drainage District. The studies include:

- Development of a SE WPCP Wet Weather Facility Plan
- Balancing CSO Regulator Wet Weather Treatment Capacities
- Aeration Basin Bottleneck Study

Projects identified by studies conducted by the Water Department will be implemented by 2031 to achieve CSO capture and wet weather flow treatmentas required by the 2011 COA and NPDES permit modification.