Case No. 2010-____
Exhibit ____A____

NORTHERN KENTUCKY
WATER DISTRICT

Project
Memorial Parkway Treatment Plant
Advanced Treatment Facility

Campbell County
184-0456

ENGINEERING REPORTS AND INFORMATION

Project Map

Basis of Design Report

Engineer's Opinion of Probable Total Construction Cost

Plans prepared by CH2M Hill and HDR Engineers titled "Advanced Treatment Facility Memorial Parkway Treatment Plant" dated November, 2009

Specifications prepared by CH2M Hill and HDR Engineers titled "Advanced Treatment Facility Memorial Parkway Treatment Plant" dated November, 2009

Case No. 2010-____
Exhibit _____A_____

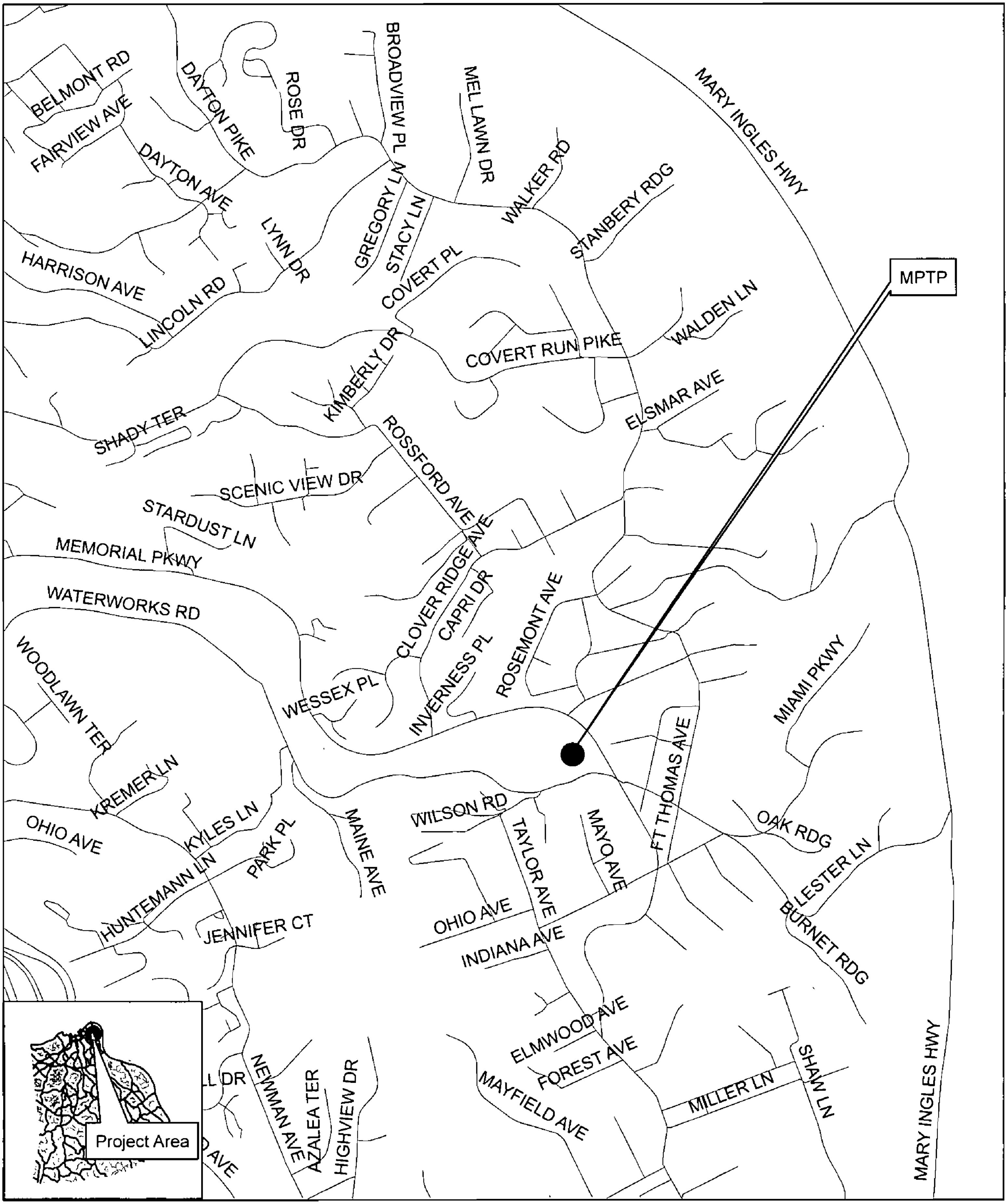
NORTHERN KENTUCKY WATER DISTRICT

Project
Memorial Parkway Treatment Plant
Advanced Treatment Facility

Campbell County
184-0456

Project Map

Site Map



MPTP
BELMONT RD
FAIRVIEW AVE
DAYTON PIKE
ROSE DR
BROADVIEW PL
MEL LAWN DR
MARY INGLES HWY
DAYTON AVE
GREGORY LN
STACY LN
WALKER RD
STANBERY RDG
LYNN DR
HARRISON AVE
LINCOLN RD
COVERT PL
WALDEN LN
COVERT RUN PIKE
KIMBERLY DR
ELSMAR AVE
SHADY TER
ROSSFORD AVE
SCENIC VIEW DR
STARDUST LN
MEMORIAL PKWY
CLOVER RIDGE AVE
CAPRI DR
WATERWORKS RD
ROSEMONT AVE
WOODLAWN TER
INVERNESS PL
WESSEX PL
MIAMI PKWY
FT THOMAS AVE
KREMER LN
WILSON RD
OHIO AVE
KYLES LN
MAINE AVE
TAYLOR AVE
MAYO AVE
OAK RDG
PARK PL
HUNTEMANN LN
LESTER LN
JENNIFER CT
OHIO AVE
INDIANA AVE
BURNET RDG
ELMWOOD AVE
FOREST AVE
NEWMAN AVE
AZALEA TER
HIGHVIEW DR
MAYFIELD AVE
MILLER LN
SHAW LN
MARY INGLES HWY
Project Area

Case No. 2010-____
Exhibit _____A____

NORTHERN KENTUCKY WATER DISTRICT

Project
Memorial Parkway Treatment Plant Advanced Treatment Facility

Campbell County
184-0456

Basis of Design Report

BASIS OF DESIGN REPORT

FOR

FORT THOMAS TREATMENT PLANT | MEMORIAL PARKWAY TREATMENT PLANT ADVANCED TREATMENT

Owner

Northern Kentucky Water District
2835 Crescent Springs Road
Erlanger, KY 41018

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January 2009

Contents

Section			Page
1	**Introduction**		**1-1**
	1.1	Basis of Design	1-1
	1.2	Project Goals	1-1
	1.3	Proposed Improvements	1-3
		1.3.1 Fort Thomas Treatment Plant	1-3
		1.3.2 Memorial Parkway Treatment	1-4
2	**Characterization of Water Quality and Flows**		**2-1**
	2.1	Introduction	2-1
	2.2	Fort Thomas Treatment Plant	2-1
		2.2.1 Water Quality	2-1
		2.2.2 Current Flows	2-5
		2.2.3 Flow Projections	2-9
	2.3	Memorial Parkway Treatment Plant	2-10
		2.3.1 Raw Water Quality	2-10
		2.3.2 FTTP and MPTP Finished Water Quality Differences	2-14
		2.3.3 Current Flows	2-15
		2.3.4 Flow Projections	2-19
3	**Review of Preliminary Design Report**		**3-1**
	3.1	Processes	3-1
		3.1.1 GAC Adsorption	3-1
		3.1.2 UV Disinfection	3-3
	3.2	Facilities	3-3
		3.2.1 Fort Thomas Treatment Plant	3-3
		3.2.2 Memorial Parkway Treatment Plant	3-4
		3.2.3 Common Elements of Both Facilities	3-5
4	**Site Visits**		**4-1**
	4.1	Introduction	4-1
	4.2	Lessons Learned	4-1
	4.3	UOSA	4-2
		4.3.1 GAC System Components	4-3
		4.3.2 Operation and Maintenance Observations	4-3
		4.3.3 Design Recommendations	4-6
	4.4	Twin Oaks Valley Water Treatment Plant	4-7
		4.4.1 GAC System Components	4-7
		4.4.2 Operation and Maintenance Observations	4-7
		4.4.3 Design Recommendations	4-9

Section				Page
	4.5	Chaparral Water Treatment Plant		4-9
		4.5.1	GAC System Components	4-10
		4.5.2	Operation and Maintenance Observations	4-10
		4.5.3	Design Recommendations	4-12
	4.6	Oasis Water Treatment Plant		4-12
		4.6.1	GAC System Components	4-13
		4.6.2	Operation and Maintenance Observations	4-13
		4.6.3	Design Recommendations	4-14
	4.7	Richard Miller Water Treatment Plant		4-15
5	**Design Standards**			**5-1**
	5.1	UV and Advanced Oxidation		5-1
		5.1.1	UV System Design Criteria	5-1
		5.1.2	UV Disinfection Technology Review	5-2
		5.1.3	Potential Site Layouts	5-4
		5.1.4	Preliminary Evaluation of UV System Costs	5-5
			5.1.4.1 UV Disinfection Equipment Costs	5-5
			5.1.4.2 Annual Operation and Maintenance Cost Estimates	5-5
			5.1.4.3 Net Present Value Equipment Cost Estimates	5-6
			5.1.4.4 Power Quality Equipment	5-7
			5.1.4.5 Relative Present Value Cost Estimates	5-8
		5.1.5	Recommendations and Procurement Strategy	5-9
		5.1.6	UV Advanced Oxidation Process (UV AOP)	5-10
			5.1.6.1 Potential Application to NKWD	5-11
			5.1.6.2 Future Conversion to UV AOP	5-12
	5.2	GAC		5-13
		5.2.1	GAC Media Type	5-13
		5.2.2	Procurement of GAC Media	5-14
		5.2.3	Carbon Specification	5-15
		5.2.4	Underdrains	5-16
			5.2.4.1 Block Systems	5-17
			5.2.4.2 Stainless Steel Underdrains	5-20
		5.2.5	Air Scour	5-20
		5.2.6	GAC Loading and Unloading Systems	5-22
			5.2.6.1 GAC Loading Procedures	5-23
			5.2.6.2 GAC Removal Procedures	5-26
		5.2.7	On-Site GAC Storage	5-29
		5.2.8	Backwash Supply	5-30
		5.2.9	Backwash Waste	5-30
		5.2.10	Analytical Requirements	5-31

Section | Page

5.3 Storage and Pumping ... 5-32
5.3.1 Fort Thomas Treatment Plant (FTTP) ... 5-32
5.3.1.1 GAC Pump Station ... 5-32
5.3.1.2 GAC Contactor Backwash Pump ... 5-33
5.3.1.3 Filter Backwash Pumps ... 5-34
5.3.1.4 Slurry Water Pump System ... 5-35
5.3.1.5 GAC Pump Well ... 5-36
5.3.1.6 Equalization (EQ) Basin ... 5-37
5.3.1.6.1 EQ Basin Size ... 5-37
5.3.1.6.2 EQ Pump ... 5-39
5.3.1.6.3 Location of Facilities ... 5-39
5.3.2 Memorial Parkway Treatment Plant (MPTP) ... 5-44
5.3.2.1 Purpose ... 5-44
5.3.2.2 Design Criteria ... 5-44
5.3.2.2.1 GAC Pump Station Wet Well ... 5-44
5.3.2.2.2 GAC Influent Pumps ... 5-46
5.3.2.2.3 Slurry Water Pumps ... 5-46
5.3.2.2.4 Backwash Pumps ... 5-47
5.4 Ancillary Systems ... 5-47
5.4.1 Dechlorination ... 5-47
5.4.1.1 Dechlorination Options ... 5-48
5.4.2 General Equipment and Systems ... 5-50
5.5 Electrical System ... 5-50
5.5.1 Design Standards ... 5-51
5.5.2 FTTP ... 5-52
5.5.2.1 Existing System ... 5-52
5.5.2.2 Existing Loads ... 5-53
5.5.2.3 Recommendations ... 5-55
5.5.3 MPTP ... 5-55
5.5.3.1 Existing System ... 5-55
5.5.3.2 Existing Load ... 5-56
5.5.3.3 Recommendations ... 5-57
5.6 Control Systems ... 5-58
5.6.1 Design Standards ... 5-58
5.6.1.1 Existing System Standards ... 5-58
5.6.1.2 Proposed Standards – SCADA ... 5-59
5.6.1.3 Proposed Standards – Access Control System ... 5-61
5.6.2 FTTP ... 5-61
5.6.3 MPTP ... 5-61

Section | Page

5.7 Architectural 5-63
5.7.1 Design Codes and Standards 5-63
5.7.1.1 Building Code Classification 5-63
5.7.1.2 Exterior Treatment and Materials 5-64
5.7.1.3 Exterior Walls 5-64
5.7.1.4 Roofs 5-64
5.7.1.5 Exterior Doors, Windows, and Louvers 5-65
5.7.1.6 Interior Treatment and Materials 5-65
5.7.2 FTTP 5-66
5.7.3 MPTP 5-67
5.8 Green Elements 5-68
5.8.1 Sustainability Initiatives 5-69
5.8.1.1 Sustainable Sites 5-69
5.8.1.2 Water Efficiency 5-70
5.8.1.3 Energy and Atmosphere 5-70
5.8.1.4 Materials and Resources 5-70
5.8.1.5 Indoor Environmental Quality 5-71
5.8.1.6 Innovation and Design Process 5-71
5.8.2 Stormwater System 5-71

6 Geotechnical Analysis 6-1

7 Hydraulic Analysis 7-1
7.1 Introduction 7-1
7.2 Fort Thomas Treatment Plant 7-2
7.2.1 Assumptions 7-2
7.2.2 Hydraulic Profile 7-3
7.2.3 Conclusions 7-3
7.3 Memorial Parkway Treatment Plant 7-3
7.3.1 Assumptions 7-3
7.3.2 Hydraulic Profile 7-4
7.3.3 Conclusions 7-4

8 Schematic Design 8-1
8.1 Fort Thomas Treatment Plant 8-2
8.1.1 Sitework 8-2
8.1.2 Access Road 8-2
8.1.3 Yard Piping 8-3
8.1.4 List of Drawings 8-3
8.1.5 List of Specifications 8-3
8.1.6 Project Schedule 8-4

Section **Page**

8.1.7 Construction Sequencing 8-4
8.2 Memorial Parkway Treatment Plant 8-5
8.2.1 Sitework 8-5
8.2.2 Access Road 8-5
8.2.3 Yard Piping 8-6
8.2.4 List of Drawings 8-6
8.2.5 List of Specifications 8-6
8.2.6 Project Schedule 8-6
8.2.7 Construction Sequencing 8-7

9 Cost Estimates 9-1
9.1 FTTP 9-2
9.1.1 Construction Cost Estimate 9-2
9.1.2 Operations and Maintenance Estimate 9-3
9.2 MPTP 9-5
9.2.1 Construction Cost Estimate 9-5
9.2.2 Operations and Maintenance Estimate 9-6

10 Kentucky Division of Water Coordination 10-1

Appendices (Located on Sharepoint Site)

A Geotechnical Reports
B WINHYDRO Output Files
C CPES - Construction and O&M
D KDOW Letter
E UV Vendor Information
F UV Evaluation - Aquionics
G Pump Vendor Information
H GAC Vendor Information (Not Included)
I Underdrain Vendor Information
J Site Visit Data Sheets

Exhibits

2-1 FTTP Water Quality Data (September 2003-August 2008) 2-2
2-2 FTTP Raw and Filtered Water TOC 2-3
2-3 FTTP Finished Water UV Transmittance 2-4
2-4 FTTP Finished Water UVT vs. Filter Effluent TOC 2-5
2-5 FTTP Flow Data (September 2003-August 2008) 2-5
2-6 FTTP Flow 2-6

Exhibits

2-7 FTTP Flow Data 2-7
2-8 FTTP Diurnal Flow, November 2007 2-8
2-9 FTTP Diurnal flow, August 2008 2-8
2-10 FTTP Flow Projections 2-9
2-11 MPTP Water Quality Data (September 2003-August 2008) 2-10
2-12 MPTP Raw and Filtered Water TOC 2-12
2-13 MPTP Finished Water UT Transmittance 2-13
2-14 MPTP Finished Water UVT vs. Filter Effluent TOC 2-14
2-15 Finished Water Quality Comparison (September 2003-August 2008) 2-14
2-16 MPTP Flow Data (September 2003-August 2008) 2-15
2-17 MPTP Flow 2-16
2-18 MPTP Flow 2-17
2-19 MPTP Diurnal Flow, November 2007 2-18
2-20 MPTP Diurnal Flow, August 2008 2-18
2-21 MPTP Flow Projections 2-19

5-1 UV System Design Criteria 5-2
5-2 Comparison of Medium Pressure and Low High UV Equipment 5-2
5-3 Comparison of UV Equipment Recommendations for FTTP 5-3
5-4 Comparison of UV Equipment Recommendations for MPTP 5-3
5-5 FTTP Medium Pressure .... End of Section
5-6 FTTP Low Pressure – High Output .... End of Section
5-7 MPTP Medium Pressure .... End of Section
5-8 MPTP Low Pressure – High Output .... End of Section
5-9 Comparison of UV Disinfection Building Footprints 5-5
5-10 Comparison of UV Equipment Costs for FTTP and MPTP 5-5
5-11 Replacement Life and Costs for UV System Components 5-5
5-12 Comparison of LH and MP Annual Operating Costs 5-6
5-13 Comparison of LH and MP 20-Year Present Value Estimates for Equipment and O&M 5-7
5-14 Comparison of LH and MP 20-Year Present Worth Estimates 5-9
5-15 UV AOP System Options for NKWD 5-11
5-16 GAC Media Sizes Considered for NKWD 5-13
5-17 Potential GAC Suppliers for NKWD 5-14
5-18 Specification Section 11208, Granular Activated Carbon (GAC) Filter Media Example .... End of Section
5-19 Block Underdrains 5-18
5-20 Block Underdrain System with Air/Water Backwash 5-19
5-21 Stainless Steel Underdrain, Including Application with Air/Water Backwash (Right) 5-20
5-22 GAC Contactor Design Criteria for FTTP 5-22

Exhibits

5-23 GAC Contactor Design Criteria for MPTP 5-23
5-24 Summary of GAC Loading Procedures 5-24
5-25 GAC Loading Requirements 5-25
5-26 Media Installation by Eduction from Open-Bed Truck (Provided by Calgon Carbon Corporation) 5-25
5-27 Media Installation by Eduction from Super Sacks (Provided by Calgon Carbon Corporation) 5-26
5-28 Summary of GAC Removal Procedures 5-27
5-29 Media Removal by Eduction to Open-Bed Truck (Provided by Calgon Carbon Corporation) 5-28
5-30 Media Removal by Eduction to Super Sacks (Provided by Calgon Carbon Corporation) 5-28
5-31 GAC Removal Requirements 5-29
5-32 EQ Basin Flows 5-38
5-33 Potential Tank Locations 5-40
5-34 EQ Basin Site Construction Evaluation 5-41
5-35 GAC Pump Well Site Construction Evaluation 5-42
5-36 Non-Economic Tank Location Factors 5-43
5-37 Pit Layout 5-45
5-38 MPTP GAC Influent Pump Details 5-46
5-39 MPTP Slurry Pump Details 5-47
5-40 MPTP Replacement Backwash Pumps 5-47
5-41 Design Standards (Draft) .... End of Section
5-42 FTTP Distribution System One-Line Diagram – Existing .... End of Section
5-43 FTTP Demand 5-54
5-44 FTTP Load Data Summary 5-54
5-45 FTTP Distribution System One-Line Diagram – Modified .... End of Section
5-46 MPTP Distribution System One-Line Diagram – Existing .... End of Section
5-47 MPTP/RWTS Demand 5-56
5-48 MPTP Load Data Summary 5-57
5-49 MPTP Distribution System One-Line Diagram – Modified .... End of Section
5-50 FTTP Network Diagram – Existing .... End of Section
5-51 MPTP Network Diagram – Existing .... End of Section
5-52 FTTP Network Diagram – Modified .... End of Section
5-53 FTTP New Electrical Loads 5-62
5-54 MPTP Network Diagram – Modified .... End of Section
5-55 MPTP New Electrical Loads 5-62
5-56 Fort Thomas AT Building 5-67
5-57 Memorial Parkway AT Building 5-68

Exhibits

7-1	Fort Thomas Treatment Plant Hydraulic Profile	7-6
7-2	Memorial Parkway Treatment Plant Hydraulic Profile	7-7
8-1	Site Plan	End of Section
8-2	Site Paving	End of Section
8-3	Yard Piping	End of Section
8-4	AT Facility West Elevation – Proposal 1	End of Section
8-5	AT Facility West Elevation – Proposal 2	End of Section
8-6	AT Facility Lower Basement Plan at EL 769.00	End of Section
8-7	AT Facility Basement Plan at EL 769.00	End of Section
8-8	AT Facility First Floor Plan at EL 784.00	End of Section
8-9	AT Facility Second Floor Plan – Proposal 1 at EL 802.00	End of Section
8-10	AT Facility Second Floor Plan – Proposal 2 at EL 802.00	End of Section
8-11	AT Facility GAC Pump Station P&ID	End of Section
8-12	AT Facility GAC Contactor Overview P&ID	End of Section
8-13	AT Facility Typical GAC Contactor P&ID	End of Section
8-14	AT Facility Waste (EQ) Basin P&ID	End of Section
8-15	AT Facility Air Scour Blower P&ID	End of Section
8-16	AT Facility UV P&ID	End of Section
8-17	Site Plan	End of Section
8-18	AT Facility Northwest and Southwest Elevation	End of Section
8-19	AT Facility Lower Level Floor Plan at EL 743.50	End of Section
8-20	AT Facility Operating Level Floor Plan at EL 760.0	End of Section
8-21	AT Facility Upper Level Floor Plan at EL 772.0	End of Section
8-22	AT Facility Sections	End of Section
8-23	AT Facility Section	End of Section
8-24	AT Facility GAC Pump Station P&ID	End of Section
8-25	AT Facility GAC Contactor Overview P&ID	End of Section
8-26	AT Facility Typical GAC Contactor P&ID	End of Section
8-27	AT Facility Air Scour P&ID	End of Section
8-28	AT Facility UV P&ID	End of Section
8-29	FTTP Design Sheet Estimate	End of Section
8-30	FTTP & MPTP Specification List	End of Section
8-31	MPTP Design Sheet Estimate	End of Section
9-1	FTTP Construction Cost Estimate	9-2
9-2	FTTP Operations and Maintenance Cost Estimate	9-4
9-3	MPTP Construction Cost Estimate	9-5
9-4	MPTP Construction Cost Estimate	9-6

SECTION 1

Introduction

1.1 Basis of Design

This report presents the basis of design for adding Advanced Treatment (AT) to the Fort Thomas Water Plant (FTTP) and Memorial Parkway Treatment Plant (MPTP) owned and operated by Northern Kentucky Water District (NKWD). The major components of advanced treatment include post-filtration granular activated carbon (GAC) adsorption followed by ultraviolet light (UV) treatment. These components were selected and preliminary design criteria were established in a report titled Preliminary Design of GAC Systems by Malcolm Pirnie/GRW, (PD Report, March 2008). The PD Report, March 2008, focused on establishing the process standards for GAC at the NKWD plants and selected the location of the proposed building to house the GAC and UV facilities at each plant.

The materials presented in this report were developed during the conduct of the Preliminary Engineering study by CH2M HILL, HDR and Thelen and Associates with the purpose of further defining the GAC and UV processes, identifying and defining support systems, and investigating and identifying means of integrating the facilities into the existing water treatment plant sites. A similar preliminary engineering study is being conducted by Malcolm Pirnie and GRW for the NWKD Taylor Mill Treatment Plant (TMTP) and coordination of the efforts for the studies was also a focus of the preliminary design. Cost estimates for the construction of the improvements were refined and operations and maintenance cost estimates were prepared for the proposed new facilities.

1.2 Project Goals

The primary overall goal of the NKWD Advanced Treatment initiative is to achieve compliance with the Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rule through the implementation of GAC at all of the water treatment plants. Another goal is to provide a multiple barrier treatment approach for disinfection, particularly to address Cryptosporidium and Giardia through the addition of UV in conjunction with the existing chlorination system. Finally the GAC treatment also provides additional removal of organics including contaminants of emerging concern (CEC).

Implementation of Advanced Treatment therefore addresses current and future water quality concerns and enables NKWD to provide superior quality drinking water to the customers.

A project chartering meeting was held on September 30, 2008 attended by representatives of the Advanced Treatment teams for all the plants. The group adopted the following goals for the projects.

- Compliance with the Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rule - GAC at FTTP is the single driver to achieving regulatory compliance. Meet schedule - FTTP must be completed by July 2011. Any delay during design puts more pressure on the construction schedule to meet the July 2011 deadline.
- Cost reduction/cost control – Minimize construction and operation costs.
- Minimize disruption of operations during construction – Strike a balance with the outages that can be tolerated and maintaining operability.
- Adopt the same look and feel to how the equipment is laid out and controlled at the three plants.
- Standardize maintenance features.
- Size buildings with enough space for maintaining equipment.
- Minimize contractors' risk and change orders.
- Have less organic demand in the distribution system.
- Carrying chlorine residual longer in the distribution system.

Discussion was held at the meeting regarding sustainability of the AT facilities and the following sustainability definition and approach was prepared and adopted.

Sustainability—shaping the built environment to maintain and enhance the natural environment—is a powerful concept that inspires innovative problem-solving.

Sustainable solutions create value to the owner and innovation from economically viable, environmentally sensitive, and socially responsible approaches:

- Reduce life cycle costs:
  - Reduce energy, water, and material consumption.
  - Reduce waste in all forms, including emissions and heat.
- Favor long-term, systems-oriented, high-value problem-solving.
- Engage owner's employees and stakeholders positively.
- Apply principles to planning, design, construction, and operations.
- Protect natural resources for use by future generations.

The sustainability approach therefore encompasses design, construction, and operations and maintenance activities and concepts. Implementation of these approaches has been fostered by the involvement of members of each group in the Preliminary Engineering study and sets the stage for continued involvement throughout the final design, construction and start-up phases of the project.

1.3 Proposed Improvements

Treatment process related improvements for both plants were identified in the Preliminary Design study and refined and expanded to include supporting facilities in the Preliminary Engineering study. At both plants the AT facilities will be incorporated into the existing process trains between the sand filters and the clearwells. This process location necessitates the addition of low head pumping to lift the filter effluent to the top of the GAC contactors and provide sufficient head to drive the water through the contactors and UV system before discharge into the existing clearwells. A full description of facilities and design criteria for each is provided in this report. Summaries of the proposed improvements at each plant are provided here.

1.3.1 Fort Thomas Treatment Plant

The following process facilities are proposed for FTTP:

- 8 GAC contactor beds.
- 3 GAC feed pumps with variable speed motors and controls.
- 1 GAC backwash pump with variable speed motor and controls, also serves as backup filter backwash pump.
- 1 Filter backwash pump with variable speed motor and controls, also serves as backup GAC backwash pump.
- GAC/Backwash tank supplying the feed and backwash pumps.
- Equalization tank to capture GAC backwash waste, GAC to waste and miscellaneous waste streams requiring no additional treatment before being pumped back to the raw water reservoirs.
- 2 Equalization basin return pumps.
- 2 Slurry water pumps for use in transporting GAC into and out of the contactors.
- 1 Air blower for air scour backwash of the GAC contactors.
- Sodium bisulfite de-chlorination system for the filter effluent consisting of a bulk tank, 2 transfer pumps, a day tank and 3 feed pumps.
- 3 Medium Pressure High Output UV reactors.

Non-process facilities include the GAC building housing all the previously mentioned improvements and meeting/conference room facilities. The building will be constructed separately from existing facilities but will include a covered breezeway to the existing laboratory. An electrical power supply system includes an engine-generator to provide backup power for the existing liquid treatment processes serving the plant downstream of the raw water reservoirs and the proposed AT facilities and an uninterruptible power supply (UPS) for the UV system.

1.3.2 Memorial Parkway Treatment

The following process facilities are proposed for MPTP:

- 6 GAC contactor beds, with 5 fully functional and 1 empty for future expansion.
- 4 GAC feed pumps with variable speed motors and controls.
- 2 Backwash pumps with variable speed motors and controls serving both the GAC contactors and the existing sand filters.
- GAC/Backwash tank supplying the feed and backwash pumps.
- 2 Slurry water pumps for use in transporting GAC into and out of the contactors.
- 1 Air blower for air scour backwash of the GAC contactors.
- 2 Medium Pressure High Output UV reactors.

Non-process facilities include a new building housing most of the previously mentioned improvements. The building will be constructed primarily within the footprint of existing abandoned flocculation basin and rectangular clarifiers although the pump station structure will expand beyond the existing walls. The backwash pumps will be installed in the existing backwash pump station and replace the existing filter backwash pumps. A sodium bisulfite dechlorination system will not be installed initially as NKWD will evaluate the need by comparing operation of the GAC system at FTTP with dechlorination to the operation at MPTP without. If need the system can be added in an existing chemical building that includes a spare chemical room equipped with a 5,000 gallon bulk tank. An electrical power supply system includes an engine-generator to provide backup power for the existing liquid treatment processes and the proposed AT facilities and a UPS for the UV system.

SECTION 2

Characterization of Water Quality and Flows

2.1 Introduction

The Stage 2 Disinfectant/Disinfection Byproduct (D/DBP) Rule will require compliance with locational running annual averages (LRAA) for total trihalomethanes (TTHM) and five haloacetic acids (HAA5) at each sampling location in the distribution system by April 1, 2012. The MCLs for TTHMs and HAA5 are 0.080 mg/L and 0.060 mg/L, respectively.

Plant operating and water quality records between September 2003 and August 2008 were reviewed to confirm the GAC and UV design criteria presented in the PD Report, March 2008. Information reviewed included the following:

- Diurnal flow records for one summer and winter month showing the variation in production rate over the course of a day.
- Maximum and average day flow.
- Alkalinity.
- Hardness.
- Iron.
- Manganese.
- Turbidity.
- Dissolved Organic Carbon (DOC)/Total Organic Carbon (TOC).
- Ultraviolet Absorbance (UVA)/Ultraviolet Transmittance (UVT).

2.2 Fort Thomas Treatment Plant

The Fort Thomas Treatment Plant (FTTP) is rated for a maximum flow of 44 mgd from the Ohio River using conventional coagulation, settling and filtration processes. The plant operates 24 hours a day, 7 days a week. Characterizations of the raw and finished water quality as well as the flow conditions are presented in the following sections.

2.2.1 Water Quality

The water quality data for FTTP are summarized in Exhibit 2-1.

EXHIBIT 2-1
FTTP Water Quality Data (September 2003 – August 2008)

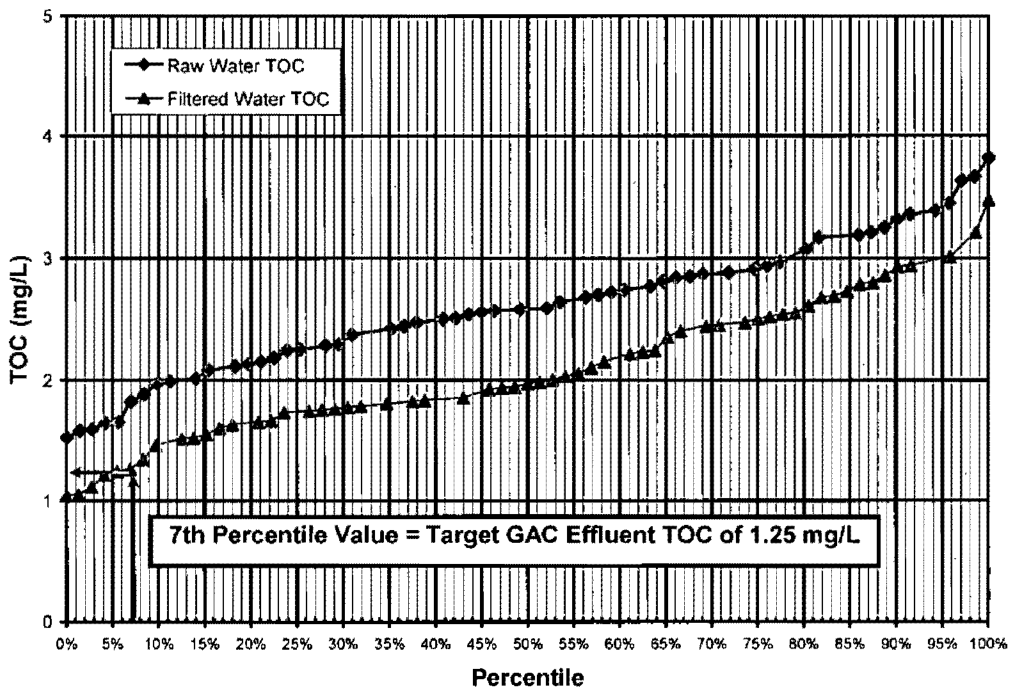
Constituent	Average	Range	Data Points	Standard Deviation	90th Percentile
Total Organic Carbon (TOC), mg/L					
Raw	2.54	1.33 – 4.40	163	0.57	3.27
Filtered	2.08	1.04 – 3.48	73	0.56	2.92
Dissolved Organic Carbon (DOC), mg/L					
Raw	2.46	0.47 – 3.69	201	0.56	3.14
Filtered	1.96	0.76 – 3.92	115	0.64	2.84
Turbidity, mg/L					
Raw	27.8	1.0 – 245.0	1,827	24.7	59.1
Settled	1.43	0.6 – 6.0	1,827	0.62	2.2
Finished*	0.07	0.03 – 0.21	1,827	0.02	0.10
Alkalinity, mg/L as CaCO3					
Raw	67	32 – 107	1,827	10	80
Finished	61	29 – 101	1,827	10	74
Hardness, mg/L as CaCO3					
Raw	128	76 – 184	1,826	18	154
Finished	124	75 – 183	1,827	19	151
Iron, mg/L					
Raw	208.9	0.0 – 5,888.7	102	823.1	5.8
Old Clearwell	0.5	0.005 – 5.4	23	1.5	0.1
New Clearwell	2.0	0.003 – 48.8	35	8.4	3.9
Manganese, mg/L					
Raw	22.2	0.032 – 510.8	103	74.7	60.5
Old Clearwell	0.6	0.001 – 7.5	82	1.7	2.7
New Clearwell	0.3	0.001 – 1.3	18	0.6	1.2
UV Absorbance (UVA254), cm-1					
Raw	0.069	0.024 – 0.300	203	0.033	0.095
Old Clearwell	0.025	0.000 – 0.095	209	0.012	0.040
New Clearwell	0.026	0.000 – 0.095	187	0.012	0.040
UV Transmittance (UVT254), %					
Raw	85.5	50.1 – 94.6	203	5.9	91.2
Old Clearwell	94.4	80.4 – 100.0	209	2.6	97.3
New Clearwell	94.3	80.4 – 100.0	187	2.6	97.1

EXHIBIT 2-1
FTTP Water Quality Data (September 2003 – August 2008)

Constituent	Average	Range	Data Points	Standard Deviation	90th Percentile
SUVA					
Raw	2.9	0.9 – 13.4	201	1.6	4.1
Old Clearwell	1.6	0.8 – 5.3	116	0.5	2.0
New Clearwell	1.5	0.9 – 3.0	115	0.3	1.9
Water Temperature, °F	62	36 - 88	1,827	15	82
*Based on combined filter effluent daily averages at 4-hour intervals.					

Filtered water TOC ranged between 1.04 mg/L and 3.48 mg/L, as shown on Exhibit 2-2. Based on conservative assumptions for the distribution system (water age) and treatment (pH, chlorine residual concentration and water temperature), the PD Report, March 2008 predicted TTHM formation would occur at a concentration of 0.064 mg/L if the target GAC effluent TOC concentration is 1.25 mg/L. Exhibit 2-2 shows that roughly 7 percent of the filtered water TOC data evaluated is less than or equal to the target GAC effluent TOC concentration. Based on current TOC levels and disinfection practices, TTHMS and HAA5 will form at concentrations in excess of the Stage 2 D/DBP MCLs of 0.080 mg/L and 0.060 mg/L, respectively. Therefore, TOC removal will be required for regulatory compliance.

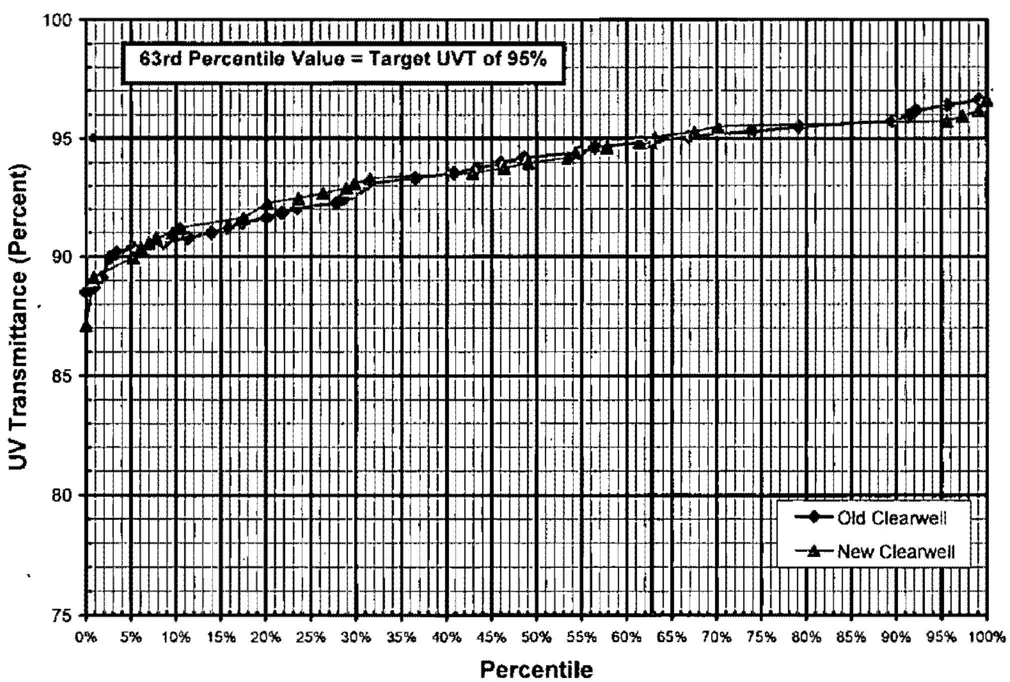
EXHIBIT 2-2
FTTP Raw and Filtered Water TOC



The UV transmittance (UVT) of water is an important parameter used in the design of UV disinfection systems. An influent UVT of 95 percent is proposed based on a review of historical plant data and a comparison with plant performance data from the Greater Cincinnati Water Works' (GCWW) Richard Miller WTP.

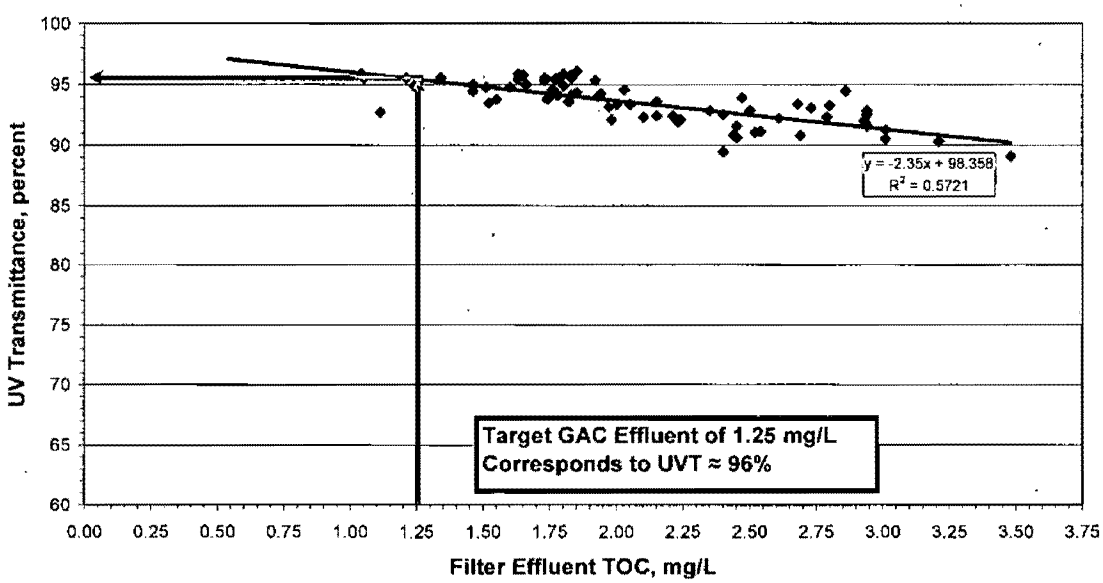
Finished water UVT for the old and new clearwells ranged from 80 percent to 100 percent, as shown on Exhibit 2-3. A frequency analysis of the UVT data indicated that 63 percent of the UVT data between September 1999 and August 2008 is less than or equal to the target UV system influent UVT of 95 percent. The GAC facilities will remove the natural organic matter, resulting in a decrease of TOC and an increase in the UVT of the water entering the UV reactors.

EXHIBIT 2-3
FTTP Finished Water UV Transmittance



A linear relationship was formed between TOC and UVT in order to determine what effluent UVT value may correspond with the target GAC effluent TOC goal of 1.25 mg/L. The relationship between filter effluent TOC and finished water UVT at FTTP is presented in Exhibit2-4. The resultant effluent UVT level corresponding to a GAC effluent TOC of 1.25 mg/L is about 96 percent. The best fit linear regression is shown and the correlation coefficient (R2 value) shows a fairly good correlation.

EXHIBIT 2-4
FTTP Finished Water UVT vs. Filter Effluent TOC



2.2.2 Current Flows

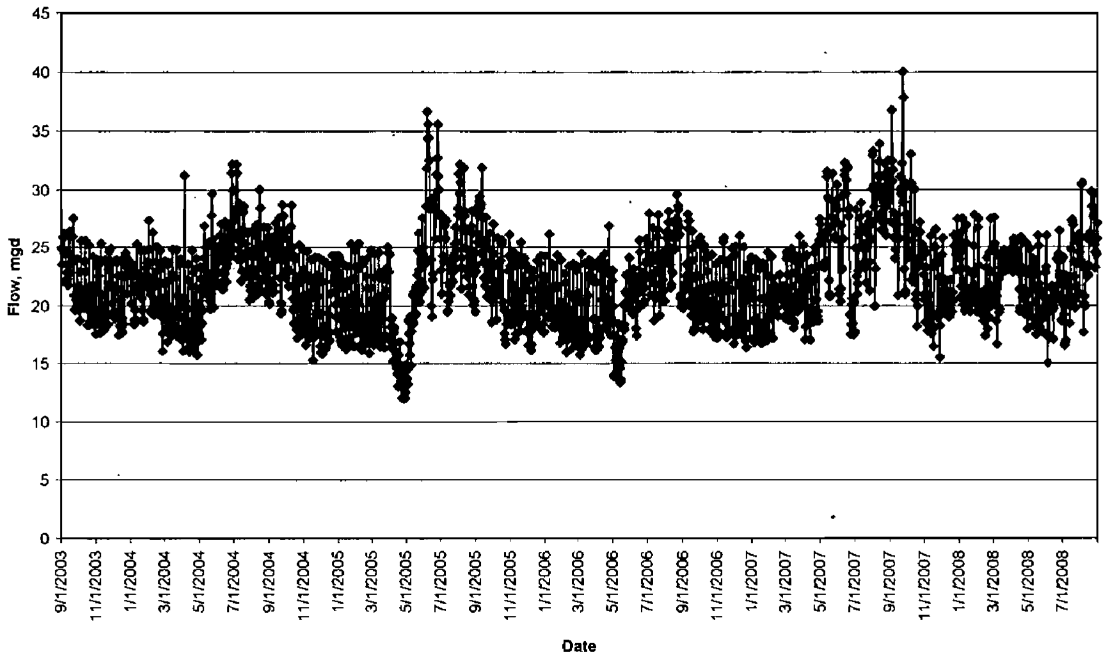
The daily average flow data for FTTP is summarized in Exhibit 2-5 and presented in Exhibits 2-6 through 2-9.

EXHIBIT 2-5
FTTP Flow Data (September 2003 – August 2008)

Parameter	Average	Range
Flow, mgd	22.0	12.0 – 40.0

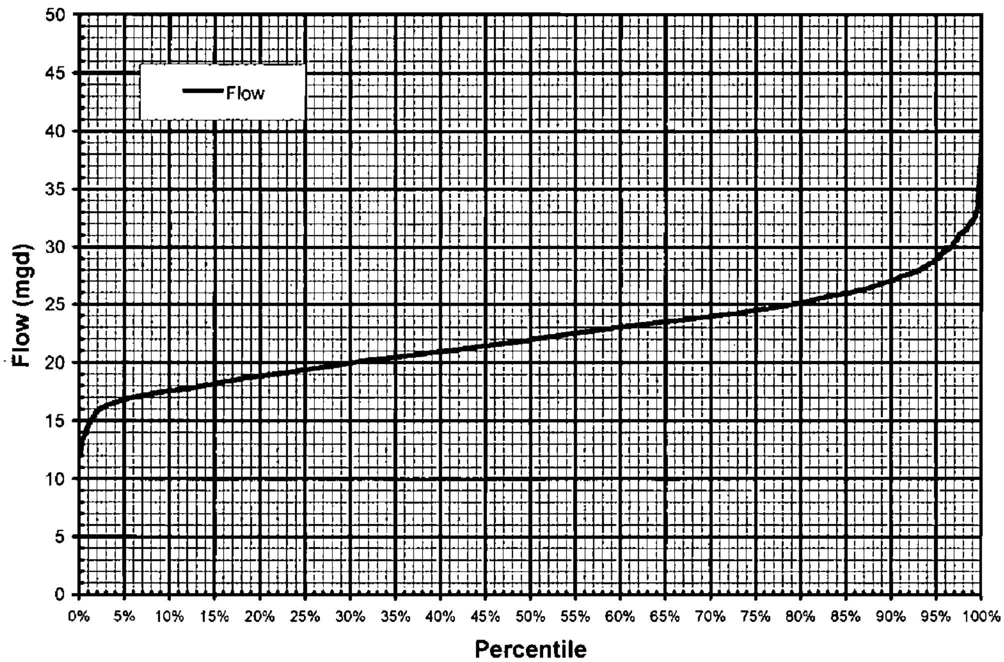
The daily average flow is presented in Exhibit 2-6.

EXHIBIT 2-6
FTTP Flow



A frequency analysis of the daily average flow is presented in Exhibit 2-7. About 48 percent of the time, flow between September 2003 and August 2008 was less than or equal to the average day flow of 22 mgd. The plot also shows that 99 percent of the time, the FTTP flow did not exceed 40 mgd.

EXHIBIT 2-7
FTTP Flow Data



Diurnal flow records for one winter and one summer month showing the variations in the production rate over the course of a day are shown on Exhibits 2-8 and 2-9, respectively. The diurnals show that:

- Minimum flow fell below 12 mgd (to about 9 mgd) overnight in November 2007.
- Variation is significant over the course of a day.
- In August 2008, instantaneous flows exceeded 40 mgd and dropped to about 12 mgd within days of each other.
- Most severe impacts of rapid flow changes are anticipated for clarification, chemical dosing, and filtration. Impacts on GAC and UV are not expected to be significant.

EXHIBIT 2-8
FTTP Diurnal Flow
November 2007

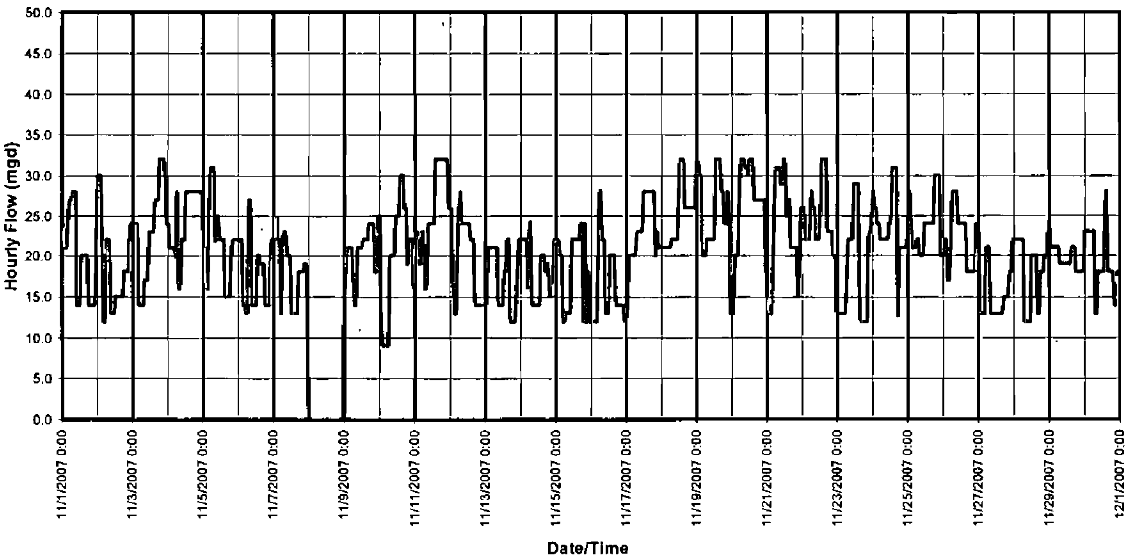
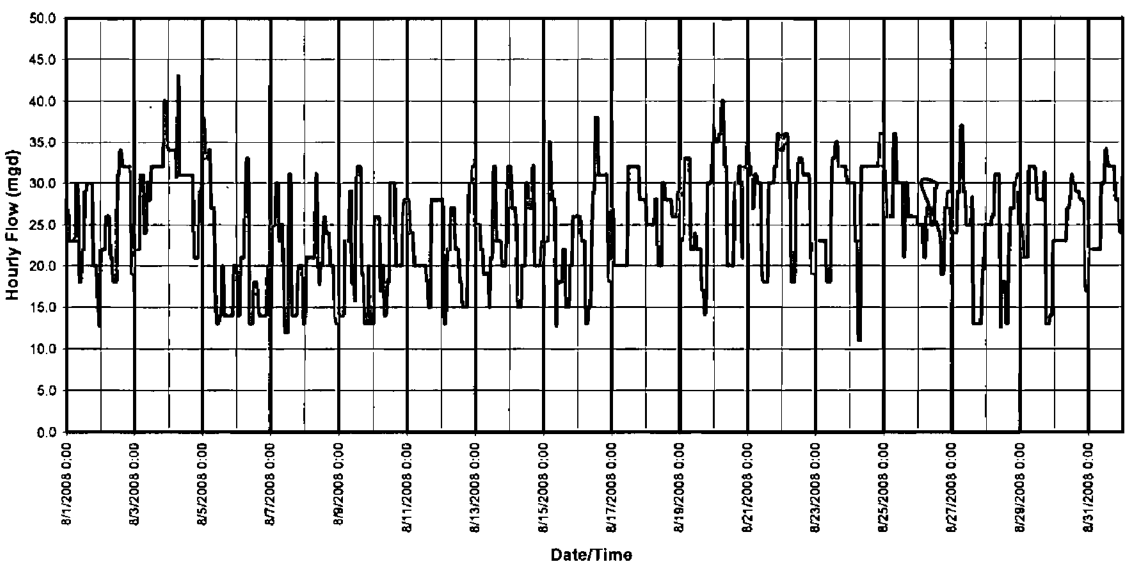


EXHIBIT 2-9
FTTP Diurnal Flow
August 2008



2.2.3 Flow Projections

The projected average day flow developed and provided by NKWD for FTTP for Year 2006 through 2030 is listed in Exhibit 2-10. The average day demands are based on the assumption that MPTP is expanded to 15 mgd in 2020 and that a major portion of the Covington area is supplied by MPTP in lieu of FTTP. The new facilities proposed for MPTP will provide treatment capacity in the advanced treatment facilities of 15 mgd; however, the plant can be expanded to at least 20 mgd in the long term. The advanced treatment facilities will have a hydraulic capacity of 20 mgd to accommodate future plant expansion. It is assumed that TMTP will supply 6 mgd through 2030 under average day conditions.

EXHIBIT 2-10
FTTP Flow Projections

Year	Average Day, mgd
2006	19.88
2007	20.32
2008	20.76
2009	21.21
2010	21.65
2011	22.09
2012	22.53
2013	22.97
2014	23.42
2015	23.86
2016	24.31
2017	24.75
2018	25.19
2019	25.64
2020	21.72
2021	22.17
2022	22.62
2023	23.07
2024	23.52
2025	23.97
2026	24.43
2027	24.88
2028	25.33
2029	25.78
2030	26.23

2.3 Memorial Parkway Treatment Plant

The Memorial Park Treatment Plant (MPTP) currently treats up to 10 mgd from the Ohio River using coagulation, high-rate ballasted flocculation (Actiflo®) and filtration processes. The plant operates 16 hours a day, 7 days a week. A characterization of the raw and finished water quality as well as the flow conditions is presented in the following sections.

2.3.1 Raw Water Quality

The water quality data for MPTP is summarized in Exhibit 2-11.

EXHIBIT 2-11
MPTP Water Quality Data (September 2003 – August 2008)

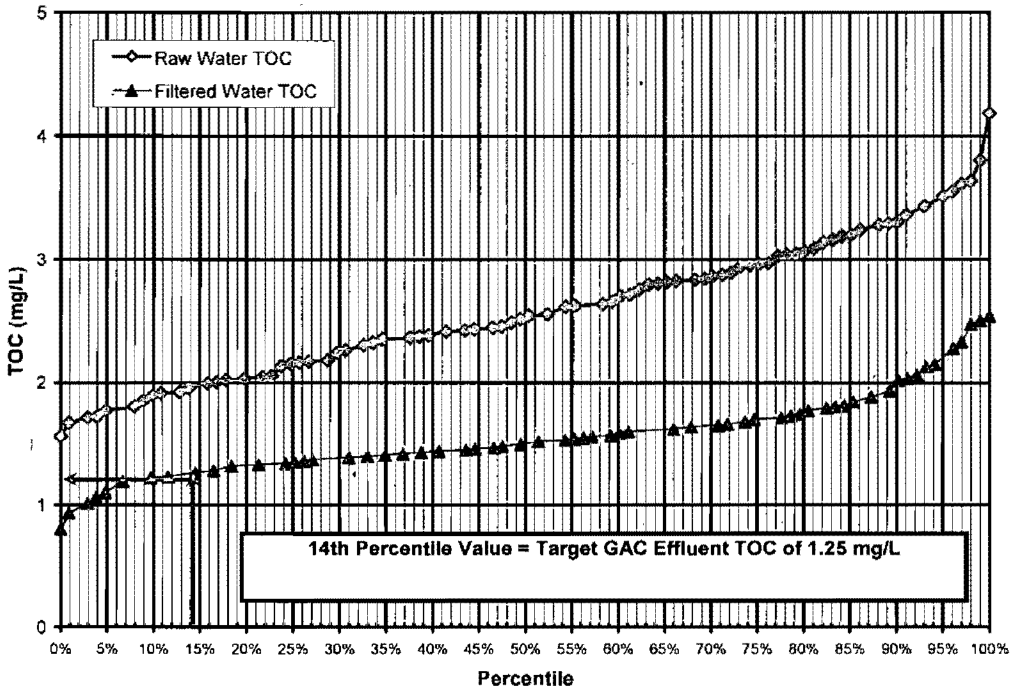
Constituent	Average	Range	Data Points	Standard Deviation	90th Percentile
Total Organic Carbon (TOC), mg/L					
Raw	2.57	1.56 – 4.18	102	0.56	3.30
Filtered	1.55	0.80 – 2.54	104	0.33	1.99
Dissolved Organic Carbon (DOC), mg/L					
Raw	2.56	1.23 – 3.85	129	0.51	3.25
Finished	1.64	0.94 – 2.74	136	0.32	2.01
Turbidity, mg/L					
Raw	12.2	1.0 – 94.1	1,695	12.1	29.0
Settled	1.18	0.5 – 3.9	1,695	0.44	1.8
Finished*	0.08	0.02 – 0.21	1,719	0.02	0.10
Alkalinity, mg/L as CaCO3					
Raw	65	44 – 110	1,719	8.8	78
Finished	56	38 – 94	1,725	7.9	66
Hardness, mg/L as CaCO3					
Raw	129	90 – 188	1,717	18	156
Finished	127	86 – 180	1,725	18	154
Iron, mg/L					
Raw	208.9	0.0 – 523.8	50	92.8	0.8
Finished	0.6	0.009 – 12.4	50	2.5	0.04
Manganese, mg/L					
Raw	3.9	0.003 – 135.2	50	20.5	0.2
Finished	0.002	0.001 – 0.004	20	0.001	0.003

EXHIBIT 2-11
MPTP Water Quality Data (September 2003 – August 2008)

Constituent	Average	Range	Data Points	Standard Deviation	90th Percentile
UV Absorbance (UVA254), cm-1					
Raw	0.069	0.010 – 0.240	128	0.029	0.095
Finished	0.021	0.000 - 0.070	138	0.011	0.030
UV Transmittance (UVT254), %					
Raw	85.6	57.5 - 97.7	128	5.3	91.2
Finished	95.3	85.1 - 100.0	138	2.3	97.7
SUVA					
Raw	2.7	0.0 – 11.6	129	1.3	3.6
Finished	1.5	0.7 – 4.1	109	0.4	1.9
Water Temperature, °F	63	37 - 86	1,724	14	81
*Based on combined filter effluent daily averages at 4-hour intervals.					

Filtered water TOC ranged between 0.80 mg/L and 2.54 mg/L, as shown on Exhibit 2-12. Based on conservative assumptions for the distribution system (water age) and treatment (pH, chlorine residual concentration and water temperature), the PD Report, March 2008 predicted TTHM formation would occur at a concentration of 0.064 mg/L if the target GAC effluent TOC concentration is 1.25 mg/L. Exhibit 2-12 shows that roughly 14 percent of the filtered water TOC data evaluated is less than or equal to the target GAC effluent TOC concentration. Based on current TOC levels and disinfection practices, TTHMS and HAA5 will form at concentrations in excess of the Stage 2 D/DBP MCLs of 0.080 mg/L and 0.060 mg/L, respectively. Therefore, TOC removal will be required for regulatory compliance.

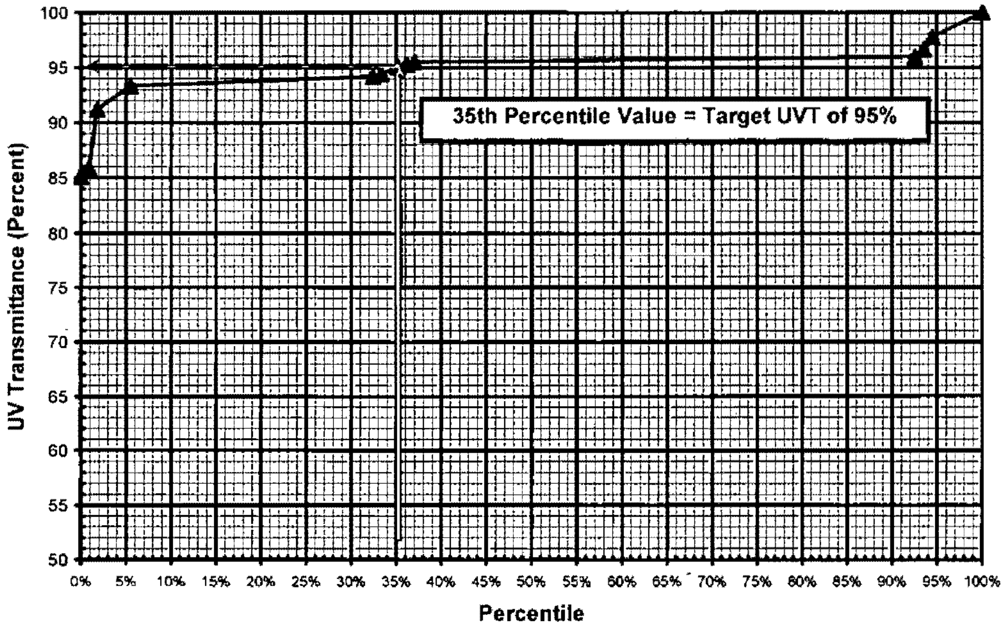
EXHIBIT 2-12
MPTP Raw and Filtered Water TOC



The UV transmittance (UVT) of water is a major parameter used in the design of UV disinfection systems. An influent UVT of 95 percent is proposed based on a review of historical plant data and a comparison with plant performance data from the Greater Cincinnati Water Works' (GCWW) Richard Miller WTP.

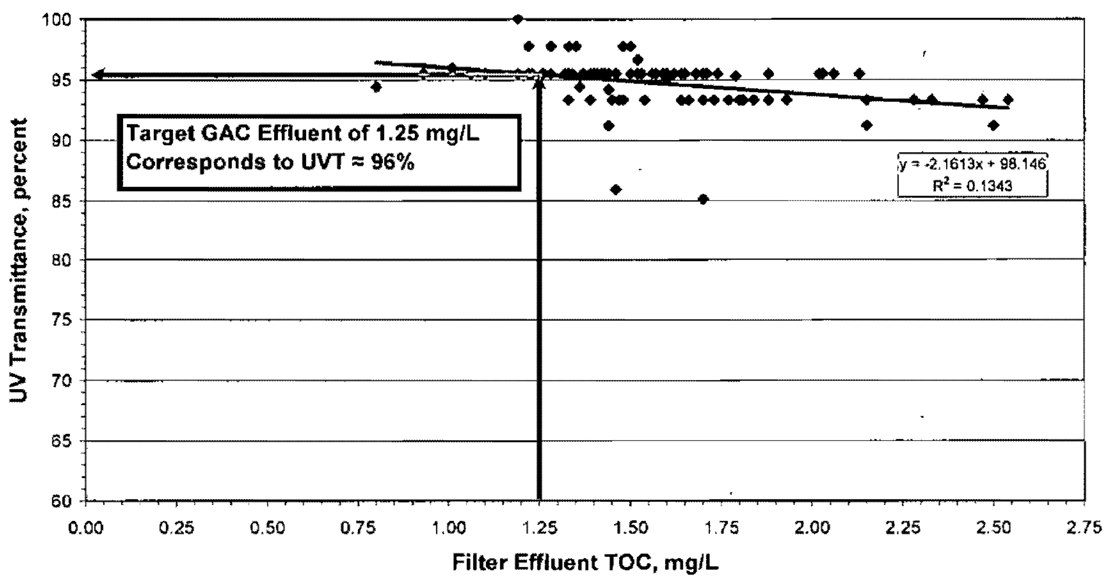
MPTP finished water UVT ranged from 85 percent to 100 percent, as shown on Exhibit 2-13. A frequency analysis of the UVT data indicated that 35 percent of the UVT data between September 1999 and August 2008 is less than or equal to the target UV system influent UVT of 95 percent. The GAC facilities will remove the natural organic matter, resulting in a decrease of TOC and an increase in the UVT of the water entering the UV reactors.

EXHIBIT 2-13
MPTP Finished Water UV Transmittance



A linear relationship was formed between TOC and UVT in order to determine what effluent UVT value may correspond with the target GAC effluent TOC goal of 1.25 mg/L. The relationship between filter effluent TOC and finished water UVT at MPTP is presented in Exhibit 2-14. The resultant effluent UVT level corresponding to a GAC effluent TOC of 1.25 mg/L is about 96 percent. The best fit linear regression is shown. The correlation coefficient (R2 value) shows scatter and not as good of a correlation as that for FTTP.

EXHIBIT 2-14
MPTP Finished Water UVT vs. Filter Effluent TOC



2.3.2 FTTP and MPTP Finished Water Quality Differences

It is interesting to note that while both plants use the same source water (Ohio River) and use conventional treatment processes, there are slight differences between the plants' finished water qualities. The differences can be attributed to the Actiflo® clarification process used at MPTP. Exhibit 2-15 presents the constituents with the most significant differences in concentrations.

EXHIBIT 2-15
Finished Water Quality Comparison (September 2003 – August 2008)

Constituent	FTTP		MPTP	
	Average	Range	Average	Range
TOC, mg/L Filtered	2.08	1.04 – 3.48	1.55	0.80 – 2.54
Alkalinity, mg/L Finished	61	29 - 101	56	38 - 94
Iron, mg/L Finished	2.0	0.003 – 48.8	0.6	0.009 – 12.4
Manganese, mg/L Finished	0.6	0.001 – 7.5	0.002	0.001 – 0.004
UV Absorbance (UVA254), cm-1 Finished	0.025	0.00 – 0.095	0.021	0.00 – 0.070

EXHIBIT 2-15
Finished Water Quality Comparison (September 2003 – August 2008)

Constituent	FTTP		MPTP	
	Average	Range	Average	Range
UV Transmittance (UVT254), % Finished	94.4	80.4 - 100.0	95.3	85.1 - 100.0
SUVA Finished	1.6	0.8 – 5.3	1.5	0.7 - 4.1

These results demonstrate that Actiflo® at MPTP does a better job at organics removal than conventional clarification at FTTP. This effectiveness will be beneficial in terms of operating costs for both post-filter GAC adsorption and for UV disinfection. Any improvements that NKWD can achieve at FTTP will be similarly advantageous.

2.3.3 Current Flows

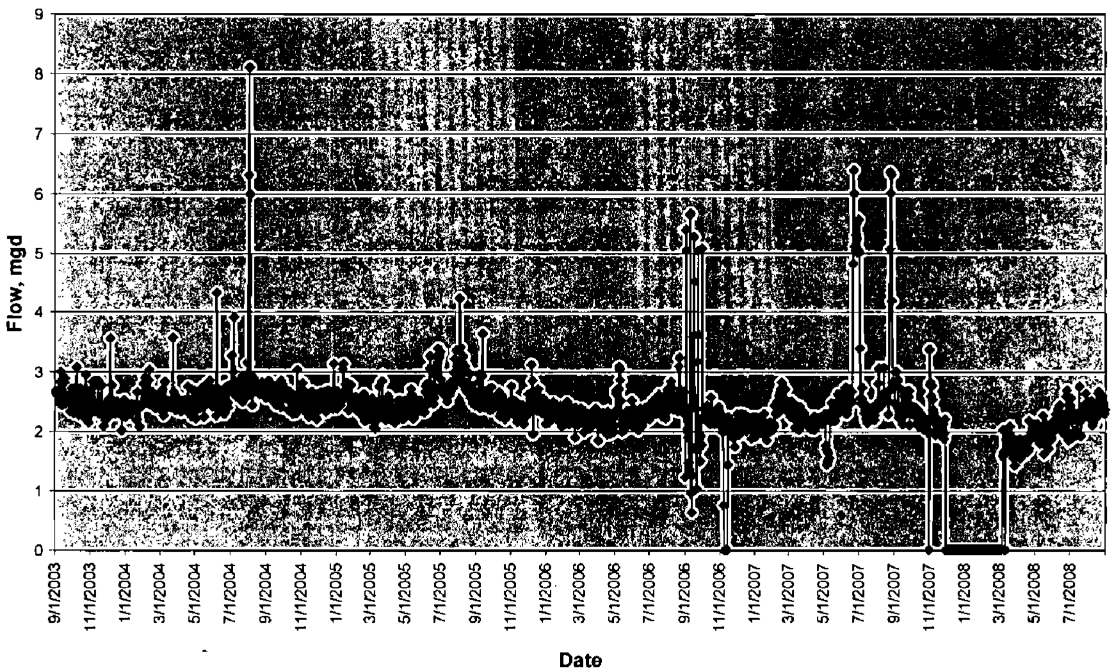
The daily average flow data for MPTP is summarized in Exhibit 2-16 and presented in Exhibit 2-17 through 2-20. The MPTP operates two shifts, 7 days per week. MPTP does not operate 3rd shift. The daily base flow is typically around 4.5 mgd; however, the average flow over 24 hours is 2.3 mgd.

EXHIBIT 2-16
MPTP Flow Data (September 2003 – August 2008)

Parameter	Average	Range
Flow, mgd	2.3	0.0 – 8.1

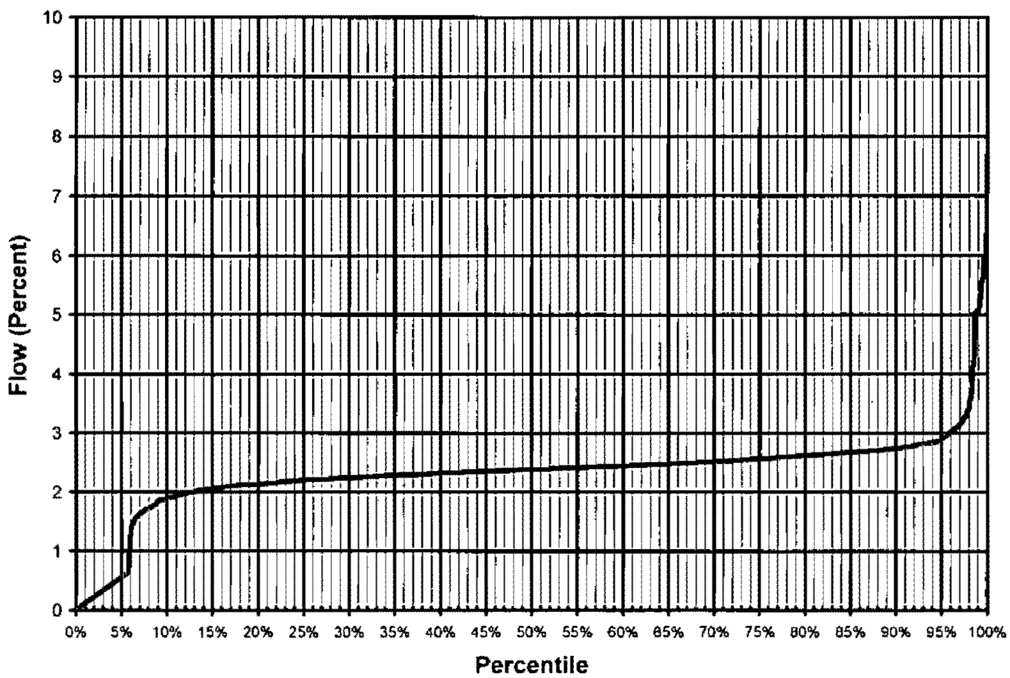
The daily average flow is presented in Exhibit 2-17.

EXHIBIT 2-17
MPTP Flow



A frequency analysis of the daily average flow is presented in Exhibit 2-18. About 39 percent of the flow data between September 2003 and August 2008 is less than or equal to the average day flow of 2.3 mgd. The plot also shows that 100 percent of the flow data has not exceeded 10 mgd.

EXHIBIT 2-18
MPTP Flow



Diurnal flow records for one winter and one summer month showing the variations in the production rate over the course of a day are shown on Exhibits 2-19 and 2-20, respectively. The diurnals show that the plant has not treated flow above 10 mgd.

EXHIBIT 2-19
MPTP Diurnal Flow
November 2007

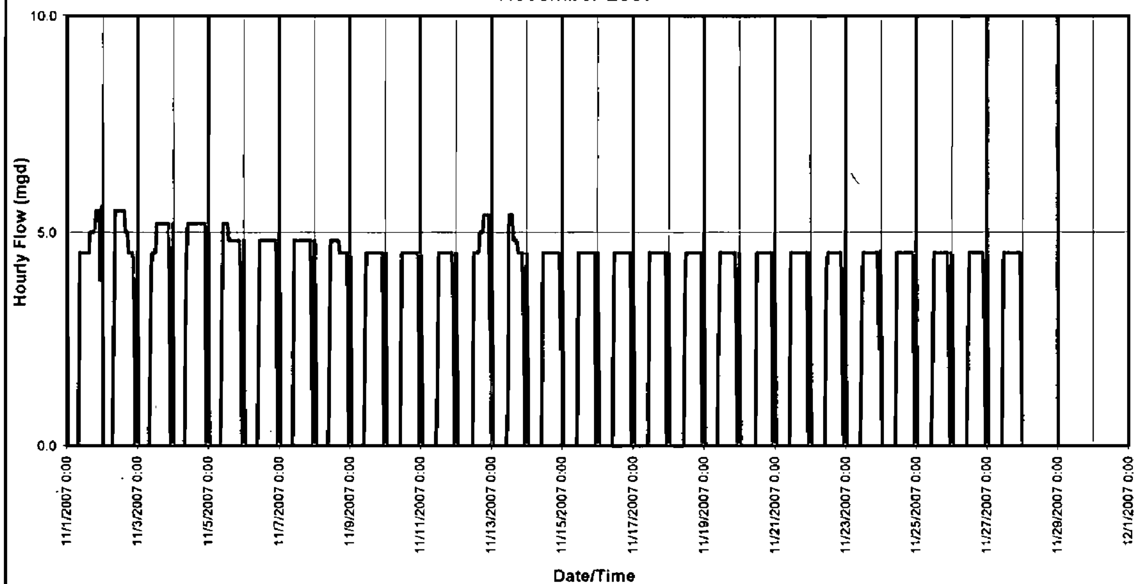
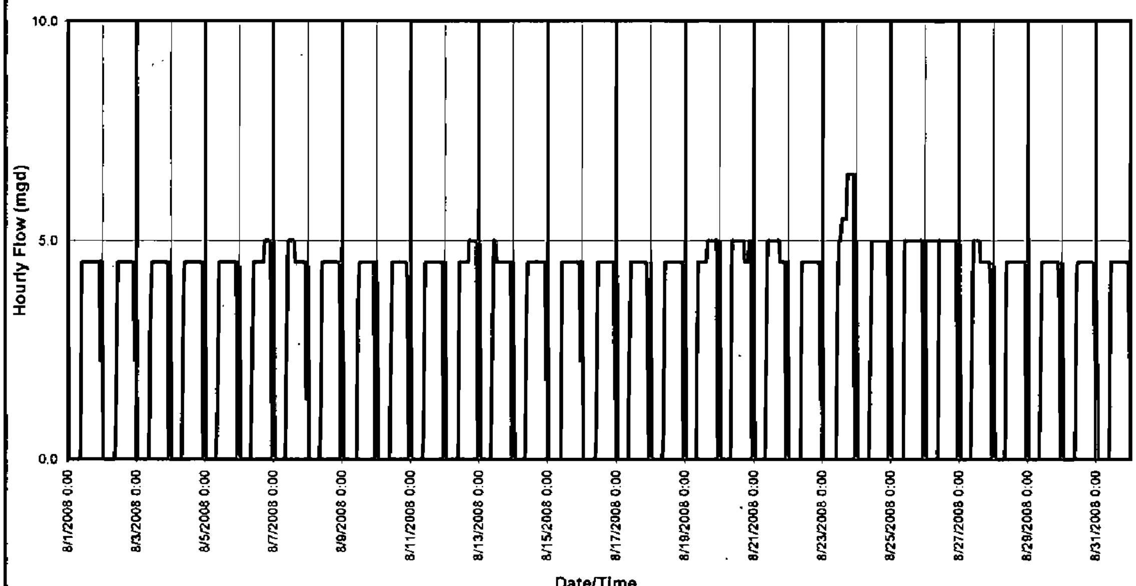


EXHIBIT 2-20
MPTP Diurnal Flow - August 2008



2.3.4 Flow Projections

The projected average day flow developed and provided by NKWD for MPTP for Year 2006 through 2030 is listed in Exhibit 2-21. The average day demands are based on the assumption that MPTP is expanded to 15 mgd in 2020 and that a major portion of the Covington area is supplied by MPTP in lieu of FTTP. The new facilities proposed for MPTP will allow the plant to be rated at 15 mgd; however, the plant can be expanded to at least 20 mgd in the long term. It is assumed that TMTP will supply 6 mgd through 2030 under average day conditions.

EXHIBIT 2-21
MPTP Flow Projections

Year	Average Day, mgd
2006	2.70
2007	2.83
2008	2.96
2009	3.08
2010	3.21
2011	3.34
2012	3.47
2013	3.60
2014	3.72
2015	3.85
2016	3.98
2017	4.11
2018	4.24
2019	4.37
2020	8.87
2021	8.90
2022	8.94
2023	8.97
2024	9.01
2025	9.04
2026	9.07
2027	9.11
2028	9.14
2029	9.18
2030	9.21

SECTION 3

Review of Preliminary Design Report

In January 2006, the United States Environmental Protection Agency (USEPA) published the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 Disinfectants and Disinfection By-Product (DBP) Rule. Both regulations will take effect in mid-2012 for the NKWD. To comply with the Stage 2 DBP Rule, NKWD will need to reduce concentrations of DBPs, particularly in warm weather months at points in the water distribution system. Monitoring of DBPs is ongoing by NKWD and levels exceeding the future standards have been identified at locations in the service area of both the FTTP and MPTP.

The Northern Kentucky Water District (NKWD), Malcolm Pirnie, and GRW, Inc., completed a preliminary design report, "Preliminary Design of GAC Systems," in March 2008. This document is referred to as the "PD Report, March 2008". The PD Report, March, 2008, summarized a review of treatment options for NKWD to comply with these new regulations, and then recommended specific compliance strategies (treatment technologies) for implementation. Available site options were reviewed for each treatment technology at each of the NKWD's three treatment plants, and specific site locations were recommended for the new facilities. The PD Report, March 2008 also included an opinion of probable project costs for each NKWD treatment plant.

One of the initial tasks for the current project, Advanced Treatment at FTTP and MPTP, was to review the key recommendations of the PD Report, March 2008. The objective was to make the preliminary engineering as efficient as possible by building on the prior recommendations. In the following sections, the key recommendations of the PD Report, March 2008 are reviewed, and the specific recommendations that were carried forward for the Advanced Treatment at FTTP and MPTP project are identified.

3.1 Processes

Based on the PD Report, March 2008, the NKWD is proceeding with implementing two new treatment technologies, post-filter GAC adsorption and UV disinfection, at the FTTP and at the MPTP. These treatment technologies are feasible approaches to meet the NKWD treatment objectives, as described in the following sections.

3.1.1 GAC Adsorption

GAC adsorption is being implemented to reduce the concentration of organics that serve as the precursors to the formation of DBPs, specifically total trihalomethanes (TTHMs) and haloacetic acids (HAAs), which are regulated under the Stage 2 DBP Rule. Based on bench-scale testing completed by the NKWD, an effluent total organic carbon (TOC) target concentration of 1.25 mg/L was established as the treatment goal for GAC adsorption. Based on the testing completed and the specific characteristics of the NKWD treatment facilities and distribution system, if TOC is removed to this concentration through upstream treatment and GAC adsorption, the NKWD anticipates compliance with the Stage 2 DBP Rule. It is recommended that NKWD review the target after the Advanced Treatment facilities are operational to determine whether seasonal or overall adjustments can be made.

The design concept for GAC adsorption was based on rapid small-scale column tests (RSSCTs) performed on several occasions by researchers under contract to NKWD. These tests, combined with simulated distribution system (SDS) tests of DBP formation, identified the treatment target noted previously. In addition, the PD Report, March 2008 included analyses that recommended the post-filter GAC adsorption process be designed with a 20-minute empty bed contact time (EBCT). This EBCT was found to provide a balance between capital cost, GAC bed life, and Operation and Maintenance cost.

Additional key assumptions and/or recommendations noted in the PD Report, March 2008 include the following:

- Operating modes were evaluated, and a staggered operation approach was recommended. With this approach, GAC media is changed in one contactor at a time, utilizing blending and the shape of the GAC exhaustion curve to reduce GAC replacement frequency and costs.
- As noted in Table 4-2 of the PD Report, March, 2008, the estimated replacement frequency for GAC was every 200 days at the FTTP and, per Table 5-2, every 240 to 260 days at the MPTP. These replacement frequencies are based on maximum design flow rates at each plant. With 8 contactors at the FTTP, a 200-day replacement frequency, and a staggered operation mode, replacement of the GAC in an individual contactor would be as frequently as every 200 days divided by 8 contactors, or every 25 days.
- The proposed design from the PD Report, March 2008 provides a 20-minute EBCT at the FTTP with all contactors in service. At the MPTP, the design EBCT is 19.8 minutes with all contactors in service.

From the preliminary design, the number of contactors, EBCT, and operation mode are feasible design criteria, consistent with standards of the industry, and these elements of the project have been incorporated into the detailed design.

Based on review of the PD Report, March 2008 by CH2M HILL/HDR, the following points are noted for consideration:

- GAC media life will be extended, with less frequent required media replacement, with EBCTs exceeding 20 minutes. All contactors should be in service at all times when available. For operation at anticipated average flowrates at each treatment plant, the GAC is expected to last more than 200 days before replacement is necessary to meet the finished water TOC target.

- GAC media life will be extended, with less frequent required media replacement, with better TOC removal through conventional treatment. The more TOC removed prior to GAC, the more bed volumes GAC will be able to treat. The bench-scale RSSCTs were conducted with 2.4 to 2.7 mg/L of TOC in the GAC influent. Optimizing coagulation and conventional treatment may allow the NKWD to further reduce GAC replacement frequency and operating costs.
- The Advanced Treatment at FTTP and MPTP project will include further evaluation of operating strategies and operations planning as the project progresses. These evaluations should include developing a plan to get into staggered operation mode. This may consist of operating fewer than all contactors during initial operation.
- The evaluation of operating modes should also address development of a plan for scheduling media unloading and new media deliveries with the GAC supplier. With varying flowrates and varying TOC loading to the post-filter GAC contactors, the initial schedule may require forecasts and conservatism to meet water quality targets.

3.1.2 UV Disinfection

The PD Report, March 2008 also included "contingencies for including a UV disinfection facility at each treatment plant" in the event NKWD desires to add an additional microbial barrier to the WTP process. The PD Report, March 2008 includes preliminary planning for UV disinfection at each facility, and a UV facility is included in the opinion of probable project costs for each NKWD treatment plant.

For the Advanced Treatment at FTTP and MPTP project, the design of UV disinfection facilities was included in the scope of work. Although Cryptosporidium sampling of the NKWD source waters does not indicate a regulatory need to provide UV disinfection, the NKWD has identified the water quality improvement and public health benefit of UV disinfection as meriting the inclusion of UV facilities in the project. This element of the project has been included in the detailed design.

3.2 Facilities

In the following sections, the new facilities are described separately for each treatment plant.

3.2.1 Fort Thomas Treatment Plant

At the FTTP, available space at the existing site is extremely limited. The PD Report, March 2008 included an evaluation of available locations for GAC facilities, and "Option 3," with the new facilities located at the south end of the plant site, east of the existing Water Quality Laboratory, was identified as the recommended location. This location does involve some key constraints, specifically constructing the building along a steep hillside with minimal room for modification to the building dimensions estimated in the PD Report, March 2008. This approach requires constructing three walls of the GAC building as retaining walls, with significant rock excavation required for construction.

To fit the GAC contactors on the selected site location, it is necessary to design and construct the contactors in a linear arrangement. CH2M HILL's preferred filter (or contactor) arrangement involves a center filter piping gallery, with the longer dimension of the filters parallel to the gallery wall to provide plenty of spacing, lay lengths for pipe and components, and access for operations. At the FTTP, the restrictive site constraints dictate the layout of the GAC contactors. This linear arrangement is feasible, and will be designed to maximize spacing and access within the available footprint.

Flow to the GAC facility will be pumped, with a new booster pump station and wetwell shown as a separate, adjacent facility. Backwash supply flows were assumed to be pumped from either the same booster pump station wetwell or from the existing finished water clearwell. The PD Report, March 2008 assumed that backwash waste and contactor-to-waste flows from GAC would be routed to an equalization basin located beneath the GAC facility.

The UV disinfection facility was assumed to be located in a separate building, adjacent to the GAC facility. As described later in this document, for economic and space planning reasons, the design has been modified to make the UV disinfection facility part of a common building with the GAC facility.

Based on review of the site constraints and the potential locations, the site location selected represents a feasible location for the new facilities.

3.2.2 Memorial Parkway Treatment Plant

The MPTP is also restrictive in terms of options for a new GAC facility. The PD Report, March 2008 reviewed two site options, and it was recommended that the GAC contactors be installed in the footprint of existing Sedimentation Basins No. 5 and No. 6. These two basins were removed from service in 1997 when the Actiflo process was installed for clarification. Similar to the FTTP, this retrofit location assumes the contactors are constructed in a linear arrangement (Configuration C of the PD Report, March 2008).

Flow to the GAC facility will be pumped, with a new booster pump station and wetwell shown as a separate, adjacent facility. Backwash supply flows were assumed to be pumped from the same booster pump station wetwell. The PD Report, March 2008 assumed that backwash waste and contactor-to-waste flows from GAC would be routed directly by gravity to the existing North Reservoir.

The UV disinfection facility was assumed to be located in a separate room on the footprint of the abandoned flocculation basins, adjacent to the GAC facility.

Based on review of the site constraints and the potential locations, the site location selected represents a feasible location for the new facilities.

3.2.3 Common Elements of Both Facilities

There are a number of elements that both the FTTP and MPTP have in common, and that will be incorporated in final design of the GAC facilities. These elements include the following:

- Access along the full gallery length, with truck access on the gallery side of the contactors.
- Dedicated GAC truck transfer station for each contactor.
- GAC contactor-to-waste piping.
- Differential pressure transmitters for each contactor to allow headloss measurement.

There are also certain, specific elements of the PD Report, March 2008 recommendations that have not been carried forward as development of the project concepts for final design has progressed. These elements, which include the type of underdrain, the inclusion of air scour, the need for dechlorination facilities, the backwash supply location, and the specific flows to be accommodated at the backwash waste equalization basin, are addressed in the following sections of this document.

SECTION 4

Site Visits

4.1 Introduction

Tours of operational GAC facilities were taken by NKWD, CH2M HILL, and HDR staff during October 2008 for the purpose of gaining insights into the design and operation of GAC contactors. The facilities included a wastewater treatment plant with both pressure and gravity contactors and a regeneration system and three water treatment plants with post-filter GAC contactors. A tour of the Greater Cincinnati Water Works' (GCWW) Richard Miller WTP to supplement the information gained on the prior trips is planned to occur during the final detailed design period. The plants were selected based on plant capacity and features of interest to the District to be incorporated at FTTP and MPTP. The following sections summarize the lessons learned; site specific GAC system components; operation and maintenance observations; and design recommendations from the tours.

4.2 Lessons Learned

The key lessons learned from the site visits include the following:

- The GAC market is very fluid as a result of increasing activated carbon use at water plants and electrical power plants and the introduction of foreign produced GAC. It is very difficult to project future costs for virgin and regenerated carbon due to the volatility in both the carbon and energy markets.
- Foreign produced carbon is increasingly available but historically the carbon has tended to break down into fines more readily than domestic carbon due to a different production method used for GAC formation.
- GAC delivery scheduling is critical when establishing a new account for initial bed fill. The supply is tight and vendors indicate a potential 8-month lead time for virgin, domestic carbon.
- Once an account is established vendors have honored supply schedules but the delivery window is on the order of weeks, not days as is the case with other treatment chemicals.
- Vendors are resistant to long-term (> 1 year) contracts with utilities.
- Vendors are increasingly interested in offering regeneration of GAC from a plant but regeneration is affected by seasonal swings in natural gas prices.

- Flexibility and simplicity are important for GAC deliveries. Most of the sites had one delivery approach in mind for GAC delivery (bulk or SuperSacks) and made modifications to the installed system later. Deliveries are dictated by how the suppliers can best deliver the GAC in the region.
- Simplify the GAC piping. Most of the sites installed more piping than they actually use. Provisions are needed to minimize plugging and ease cleaning of pipes. Suppliers tend to use their own hoses, eductors, and hoppers or cyclones for delivery or removal of GAC.
- Vendors provide crews for removing spent carbon and replacing new or regenerated carbon and the cost is included in the contract including the cost of replacing carbon lost as fines.
- All of the underdrains used at the tour sites were stainless steel. There was mixed success with the Johnson Screens. The Glendale, Arizona Oasis plant experienced trouble with the Triton (half circle) underdrains. Any underdrain, regardless of material of construction, can plug if the GAC is not placed properly; therefore, a good placement and defining plan is required.
- Considerable release of fines occurs when loading new or regenerated carbon in contactors. GAC should be specified by volume or tank level and not by mass. GAC also should be loaded in lifts with backwashes in between the lifts followed by contactor to waste operation for final de-fining.
- When GAC is loaded into a basin in the slurry form the GAC should be submerged and allowed to soak up water for several hours before backwashing and when placed in dry form the resting period should be considerably longer
- A robust supply of slurry water is needed for carbon transport for loading and unloading basins. At least 110 psi and 100 gpm are needed.
- Air scour is preferred by the plants that have it.
- The level of effort to operate the GAC facilities is similar to that for conventional sand filters.
- Instrumentation such as TOC analyzers, turbidity analyzers can provide valuable operating information but due to the extended carbon delivery window and the variations in carbon life, monitoring of contactor performance parameters on a daily or weekly basis is normally adequate for operations.

4.3 UOSA

The UOSA Millard Robbins Water Reclamation Plant, located in Centerville, Virginia, was toured on October 7, 2008.

Tour Hosts:

- Bob Angelloti – Director of Technical Services
- Matt Brooks – Operations Process Control

- Jack Sellman – Operations Supervisor
- Bill Kulik – Controls System Engineer

Attendees:

- Amy Kramer/NKWD
- Richard Harrison/NKWD
- Bill Wulfeck/NKWD
- John Schmiade/NKWD
- Brent Tippey/HDR-Quest
- Paul Swaim/CH2M HILL
- Nick Winnike/CH2M HILL

Key observations from the visit are presented in the following sections.

- Design Capacity 54 mgd.
- Average Day Flow 30 mgd.
- GAC system follows sand filters.

4.3.1 GAC System Components

- 32 upflow/downflow pressure contactors (1 MGD capacity each).
- Each pressure vessel holds 80,000 lbs of carbon.
- Eight upflow/downflow 2-cell gravity contactors, 10ft media depth, flat bottom with 1,200 plastic US Filter nozzles per cell.
- Two 500 cu ft blow down tanks for transferring carbon from gravity contactors.
- Two 5,000 cu ft carbon storage/transfer tanks, capacity equal to 1 cell of a gravity contactor.
- Multiple hearth regeneration furnace (6 hearths).
- Two defining tanks.
- Dewatering bin at top of incinerator holds 500 cu ft (12,000 lbs) of carbon.
- 10 million gallon ballast pond upstream of contactors.

4.3.2 Operation and Maintenance Observations

- Contactors operated in biological mode, remove COD and prolong carbon life.
- CBOD removal of 3 mg/l from biofilm on GAC.
- UOSA does not chlorinate backwash water because it can kill biomass.
- Filter effluent turbidity 0.15-0.25 NTU.
- GAC Contactor effluent 0.5 NTU.
- GAC Influent TOC around 5 mg/L.

- GAC Effluent TOC 1.5 to 2.0 mg/L up to 3.5 mg/L.
- Organics are mostly dissolved.
- F300 Calgon used based on pilot testing of different sizes. UOSA doesn't have to go out for bid for procurement because of performance study.
- Evaluated Chinese carbon in study, but was 30% to 35% less effective than domestic.
- UOSA will purchase single reactivated carbon but not later generation; this saves about 25% of purchase cost, but delivery can take several months depending on availability.
- UOSA rarely does a "wholesale" replacement of carbon.
- UOSA doesn't require acid wash of regenerated carbon in purchase specification.
- Calcium on the carbon catalyzes reaction during regeneration and its removal with acid wash is not wanted.
- 4-5 days of contactor to waste to wash out fines after regeneration or new carbon.
- 4-5 million gallons of contactor to waste flow required to remove fines from 80,000 lbs of regenerated or new carbon.
- Pressure vessels regenerated about 1/3-2/3 of carbon at a time.
- Defining process to remove fines prior to filling pressure vessels.
- More fines in virgins than regenerated carbon.
- Add water to wet carbon for better fines control when unloading.
- Water tight trucks used for spent carbon hauling.
- Use vactor truck with screen for removing water from spent carbon while loading onto truck.
- 4 hours to unload new carbon, some drivers took twice that long when not observed by plant staff.
- 4-5 hours to load spent carbon in truck.
- GAC building does not have dehumidification.
- Keep lights off to keep algae growth down.
- Well screens over backwash troughs.
- Keep pH under 8 to reduce calcium scaling on carbon.
- Regenerate pressure vessels every 6 months, gravity contactors every 3 months.
- 10 percent carbon loss at regeneration.
- Regeneration furnace runs 10-12 weeks, twice a year late fall and early spring.

- UOSA calculation concluded cheaper to regenerate on-site than to buy new carbon.
- Storing carbon outside made it more friable.
- Plant control system set GAC contacted water flow target and let flows upstream fluctuate to match.
- Gravity contactors have flat bottom and leave last 20 percent of carbon (2 ft) in tanks because of difficulty removing below this level.
- For gravity contactors, the old carbon is placed in the upflow cell followed by the regenerated carbon in the downflow cell.
- If both gravity cells have old carbon, both cells are operated in the downflow mode.
- Takes less than a day to remove carbon from a gravity contactor (all but bottom two feet).
- Pressure vessel coating should be factory inspected.
- Use SCADA to accumulate total flow through each contactor after regeneration.
- Match influent slurry water flow with drain flow for pressure vessels as moving carbon into vessel.
- Stagger exhaustion of vessels whether pressure or gravity.
- Each operator has own approach to removing spent carbon, some use eductor but others just slurry and pump.
- UOSA does not maintain entire carbon content of any vessel at same age, replace only part at a time.
- Wire brushing well screens required in pressure vessels.
- Apparent bulk density metric used to determine completion of regeneration.
- Staffing requirements comparable to operating filters for normal operation of GAC.
- 50 psi water supply used to push carbon from pressure vessels.
- 110 psi eductor water supply used for unloading trucks.
- Can put booster pumps on eductor effluent for moving carbon from truck to facility, head needs will dictate need.
- Backwash of gravity contactors based on headloss.
- Contactor backwash duration is manually controlled based on color of water.
- Backwash water sent to retention ponds that return flow to the head of treatment plant. UOSA has less than one day of storage at 45 MG each.
- Backwash by gravity; no pumps.

- Only one retention pond is lined. Ponds have shale bottoms. UOSA scrapes the bottom of ponds annually.
- Operators have to manually operate valves for pressure vessels to get full capacity.
- Pressure vessels were modified to reduce media depth from original 20 feet and went to downflow instead of upflow configuration. UOSA still has the ability to go upflow, if desired.
- Post filters are not used anymore in the downflow mode after pressure vessels. Screens were getting clogged by fines in upflow mode, but don't have a problem in the downflow mode.
- Only one other US Filter upflow installation has plastic nozzles and they failed too. UOSA provides small, 1 1/2 inch hose and water to spray into truck hopper to prevent bridging when unloading truck.

4.3.3 Design Recommendations

- Gate valves on carbon lines should be installed in the vertical position upside down at a 45 degree angle to prevent the GAC from compacting under the gate.
- Air supply not needed for unloading open top carbon trucks.
- Initially had fixed nozzle spray system in contactors to assist in carbon removal but were not effective.
- Properly insulate dissimilar metals to prevent corrosion.
- Floor drains plug with carbon, suggest cleanable pit with overflow.
- Carbon steel piping abraded within 15 years especially at bends.
- Sight glass (Ernst, Farmingdale, NJ) at frequent locations in carbon transport piping.
- Cleanouts at all low spots in vertical piping and every 30 ft in horizontal runs of carbon transport piping.
- Plastic nozzles eroded in upflow mode and had to be replaced after 6 months.
- Plastic nozzles not a problem in downflow mode.
- Stainless steel nozzles are available as custom order.
- Made slits in nozzles 2 times bigger to avoid biological plugging.
- Don't use iodine or molasses number.
- 10 MG of ballast pond capacity for feeding GAC, need a minimum of 3 MG, recommend 10 percent of forward flow minimum.

4.4 Twin Oaks Valley Water Treatment Plant

The Twin Oaks Valley WTP, located in San Diego, California, was toured on October 27, 2008.

Tour Host:

- Brian McDonald – CH2M HILL/OMI Project Manager Operations

Attendees:

- Amy Kramer/NKWD
- Ron Lovan/NKWD
- Mike Greer/NKWD
- Matt Piccirillo/NKWD
- Amy Matracia/NKWD
- Laura Talarek/NKWD
- Kevin Owen/NKWD
- Larry Anderson/HDR
- Brent Tippey/HDR-Quest
- Paul Swaim/CH2M HILL
- Nick Winnike/CH2M HILL

Key observations from the visit are presented in the following sections.

- Design Capacity 100 mgd.
- Average Day Flow 85 mgd.
- GAC system follows membranes and ozone contactor.
- Surface water treatment drawing supply from either Colorado River system or California Delta water system, Regional water consortium controls supply.
- Began operation June 2008.

4.4.1 GAC System Components

- 10 downflow gravity contactors, 6 ft media depth, flat bottom with AWI underdrains and air scour system.
- Each contactor contains about 161,000 lbs of GAC.
- Contactors are open to air, not within a building.
- GAC stored in supersacks outdoors.
- 2 150,000 equalization tanks for membrane permeate, GAC backwash, and centrifuge centrate.

4.4.2 Operation and Maintenance Observations

- Contactors operated in biological mode, stabilize AOC after ozone.

- Backwash water supply is not chlorinated but chlorine is added in summer to control algae and midge flies.
- Membrane effluent turbidity 0.02-0.03 NTU.
- GAC Contactor effluent 0.05-0.08 NTU.
- GAC Influent TOC is not measured because it is not a factor of performance and compliance.
- GAC Effluent TOC is not measured because it is not a factor of performance and compliance.
- BDOC is checked on occasion for contract compliance.
- 1.2 mm GAC used, larger than for absorbers, provides medium for biological stabilization.
- Selected Chinese carbon based on price and plan for infrequent replacement.
- Carbon replacement not intended with biological operation, carbon added only to replace attrition.
- Filled basins with GAC by lifting supersacks over basin and dry drop into bed.
- After carbon fill, ramp up flow to contactors to minimize carbon loss.
- Losing carbon in bed where air supply for air scour appears to be at highest pressure, tracking down causes.
- During a demonstration backwash carbon loss was also observed through holes in wall to backwash trough. Holes intended to drop water level before starting air scour and are intended to have screens to prevent carbon loss.
- Uneven carbon surface was evident with highest level on trough side and lowest level on other side.
- Air scour is beneficial but no testing backwash water savings from air scour has been undertaken.
- Water flows by gravity from ozone contactor through GAC system, flow control valves provide for uniform flow through all contactors.
- Gravity contactors have flat bottom, filled beds to full depth before backwash.
- Backwash frequency, once per day, to date has been determined primarily by need to control midge flies.
- GAC is not hauled in bulk. Supersacks are used and GAC is placed with a crane.
- Intend to backwash of contactors based on headloss.
- Weekly HPC analysis conducted to determine need for chlorination of backwash for algae control.
- Basins are backwashed before being idled and again before coming on line.

- Backwash by gravity from tank on hill above basins; no pumps.
- Backwash water sent to equalization tanks with membrane concentrate then treated with plate settlers and return to the head of treatment plant.
- Mixing pumps in EQ basin experienced seal failure after defining carbon from initial bed fill.
- Plant has requirement of zero discharge of liquid streams and draws supply from existing concrete reservoir, therefore contactor to waste capability was not provided.
- In spite of carbon loss, GAC has not been detected in downstream water reservoir.
- Not confident in accuracy of on-line Hach analyzer, tends to vary from lab tests.
- Original operations plan was to bring contactors on line up to full design capacity and run as many contactors as needed to satisfy production demands. Have found that operating all contactors at the same rate produces better finished water turbidity.

4.4.3 Design Recommendations

- Contactor to waste should be provided if not precluded by other operational restrictions.
- Air scour recommended as it aids in removal of biology and fines.
- 304 stainless steel in plate settler starting to stain just a few months after startup, recommend 316 stainless.

4.5 Chaparral Water Treatment Plant

The Chaparral WTP, located in Scottsdale, Arizona, was toured on October 28, 2008.

Tour Hosts:

- Art Nunez- Water and Wastewater Treatment Director
- Don Henderson – Senior Water Treatment Plant Operator
- Binga Talabi – Laboratory Manager

Attendees:

- Amy Kramer/NKWD
- Mike Greer/NKWD
- Matt Piccirillo/NKWD
- Amy Matracia/NKWD
- Laura Talarek/NKWD
- Kevin Owen/NKWD
- Larry Anderson/HDR
- Brent Tippey/HDR-Quest

- Paul Swaim/CH2M HILL
- Nick Winnike/CH2M HILL

Key observations from the visit are presented in the following sections.

- Design Capacity 30 mgd.
- Average Day Flow 14 mgd.
- GAC system follows membranes.
- Surface water treatment drawing supply from SRP canal system, Regional water consortium controls supply from one of 3 rivers.
- Began operation March 2006.

4.5.1 GAC System Components

- 10 downflow gravity contactors, 8 ft media depth, and 16.6 EBCT design rate.
- sloped bottom with Johnson Screen underdrains.
- Each contactor contains 140,000 lbs of GAC.
- GAC stored in supersacks outdoors.

4.5.2 Operation and Maintenance Observations

- Scottsdale has been running the Chaparral plant since 2006 but are starting up a larger GAC plant at this time.
- Contactors operated for absorption have noted that sometimes TOC goes down but THMs increase.
- Backwash water supply is from finished water reservoir and is dechlorinated using sodium bisulfite.
- Backwash based on headloss and occurs about 30-day intervals.
- Membrane effluent turbidity 0.03 NTU.
- GAC Contactor effluent 0.05 NTU.
- GAC Effluent TOC 1.6 mg/L.
- 12x40 mesh GAC used at the new plant.
- Initially used Calgon, Norit and Jacobi (Chinese) carbon and found Jacobi to be inferior with more fines.
- Have removed all original carbon and landfilled all Jacobi.
- Have been told but did not verify that Chinese carbon production leaves out a step in the particle production which saves cost but results in more fines.

- Have contract with Calgon to remove, regenerate and replace GAC.
- Carbon is hauled to Midwest for regeneration.
- Their first generation reactivated GAC performs as good or better than the virgin carbon.
- Calgon contract is 1 year term, nothing longer offered by vendor without tying to cost indexes for inflation.
- Supersacks don't last more than 3 months outside.
- Calgon filling hopper is 6 ft x 6 ft x 13 ft tall and cyclone for removing carbon is 12 ft x 12 ft x 15 ft tall.
- Floor slope in contactors is not adequate to provide benefit in removing carbon.
- Backwash laterals cause carbon to dam up behind it.
- Have stainless steel Johnson Screen underdrains which are expensive but wanted the best. Not sure if the extra cost was justified.
- Remove carbon using eductor and hose system and no problem getting carbon completely removed.
- Have staggered replacement schedule for carbon. It took years to achieve.
- Have sample ports at 3 depths in the contactors but have not used them.
- Put water in bed then backwash in stages during GAC loading after each 1/2 bed lift and again after filling. Backwash for 30 minutes each time then contactor to waste 90 minutes.
- Backwash at a lower rate for fluffing about once a month did not provide any benefit.
- Run full design flow rate of 3 mgd of contactor to waste flow for a total volume of about 140,000 gal to remove fines after GAC replacement.
- Initially filled basins with GAC by lifting SuperSacks over basin and dry drop into bed.
- Takes about 1 ½ days to remove spent carbon and 2 days to place new carbon. Place in two lifts and let sit overnight after first lift.
- 100 psi and 200 gpm water supply used for educting carbon, have to run pumps in series to provide the necessary pressure.
- Vendors originally proposed regenerated GAC prices to be about half of virgin prices but in the recent round of bidding the vendors offered less than 10 % discount for regenerated GAC.
- Have not had any problems taking a bed out of service for a period of hours or days and putting it back in service.

- Backwash water sent to wash water recovery basing with membrane concentrate then treated with plate settlers and return to the head of treatment plant.
- Submersible pump used in EQ basin.
- After plant startup the flow to individual contactors was adjusted to exhaust the carbon at different times to accomplish a staggered replacement schedule.
- Still optimizing GAC operation but believe that pre-chlorinating the membrane effluent before introducing to GAC may aid in precursor removal in beds.
- Operators run contacted water samples through lab filter to check for carbon fines after backwash or loading contactors.
- S-Can monitor used for SUVA and has performed well but is expensive at $30,000.

4.5.3 Design Recommendations

- Carbon bid specification should quantify volume not weight and include backwash at least twice during fill to ensure full intended EBCT.
- 3 or 4 inch eductor should be used for carbon loading and unloading.
- A single eductor with hoses for connection to truck and basin is adequate, don't need individual eductors.
- Provide at least 110psi and 100 gpm motive water system.
- Provide flexible unloading system as vendors planned bulk delivery and then changed to SuperSacks after design.
- Obtain test columns or other features desired to operate and optimize contactors as obtaining budget for such features later is difficult.
- Provide TOC analyzer (Sievers) but put it in the lab.
- Provide wash water recovery basin size to accommodate both GAC backwash and other discharges that may result from turbidity spikes in raw water supply.
- Provide containment for water that escapes during loading and unloading operations outside building.

4.6 Oasis Water Treatment Plant

The Oasis WTP, located in Glendale, Arizona, was toured on October 28, 2008.

Tour Host:

- Dawn Slauter - Utilities Supervisor Oasis Water Campus

Attendees:

- Amy Kramer/NKWD
- Mike Greer/NKWD

- Matt Piccirillo/NKWD
- Amy Matracia/NKWD
- Laura Talarek/NKWD
- Kevin Owen/NKWD
- Larry Anderson/HDR
- Brent Tippey/HDR-Quest
- Paul Swaim/CH2M HILL
- Nick Winnike/CH2M HILL

Key observations from the visit are presented in the following sections.

- Design Capacity 10 mgd.
- Average Day Flow 7 mgd.
- GAC system follows sedimentation basins and operates as filtration process.
- Contactor beds are open air with no building above.
- Surface water treatment drawing supply from SRP canal system, Regional water consortium controls supply from one of 3 rivers.
- Began operation October 2007.

4.6.1 GAC System Components

- 5 downflow gravity contactors, 6 ft media depth.
- Flat bottom with Johnson Triton (semi circle) underdrains.
- Each contactor contains 81 sacks (about 80,000 lbs) of GAC.
- GAC stored in SuperSacks outdoors.

4.6.2 Operation and Maintenance Observations

- Plant has been in operation for a year and the carbon has been changed out at least once in each contactor.
- Contactors operated as filters and typically run about 96 hours between backwashes.
- Minimal biology in filters.
- Raw water turbidity to plant ranges from 2 -1,000 NTU.
- Use S-CAN for raw and finished water analysis.
- GAC Effluent TOC target is 2 mg/L.
- 8 x 20 mesh (1.0 to 1.2 mm) GAC used.
- Initially installed Calgon carbon and have replacement contract with Calgon which was the only bidder to offer regeneration of Oasis carbon. Satisfied with performance of regenerated carbon.

- Flat floor in contactors but grade tolerance in specification was ¼ inch and this has contributed to problems with the underdrain.
- Johnson Triton underdrains provided with air scour. Both air and water pipes run beneath basin and enter underdrain laterals from below.
- Underdrain laterals are held down only by angle iron supports at 3 locations across basin. When air is activated the underdrains vibrate which has caused the seal on the air penetration into the bottom of the laterals to fail resulting in carbon loss into air headers.
- Procured underdrains on direct purchase contract and are working with Johnson to resolve the problem but this is a new product and Johnson is struggling with determining a fix.
- Initial installation of carbon was by dry drop from SuperSacks into beds.
- Remove and replace carbon using eductor and hose system with SuperSacks. No installed carbon loading pipes, just run hoses over wall of basin.
- The removal and replacement process can be completed in 2 days.
- Carbon is hauled to Midwest for regeneration.
- No problem removing carbon from basins.
- Backwash 3-4 times (~ 150,000 gallons) to remove fines.
- Air scour helps remove fines.
- Operate contactors to achieve a staggered carbon replacement schedule.
- Stated preference for Leopold type flat underdrain system.
- Backwash on head loss, turbidity or time.
- Backwash water sent to 500,000 gallon equalization basin then onto a clarifier before being returned to the raw water pump station.
- Submersible pumps serve the equalization basin.
- Backwash water is supplied from a 230,000 gallon backwash pump station at the front end of a finished water reservoir before chlorine is added.
- Use turbidimeters, particle counters and Sievers TOC analyzer (in lab) and like all instruments.

4.6.3 Design Recommendations

- Flat floor and flat underdrain system with air scour.
- Provide simple carbon loading and unloading system as vendors have their own equipment.

4.7 Richard Miller Water Treatment Plant

A tour of the Greater Cincinnati Water Works' (GCWW) Richard Miller WTP has not been scheduled at this time.

- 240 mgd post-filter GAC contactors.
- Carbon loading.
- Regeneration.

SECTION 5

Design Standards

5.1 UV and Advanced Oxidation

This section presents the preliminary design recommendations for the installation of UV disinfection at the Fort Thomas Treatment Plant and Memorial Parkway Treatment Plant. The design objective of 2.5 log inactivation of Cryptosporidium was used to compare various types of UV disinfection technologies on the basis of footprint and lifecycle costs. After reviewing several UV disinfection products that met the design criteria, the decision was made to proceed with a procurement strategy for the installation of medium pressure UV equipment at both treatment plants. Building layouts that will accommodate three UV reactor trains at FTTP and two UV reactor trains at MPTP were found to be the most cost-effective.

5.1.1 UV System Design Criteria

The UV systems will be designed and operated to provide 2.5 log inactivation of Cryptosporidium per the requirements in the EPA UV Disinfection Guidance Manual (UVDGM). This will also provide at least 2.5 log inactivation of Giardia. Viruses will be inactivated using the existing chlorine dosing and contacting system. To achieve 2.5 log inactivation of Cryptosporidium, the UVDGM requires a UV dose of 8.5 mJ/cm2 that must be demonstrated through manufacturer validation testing and application of a validation factor to account for uncertainties in the validation. Manufacturers must provide documentation supporting that their equipment recommendations have been validated in accordance with the UVDGM. In addition to the UV dose requirements, UV system designs are developed based on the following:

- Peak design flow.
- Influent water quality (UV transmittance).
- UV output over the course of the lamp lifecycle.
- Fouling potential.
- Redundancy requirements (one unit out of service at peak design flow).
- Headloss considerations.

The design criteria in Exhibit 5-1 are proposed for the UV disinfection systems at FTTP and MPTP. Data analysis supporting the selection of a 95% UV transmittance (UVT) for both plants is summarized in Section 2.

EXHIBIT 5-1
UV System Design Criteria

Design Criteria	Value
Peak Design Flow (mgd) FTTP MPTP	 44 20
Average Design Flow (2009 - 2028) (mgd) FTTP MPTP	 23.5 6.1
Design Dose Log Inactivation - Cryptosporidium Delivered UV Dose (mJ/cm2)	 2.5 8.5
Minimum UVT	95%
End-of-Life Lamp Output (EOLL)	70%
Allowance for Fouling	90%
Maximum Head Loss through UV reactors (in)	24 inches
Redundancy Requirement	One standby unit out-of-service

5.1.2 UV Disinfection Technology Review

There are two types of UV disinfection technology that are under consideration for MPTP and FTTP: 1) low pressure – high output (LH) and 2) medium pressure – high output (MP). Equipment manufacturers for LH systems include Wedeco and potentially Trojan. Several manufacturers of medium pressure equipment include Trojan, Calgon, Aquionics, and Ozonia. Wedeco, Trojan, and Calgon offer reactors that have been validated in the 20 mgd flow range. In general, LH UV systems typically require more space and may have higher equipment costs because more lamps are used to provide the same dose as medium pressure lamps. However, LH UV systems typically use less energy to meet UV dose requirements, potentially resulting in lower lifecycle operating costs. LH and MP manufacturers also differ in the number of UV sensors that are included in a reactor: Wedeco provides one sensor per operable set of lamps; that may be one sensor per reactor (e.g., model BX3200) or one sensor per row (e.g., model K143). MP manufacturers typically provide one sensor for each lamp. LH and MP UV systems are compared for footprint, number of lamps, energy consumption, and lamp and ballast replacement costs in Exhibit 5-2.

EXHIBIT 5-2
Comparison of Medium Pressure and Low High UV Equipment

	LH	MP
Footprint	2x	1x
Number of Lamps	10x	1x
Power Consumption	1x	2x
Lamp Replacement Cost	3x	1x
Ballast Replacement Cost	1x	2x

Technologies used among manufacturers typically vary in the reactor design, lamp wattage, and the ability to turn down lamps to adjust for different flows or water quality. Manufacturers of LH and MP equipment were asked to provide their recommendations for UV equipment at FTTP and MPTP based on the design and operating criteria provided in Exhibit 5-1. In addition, preference was expressed for the use of the same or similar reactor equipment/technology at both plants when feasible. Manufacturer offerings are compared in Exhibit 5-3 and 5-4 below.

EXHIBIT 5-3
Comparison of UV Equipment Recommendations for FTTP

	Wedeco	Trojan	Aquionics	Calgon
Number of Trains	3	3	5	3
UV Technology Type	LH	MP	MP	MP
Reactor Model	K143	2L24	InLine 12000+	Sentinel 3x10 kW
Number of Duty Reactors	2	2	4	2
Number of Standby Reactors	1	1	1	1
Reactor Flow (mgd)	22	22	11	22
Reactor flange diameter (in)	30	24	20	36
Number of lamps – per reactor – total	36 108	2 6	6 30	3 9
Lamp Power (kW/lamp)	0.36	9.8	5	10
Max Reactor Power (kW)	13	19.6	30	30
Installed Power Load (kW) (excludes standby)	26	36.4	120	68
Power Load @ Avg Flow (kW)	11.9	23.8	60	14.7
Estimated Headloss at peak flow (in)	20	11.1		6

EXHIBIT 5-4
Comparison of UV Equipment Recommendations for MPTP

	Wedeco	Trojan	Aquionics	Calgon
Number of Trains	2	2	3	2
UV Technology Type	LH	MP	MP	MP
Reactor Model	K143	2L24	InLine 12000+	Sentinel 2x10 kW
Number of Duty Reactors	1	1	2	1
Number of Standby Reactors	1	1	1	1
Reactor Flow (mgd)	20	20	10	20
Reactor flange diameter (in)	30	24	20	24
Number of lamps – per reactor – total	24 48	2 4	6 18	2 4

EXHIBIT 5-4
Comparison of UV Equipment Recommendations for MPTP

	Wedeco	Trojan	Aquionics	Calgon
Lamp Power (kW/lamp)	0.36	9.8	5	10
Max Reactor Power (kW)	8.64	18.2	30	22
Installed Power Load (kW) (excludes standby)	8.64	18.2	60	22
Power Load @ Avg Flow (kW)	8.64	9	30	9.6
Estimated Headloss at peak flow (in)	20	9.5		14

Wedeco, Trojan, and Calgon provided equipment recommendations that were based on the same number of reactor trains (3 at FTTP and 2 and MPTP). As Aquionics does not have a reactor validated in the same flow range, their product recommendations required 2 additional treatment trains at each plant. In addition, Wedeco, Trojan, and Calgon have significantly lower peak and average power requirements in proposals for both plants compared with Aquionics.

5.1.3 Potential Site Layouts

After collecting equipment recommendations from several UV manufacturers, four preliminary facility layouts were developed for the purposes of estimating footprint and building costs:

- FTTP Medium Pressure (Exhibit 5-5 located at the end of this Section).
- FTTP Low Pressure – High Output (Exhibit 5-6 located at the end of this Section).
- MPTP Medium Pressure (Exhibit 5-7 located at the end of this Section).
- MPTP Low Pressure – High Output (Exhibit 5-8 located at the end of this Section).

The layouts were created based on reactor and control panel dimensions provided by Wedeco (LH) and Trojan (MP). Three feet of spacing was provided between MP reactors per manufacturers' recommendations for maintenance and electrical code requirements. In LH layouts, 12 feet center-to-center spacing between reactors was provided to allow for maintenance platforms, which are recommended due to the height of the reactors. Estimates of building footprints for the four manufacturers evaluated are provided in Exhibit 5-9. In general, building footprints for LH UV systems were estimated to be 1.8 times the area required for MP systems that accommodate Trojan and Calgon equipment.

EXHIBIT 5-9
Comparison of UV Disinfection Building Footprints

UV System Type (Mfrs. accommodated)	FTTP	MPTP
LH (Wedeco)	3,150	2,280
MP (Trojan, Calgon)	1,710	1,250
MP (Aquionics)	2,400	1,620

5.1.4 Preliminary Evaluation of UV System Costs

5.1.4.1 UV Disinfection Equipment Costs

UV equipment manufacturers were asked to provide budgetary cost proposals for equipment and operating costs using the design criteria presented in Exhibit 5-1. Equipment costs from LH and MP manufacturers are compared in Exhibit 5-10. Cost proposals submitted by the four manufacturers evaluated are included in Appendix E. As shown in Exhibit 5-10, the quotes submitted for LH equipment are substantially more than for the MP equipment.

EXHIBIT 5-10
Comparison of UV Equipment Costs for FTTP and MPTP

Manufacturer	Equipment Cost*	
	FTTP	MPTP
Wedeco	$ 810,000	$ 540,000
Trojan	$ 440,000	$ 293,500
Calgon	$ 332,000	$ 183,000
Aquionics	$ 891,900	$ 542,600
*Includes reactors, lamps, and control panels		

5.1.4.2 Annual Operation and Maintenance Cost Estimates

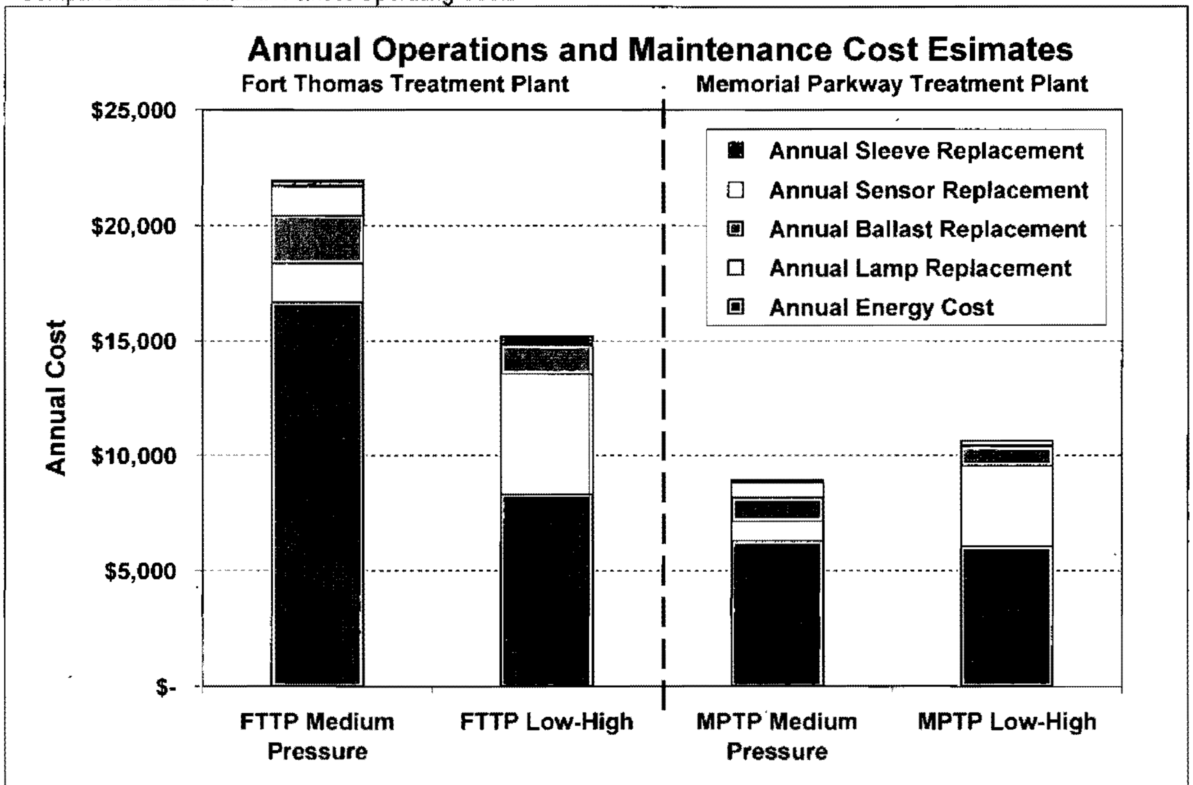
In general, energy consumption comprises the greatest portion of annual operations and maintenance (O&M) costs for UV disinfection systems. Other O&M costs are from the replacement of lamps, ballasts, sensors, and sleeves over the course of the UV system's lifecycle. Replacement lives and costs for these items provided by Wedeco and Trojan are shown in Exhibit 5-11.

EXHIBIT 5-11
Replacement Life and Costs for UV System Components

	Warranteed Replacement Life		Replacement Cost	
	Trojan	Wedeco	Trojan	Wedeco
Lamps	9,000 hrs	12,000 hrs	$ 429	$ 199
Ballasts	120 mths	60 mths	$ 5,200	$ 350
Sensors	5 yrs	10 yrs	$ 1,559	$ 684
Sleeves	5 yrs	20 yrs	$ 299	$ 180

Using information shown in Exhibit 5-11 and calculations of annual energy costs based on the design average flows for FTTP and MPTP, the annual O&M costs were determined (Exhibit 5-12). These estimates do not include the labor cost for the replacement of parts or other routine system maintenance activities.

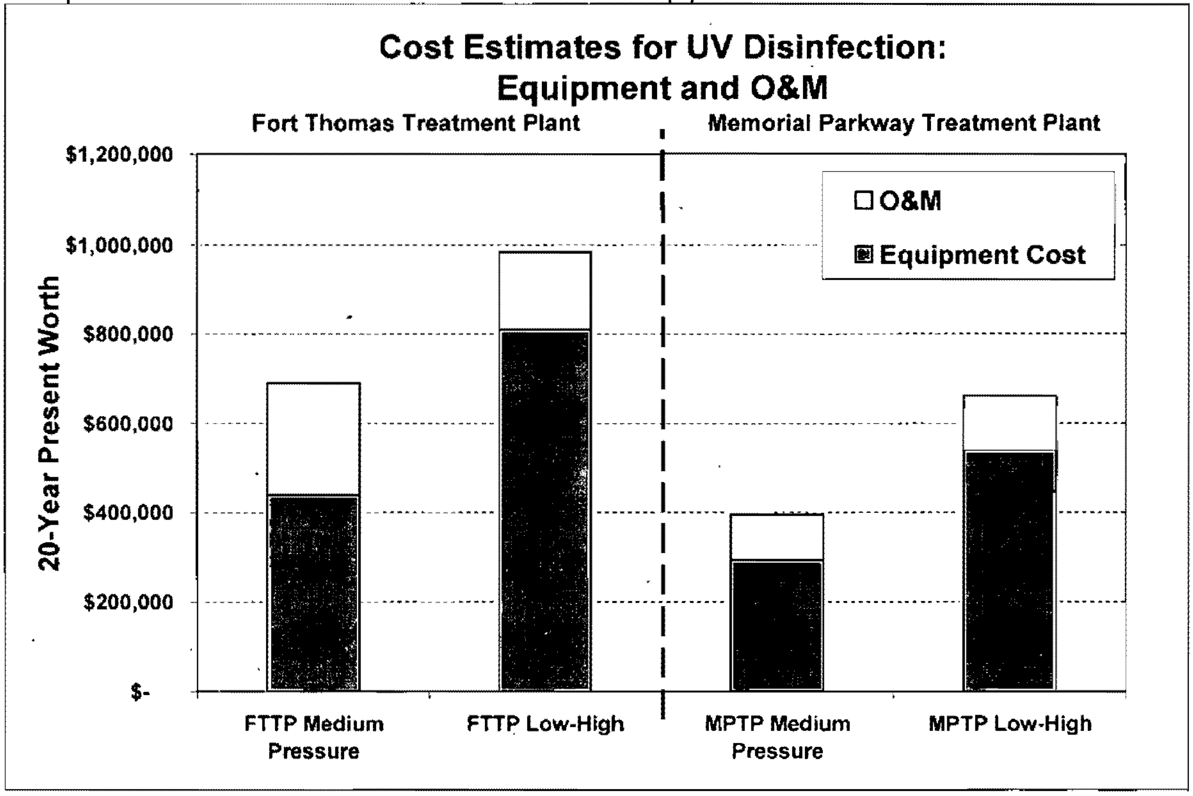
EXHIBIT 5-12
Comparison of LH and MP Annual Operating Costs



5.1.4.3 Net Present Value Equipment Cost Estimates

Exhibit 5-13 compares the net present value (NPV) of the LH and MP UV disinfection systems, including equipment costs and the NPV of the O&M costs. Although O&M costs are less, the LH system is estimated to have a higher net present value cost due to higher equipment costs from the manufacturer quotation.

EXHIBIT 5-13
Comparison of LH and MP 20-Year Present Value Estimates for Equipment and O&M



5.1.4.4 Power Quality Equipment

Power quality equipment costs were considered as part of the cost comparison of MP and LH UV equipment. Power quality equipment includes a standby engine generator and UPS. In general, MP systems have higher installed and average operating power requirements compared with LH systems, resulting in higher power quality costs for MP systems (Exhibits 5-3 and 5-4).

The UV systems at FTTP and MPTP will include standby power provided by diesel engine generators. The diesel engine generators will also serve loads for the associated GAC facilities. A UPS system will be needed to provide clean, reliable power to the UV system while the generator is starting to prevent the lamps from losing their arc and having to re-start. The re-start times for LPHO and MP type UV lamps may take up to 10 minutes, and may be required by voltage sags of 10% or power interruptions as short as 1/2 cycle (0.0085 seconds).

The recommended duration of the UPS is 5 minutes to ride through all voltage sags/interruptions and to allow the standby generator adequate time to start and carry the load. The UPS will also allow the UV system to ride through intermittent voltage sags or momentary power interruptions in the regional or local power system, or intermittent power disturbances caused within the plant. Based on a brief review, a battery type (static) UPS should be used rather than a flywheel (rotary) type based on cost. The flywheel type UPS had the advantage of not requiring energy storage batteries, but the smallest units that are currently available have a rating of 130kW and an installed cost of approximately $110,000. The rating of a battery type UPS can be sized to more closely match the power requirements of the installed UV system, and has approximately half the installed cost of the flywheel type UPS systems.

5.1.4.5 Relative Present Value Cost Estimates

20-year present value relative cost estimates were developed for LH and MP UV disinfection options for the following categories:

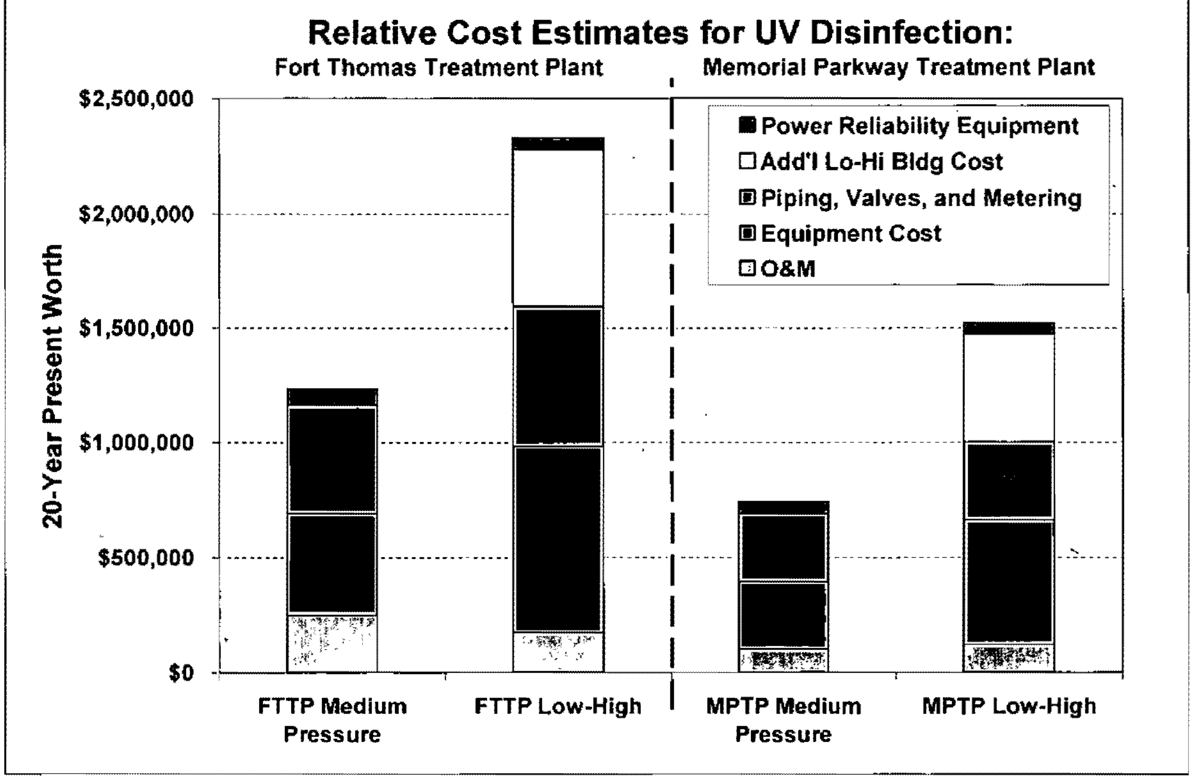
- O&M (include energy costs and lamp, ballast, sleeve, and sensor replacement costs).
- UV equipment.
- Piping, valves, and metering.
- Cost for LH building space in excess of MP building space required.
- Power reliability/quality equipment.

Using information provided by Wedeco and Trojan, relative costs for LH and MP UV system options for FTTP and MPTP are compared in Exhibit 5-14. Figures contained within Appendix F compare these costs to those estimated for an Aquionics system to evaluate the cost for a medium pressure option that requires a greater number of reactor trains and has higher energy requirements.

The relative cost estimates include estimates for construction, other markups, and a 30% contingency. However, they only include the difference in generic building space requirements between LH and MP systems and are not intended be an opinion of probable construction cost for the finished facility. Opinions of probable construction cost are presented in Section 9.

In general, comparison of the relative costs suggests that using low pressure – high output UV equipment would be significantly more expensive than medium pressure equipment, when including the extra building space required. The higher cost for a LH system is largely due to its higher equipment cost and larger footprint requirements. Including the 20-year present worth cost estimate for O&M does not result in a more attractive lifecycle cost for LH UV equipment.

EXHIBIT 5-14
Comparison of LH and MP 20-Year Present Worth Estimates



5.1.5 Recommendations and Procurement Strategy

UV disinfection system costs and technology comparisons for LH and MP equipment were presented in a meeting with NKWD staff on November 7, 2008. Due to the significantly higher present value costs and larger footprints for a low pressure – high output system compared with a medium pressure system, the decision was made to proceed with a procurement strategy that would specify MP equipment in the construction bidding documents.

The procurement approach will consist of the following:

- Specification of medium pressure UV reactor equipment in construction bidding documents.
- Design based on 3 reactor trains at FTTP and 2 reactor trains at MPTP.
- Procurement specification based on lifecycle cost and other criteria that account for O&M differences between different types of UV equipment, i.e., it will include price for equipment supply and installation as well as O&M costs (energy costs, replacement costs for lamp, ballasts, and other parts, and labor costs from maintenance).

- Procurement approach will include mandatory alternative bid prices for Calgon and Trojan reactors to allow opportunity for selection of the same brand at both plants if NKWD procurement regulations permit such selection.

This procurement approach offers several benefits:

- Reducing the need to accommodate multiple types of UV equipment streamlines the design process, decreasing the risk of change orders during construction.
- Bidding based on lifecycle cost considers both equipment installation and purchase cost as well as O&M costs, which can vary significantly between UV manufacturers and technologies and can comprise a substantial portion of the system's 20-year net present worth.
- The use of the same brand of UV equipment at both plants will result in greater efficiencies in plant operation as training, inventory management, and operations and maintenance functions and expertise can be shared between the two plants.

5.1.6 UV Advanced Oxidation Process (UV AOP)

Following the widespread implementation of ultraviolet (UV) disinfection, many utilities have begun to consider the potential use of UV light at much higher doses, together with upstream hydrogen peroxide feed, as an advanced oxidation process (AOP). UV AOP has been evaluated on a handful of drinking water treatment projects with high water quality goals, and for sources of supply that are affected by typical point-source and non-point source influences. UV AOP systems have been implemented for municipal use by the Orange County (CA) Water District (70 mgd) and designed for the Aurora (CO) Reservoir Water Purification Facility (50 mgd), so UV AOP represents a viable technology for treatment plants in the same size range as NKWD's FTTP and MPTP.

UV AOP is a chemical oxidation process used to oxidize complex organic constituents that are difficult to degrade biologically into simpler end products. In this process, hydrogen peroxide (H2O2) is dosed upstream of the UV reactors and when the UV photons are absorbed by the dissolved H2O2, hydroxyl radicals are formed. Hydroxyl radicals are highly reactive chemical species that react unselectively with organic molecules present in water. The initiation of this advanced-oxidation process enables the destruction of contaminants through the process of oxidation. At the same time, many contaminants are destroyed directly by UV light photolysis. Concurrently, disinfection also occurs. The contaminants that can be reduced by UV/AOP include:

- Bacteria, viruses, Giardia, Cryptosporidium, and other pathogens.
- Many endocrine disrupting compounds (EDCs).
- Many pharmaceutical and personal care products (PPCPs).
- Some disinfection by-products (e.g., NDMA and other nitrosamines).
- Many synthetic organic chemicals (SOCs), pesticides, herbicides, volatile organic chemicals (VOCs), and solvents.

Drinking water utilities have evaluated UV AOP for seasonal use for taste and odor control or for year-round use as a barrier against emerging contaminants. UV AOP typically uses much higher UV doses than are necessary for UV disinfection. A typical UV dose for UV AOP is greater than 500 mJ/cm2, which is more than an order of magnitude higher than a typical UV disinfection dose. In addition, only a fraction of the hydrogen peroxide is consumed by the process, so the residual peroxide must be quenched. Quenching is typically accomplished by chlorine, although other chemicals such as sodium bisulfite are also feasible.

5.1.6.1 Potential Application to NKWD

For the NKWD, the potential application of UV AOP would be as: 1) primary disinfection for Cryptosporidium, and 2) a general barrier for "emerging contaminants," including EDCs, PPCPs, and other contaminants associated with anthropogenic activity. For drinking water UV AOP installations, the typical drivers for implementing UV AOP have been taste and odor control or destruction of NDMA. The NKWD already plans to implement GAC adsorption, an effective barrier for taste and odor control and for most emerging contaminants. NDMA is not well removed by GAC or by the other treatment processes used by the NKWD, but the NKWD has sampled for NDMA on a few occasions, and NDMA has not been detected in the raw water.

Two options were considered for UV AOP for the NKWD: 1) design UV AOP to provide 1-log (90 percent) destruction of the hormones, Estradiol and Ethinylestradiol, or 2) 2-log (99 percent) destruction of the hormones, Estradiol and Ethinylestradiol. The hormones, Estradiol and Ethinylestradiol, were identified as a potential design target because they are indicative of anthropogenic discharges in a watershed, and they are also indicative of treatment effectiveness (e.g., not the easiest, nor the most difficult, compound to destroy). System characteristics for each option are shown in Exhibit 5-15.

EXHIBIT 5-15
UV AOP System Options for NKWD

Item	Option 1	Option 2
Performance Target	1-log Estradiol & 1-log Ethinylestradiol	2-log Estradiol & 2-log Ethinylestradiol
Performance for NDMA	50 percent	90 percent
Performance for Atrazine	50 percent	90 percent
Reactor Type*	Trojan SWIFT 16L30*	Trojan SWIFT 16L30*
Lamps per Reactor	16	16
Number of Reactors per Trains	2	3
Number of Trains	2	3
Hydrogen Peroxide Dose, mg/L	6 mg/L	6 mg/L
Total Connected Electrical Load, kW	798 kW	1,795 kW
UV Equipment Cost	$2.1 Million	$4.3 Million
Annual Power Cost	$280,000 per year	$629,000 per year
Annual Hydrogen Peroxide and Chlorine Quenching Chemical Cost	$880,000 per year	$880,000 per year

EXHIBIT 5-15
UV AOP System Options for NKWD

Item	Option 1	Option 2
Performance Target	1-log Estradiol & 1-log Ethinylestradiol	2-log Estradiol & 2-log Ethinylestradiol
Performance for NDMA	50 percent	90 percent
Performance for Atrazine	50 percent	90 percent
Reactor Type*	Trojan SWIFT 16L30*	Trojan SWIFT 16L30*
Note: * Reactor type shown is a medium-pressure reactor from one UV manufacturer. There are other equipment options available, but this was selected as an example.		

As shown, UV AOP would require more UV reactors compared to UV disinfection, and the construction costs and O&M costs would increase significantly. Of the two options, Option 1 is less costly, but treatment performance is marginal with only 50 percent destruction of NDMA and atrazine. Option 2 provides 1-log removal of NDMA and atrazine, but at higher construction and O&M cost. Based on the performance of other treatment barriers, the sampling results for NDMA, and the additional cost for UV AOP, the NKWD decided not to include UV AOP in this project.

5.1.6.2 Future Conversion to UV AOP

In the future, the NKWD may elect to consider expansion and conversion of the planned UV disinfection system to UV AOP. This would require the addition of UV reactors in series, and possibly conversion to larger UV reactors. For example, for UV disinfection at the FTTP, Trojan would supply three trains, with one 24-inch diameter UV reactor per train. To convert to UV AOP Option 2, each train would need to be increased to 30-inch diameter piping, and three reactors would be required in series for each train. The current UV disinfection design assumes 24-inch diameter reactors from Trojan, with 5 upstream and 3 downstream diameters of straight-run piping, for a total straight run of approximately 20 feet of length. For UV AOP using the larger reactors and three reactors in series per train, three reactors could be installed flange-to-flange-flange in the existing building space, with 1-ft spool pieces between reactors. Additional chemical storage and feed equipment and additional electrical service capacity would be required. Thus, conversion to UV AOP would require expansion of chlorine facilities, installation of new hydrogen peroxide facilities, expansion of pumping capacity to overcome additional headloss, replacement of UV train piping, and additional power feed, but it appears that the UV reactors could be incorporated in the planned building space. During detailed design, means of increasing pumping capacity at the GAC influent pump station will be evaluated to accommodate the potential future implementation of UV AOP.

At some time in the future, if the NKWD elects to further consider a new treatment technology for destruction of emerging contaminants, it is recommended that ozone and UV AOP both be considered further. Ozone is a viable alternative to UV AOP, and ozone is typically more economical than UV AOP as a general barrier for the treatment of emerging contaminants. Although ozone is not effective for NDMA destruction, it is equally effective or more effective than UV AOP for many contaminants. For the NKWD, ozone would most likely be best implemented after clarification, and GAC would provide biological stabilization prior to water distribution.

5.2 GAC

In the following sections, the major components of the GAC facilities are addressed.

5.2.1 GAC Media Type

The March 2008 PDR summarized RSSCT results and noted that tests were conducted with two bituminous-coal based GAC products, and one lignite-coal based carbon (Norit HYDRODARCO® 4000). The results demonstrated that the lignite based carbon performed significantly worse than the two bituminous carbon products in terms of adsorption of TOC. Consequently, the lignite based carbon was not recommended for use in the GAC facility. The use of GAC from different source materials (e.g., wood-based GAC) other than those specifically demonstrated through RSSCTs is not recommended.

For drinking water applications, bituminous coal is the typical raw material for activated carbons. GAC from bituminous coal has properties including high adsorption capacity, good abrasion resistance, and low ash levels. Two sizes of bituminous GAC were considered for the NKWD, as shown in Exhibit 5-16.

EXHIBIT 5-16
GAC Media Sizes Considered for NKWD

Parameter	12 x 40 Mesh (e.g., FS400)	8 x 30 Mesh (e.g., FS 300)
Type of Carbon	Virgin bituminous	Virgin bituminous
Effective Size	0.55 – 0.75 mm	0.8 – 1.0 mm
Uniformity Coefficient	1.9	2.1
Iodine Number	1000 mg/g	900 mg/g
Clean Bed Headloss (at 5 degrees C, 4.4 gpm/sf and 12 ft media depth)	5.5 ft	2.7 ft
Backwash Flowrate for 30% Bed Expansion	11.8 gpm/sf	18 gpm/sf
GCWW Media?	Yes	No
Basis for RSSCT Results?	Yes	No
Available From More Than One Vendor?	Yes	Yes

NKWD's RSSCTs assumed the use of 12 x 40 mesh GAC media, with an effective size of 0.55 to 0.75 mm. This specific GAC media size is consistent with the GAC used successfully in post-filter contactors by Greater Cincinnati Water Works (GCWW) at the Richard Miller WTP, which also treats Ohio River water. For a different GAC size, the RSSCT results would need to be re-evaluated, with calculations revised based on the other media sizes under consideration.

The 12 x 40 mesh size GAC offers high adsorptive capacity, as indicated by an iodine number of 1,000 mg/g. This size GAC is on the small side of the spectrum of GAC used at WTPs, but filtration will remove particulate matter upstream of GAC contactors. Thus, post-filter GAC contactors can use smaller media, with better adsorptive capacity, because headloss accumulation from particle retention in the media will be minimal. For these reasons, 12x40 mesh GAC media was adopted for the project.

For 12x40 mesh GAC, there are multiple potential suppliers. GAC suppliers of this size media are shown in Exhibit 5-17. This specific media size is equivalent to "Filtrasorb 400" from the Calgon Carbon Corporation and to Norit Americas' "Norit GAC 1240."

EXHIBIT 5-17
Potential GAC Suppliers for NKWD

	CALGON	NORIT	SIEMENS WESTATES	CARBOCHEM
	FILTRASORB F400	NORIT GAC 1240	AQUACARB 1240	LQ-1240
IODINE NUMBER mg/g (Min)	1000	1020	1000	950
moisture wt % (Max%)	2	2		
abrasion # (Min)	75	75	80	92
Effective size mm	.55 to .75	0.65	.55-.75	
UC (max)	1.9	1.6	1.9	
Ash, weight % (Max)	9			
Apparent density, g/cc (Min)	0.44	0.5	.46-.54	0.5
Mesh Size (US Sieve			12 x 40	

5.2.2 Procurement of GAC Media

It is recommended that the NKWD procure virgin GAC as part of the construction project for Advanced Treatment at the FTTP & MPTP. Among virgin, bituminous-coal based activated carbon products, differences in raw materials and activation methods influence the final properties of the carbon. Thermal activation of GAC can be accomplished through either direct activation or re-agglomeration. According to the Calgon Carbon Corporation, both products result in an activated carbon with similar iodine number values, re-agglomeration adds pore structure into the carbon granule, which results in a more uniform activation. Direct activation often results in granules that are over-activated along the outer edge of the granule and under-activated at the core. From field testing reported by the Calgon Carbon Corporation, and by others including GCWW and the City of Scottsdale, performance has been shown to be superior with re-agglomerated GAC. Thus, re-agglomerated GAC is recommended for the NKWD.

The Twin Oaks Valley Water Treatment Plant (TOVWTP) near San Diego, California, procured GAC manufactured in Asia. In this application, GAC is used solely to facilitate biological activity for reduction of biodegradable organic carbon (BDOC). From the project experience at the TOVWTP, GAC manufactured in Asia was more economical than GAC manufactured in the United States. The Calgon Carbon Corporation reports that GAC manufactured in Asia is direct activated, rather than re-agglomerated. Thus, the recommendation for re-agglomerated GAC, and GAC manufactured in Asia is not likely to comply with the GAC media specification.

5.2.3 Carbon Specification

There are various concepts for removal and replacement of GAC media in gravity contactors (i.e., GAC change-outs). The overall concept for the supply and removal of GAC media for the NKWD is to contract out media change-out operations to a company able to provide, or manage, all materials and services required for media exchange. The general scope of these services may include providing virgin GAC media, new media installation, spent media removal, and media regeneration and/or disposal. These services can be procured on a single change-out, annual, or multi-year services agreement. However, an agreement established for a longer duration commitment may have the advantage of fixed price and may even offer a lower unit cost due to economies of scale. Observations by representatives of the utilities at the plants that were toured indicated that vendors may be resistant to offering long term contracts without the provision for escalation clauses related to fuel or other prices.

Exhibit 5-18 includes the draft technical specification section for procurement of GAC media and is located at the end of this Section. The specification section is written for the FTTP, but the media characteristics will be the same for the MPTP as well. It is anticipated that a single contract for GAC media for all plants will be held by NKWD.

For the initial installation of GAC in the construction project, virgin GAC will be required for the contactors at each treatment plant, and the GAC supply will be bid as part of the general construction contract. During construction, a separate specification for GAC removal and replacement will be developed for the first year or more of facility operation. For plant operations in the future, custom regeneration of NKWD's GAC will likely be more economical than purchase of new batches of virgin GAC for media replacement. For custom GAC regeneration, options include:

1. Obtain bid pricing from GAC suppliers for custom GAC regeneration, including media removal at NKWD's treatment plants, transport to regeneration facilities, regeneration, GAC makeup, return transportation and placement in the contactors.
2. Develop an agreement with Greater Cincinnati Water Works (GCWW) for regeneration of NKWD media at GCWW's regeneration facilities.
3. Construct regeneration facilities at NKWD facilities and arrange GAC transport capabilities for internal (NKWD) transfer.

For Option 1, as described in the site visit notes, Scottsdale's bids included slightly lower unit costs for custom GAC regeneration by the GAC supplier versus virgin GAC purchase. From discussions with the Calgon Carbon Corporation, they regenerate GAC for drinking water treatment plants at a facility in Columbus, Ohio. Thus, it is anticipated that transport costs would be less compared to a more distant location such as Scottsdale (AZ), and consequently, custom GAC regeneration may be more favorable economically compared to virgin GAC for the NKWD.

Any decision to further evaluate Options 2 and 3 will need to consider cost, permitting, political ramifications, and other factors. These options also require identifying an approach to GAC media loading, unloading, and transport. A contract would be required with a GAC supplier to provide make-up carbon for the quantity lost as fines in the routine operation of the system and in the removal, regeneration and replacement process.

The use of virgin GAC or custom regenerated GAC is recommended over additional options, such as purchasing regenerated carbon from a common pool, because of the NKWD's objectives of effective DBP precursor removal and overall public health protection.

NKWD prefers to keep an option open to investigate alternate carbon sources in the future such as no bituminous based products. To support such investigations NKWD requests that space be provided in the AT Building at FTTP sufficient for installation of a future pilot GAC column system. RSSCT testing could also provide useful data in evaluating alternative GAC supplies with a considerably shorter test duration. Therefore multiple options will exist for testing at such time as NKWD chooses to do so.

5.2.4 Underdrains

The PD Report, March 2008 recommended a sloping floor in the GAC contactors, with stainless steel, wedge-wire style underdrains. The PD Report, March 2008 also noted that A-frame style underdrains have also been used successfully for GAC contactors. From CH2M HILL experience, plastic block lateral underdrains also represent a feasible option.

The construction of a sloped floor in the contactor significantly impacts the potential options for the contactor underdrains. After consideration of a sloped floor for NKWD, it was determined that the sloped floor would unnecessarily add to the depth of construction without significant benefit in terms of GAC empty bed contact time or added efficiency for GAC media removal. Therefore, a flat floor contactor design was selected.

The underdrain selection is also influenced by the type of backwash desired (i.e., water only or air/water), and the size of media used. For NKWD, small GAC media will be used, and air scour will be included (as described in the following section). The three types of underdrains generally used for new construction are:

- Block systems.
- False floor and nozzle systems.
- Stainless steel underdrains.

For the NKWD facilities, block systems and stainless steel underdrains represent the most feasible approaches. False floor and nozzle systems were not considered further because of the additional depth (at least 18 inches additional depth of contactors) required for construction.

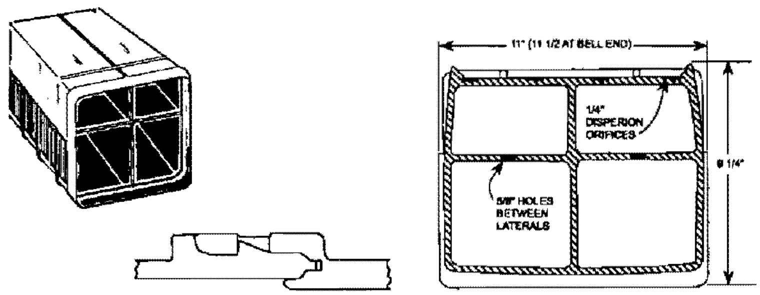
5.2.4.1 Block Systems

Significant advances in underdrain block system technology have occurred and been delivered to the market in the last 15 years. In the past blocks were made of vitrified clay and capable of water-only backwash, they are now made of high-density polyethylene and are capable of air-water backwash. The plastic blocks are lighter, easier to install, and are more forgiving of hydraulic shock. Plastic block systems are currently manufactured by F.B. Leopold Company (Type S ® and Type SL) and Infilco Degremont Technologies (TetraTM U Block and LP Block). Other manufacturers that have developed this technology include USFilter/Siemens (MULTIBLOCK®), and Roberts Filter Group (TrilateralTM).

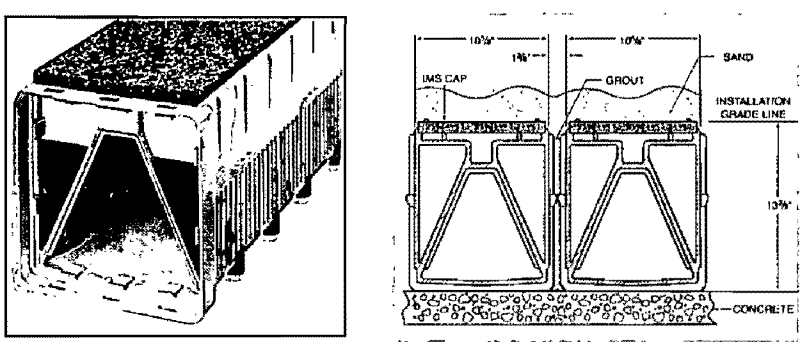
Typical plastic underdrain blocks are shown in Exhibit 5-19. These systems can utilize an integral media support cap (Leopold's IMS® cap or Infilco Degremont's Savage Plate®) to replace the traditional gravel support layers. Note that Infilco Degremont's Savage Plate comes in three different types: B plate, S plate, and T plate. Plate selection is based on the application, where the S plate is used when the media effective size is greater than 0.45 mm. This cap is made of sintered plastic beads and is bolted to the top of the underdrain.

The Leopold block system with IMS caps has a nominal pore size of approximately 0.35 mm for the IMS. With the small GAC size recommended for NKWD, the size difference between the GAC and the IMS cap is less than most projects. To reduce potential that plugging problems with IMS caps are minimized, a 4-inch deep layer of large diameter sand is recommended between the GAC and the underdrain. This sand layer is recommended regardless of the block system selected.

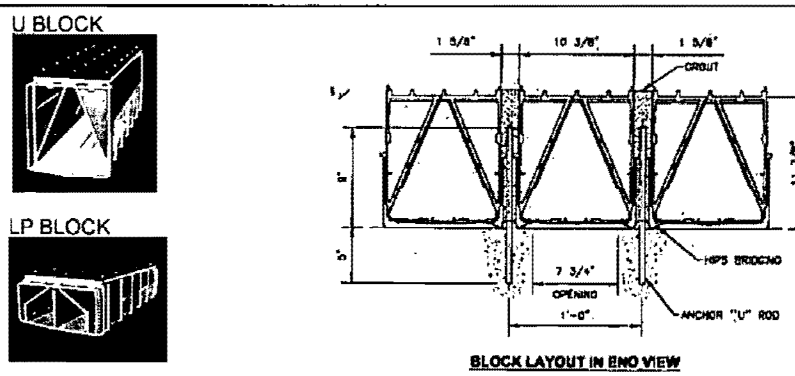
EXHIBIT 5-19
Block Underdrains



A. Dual Parallel Lateral (F.B. Leopold Co.)



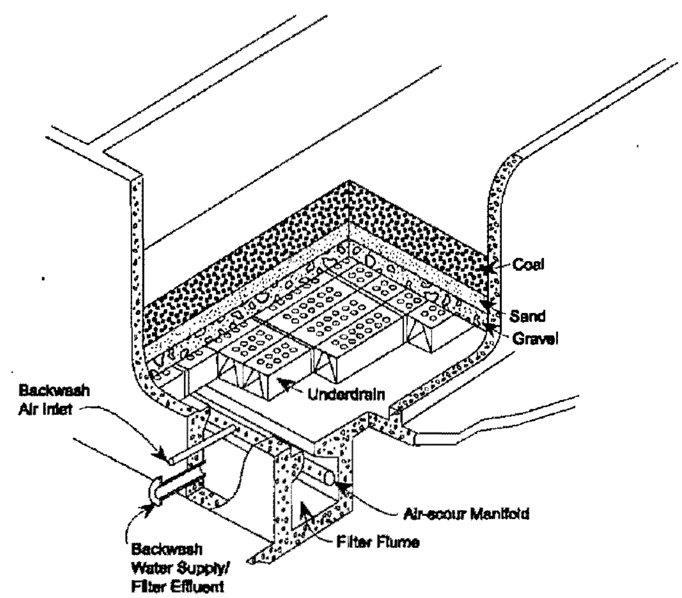
B. Universal Type S Underdrain with IMS Cap (F.B. Leopold Co.)



C. Tetra Block with S Plate (Infilco Defragment)

A typical plastic block underdrain system with air/water backwash is shown in Exhibit 5-20. The blocks are grouted to the filter (or contactor) floor and anchored with steel rods. Note that either a front or a center flume design can be used to accommodate the desired filter box length-to-width ratio while maintaining the maximum allowable lateral length. Different manufacturers have different requirements for the flume geometry and lateral lengths, so the proposed manufacturers will be contacted during detailed design. Fluid velocities in the flume should not exceed 6 feet per second (lower velocities are recommended). In general, a larger flume cross section provides lower fluid velocities but is more demanding of the underdrain blocks to maintain structural integrity.

EXHIBIT 5-20
Block Underdrain System with Air/Water Backwash



The dimension across the laterals is constrained to a multiple of the installed lateral width, including grout between laterals. The installed width varies between manufacturers with Leopold's Type S laterals having a nominal width of 11-inches and nominal height of 12 inches (without the IMS cap). Infilco Degremont's TETRA U Block laterals have a total height of 11-7/8 inches and width of 10-3/8 inches, so the same box dimensions may not be applicable to both lateral types. Leopold and Infilco Degremont both offer a low-profile block underdrain, but this underdrain was not considered for NKWD because the lateral length is limited significantly. For example, the Leopold Type S lateral has maximum length of 48 feet, whereas the Type SL (low-profile underdrain) is limited to 16 feet of length.

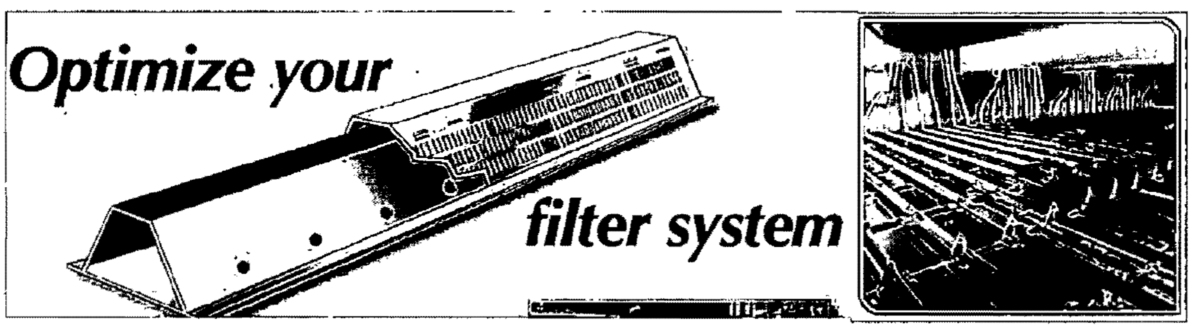
The dimension along the laterals (lateral length) is limited by the ability of the laterals to convey backwash flows without introducing unacceptable maldistribution along their length. As per CH2M HILL specifications the manufacturer should guarantee that the maldistribution will be less than 5 percent in the field over the length of the lateral. If tests are performed in a hydraulic laboratory to demonstrate meeting this requirements, then the maldistribution under laboratory conditions should be less than 3 percent.

5.2.4.2 Stainless Steel Underdrains

Stainless steel underdrains, such as the Johnson Triton product, were investigated on the site visits documented in Section 4. From the project experiences noted during the site visits, this type of underdrain did not perform well in combination with air scour. As a result, this type of underdrain was not considered further. The Johnson header lateral was also ruled out, since this underdrain cannot accommodate air scour.

AWI manufactures low profile stainless steel underdrains and underdrain panels for new installations and retrofits. The stainless steel underdrains are custom-designed for orifice sizing to match the design conditions of filtration and backwashing. Illustrations of the AWI underdrains are shown in Exhibit 5-21. CH2M HILL has installed these underdrains at several large new water treatment plants with success. However, the cost of the underdrain itself is typically higher than the standard block underdrain due to the materials of construction. In addition, there is a strong likelihood of a single bidder. For these reasons, the NKWD elected to use plastic block underdrains at the FTTP and the MPTP.

EXHIBIT 5-21
Stainless Steel Underdrain, Including Application With Air/Water Backwash (Right)



5.2.5 Air Scour

Air scour provides some agitation and cleaning of filter media throughout its depth and can reduce the water requirements for backwashing. Simultaneous air plus subfluidization water wash (upflow water wash with air scour) provides the most effective agitation and cleaning of the filter media throughout its depth. Upflow water wash with air scour is CH2M HILL's preference, particularly for installations with deep bed (≥4 feet of media) filters or contactors.

For the FTTP and MPTP post-filter GAC contactors, media depth will be 12 feet (FTTP) and 10 feet (MPTP). With this depth of media, air scour offers more effective backwashing of the deep beds. Air scour will also enhance the ability to remove fines by backwashing. With air scour, it will be easier to remove fines by backwashing, and better fines removal through backwashing will mean less fines removal through underdrains. In addition, more efficient fines removal will minimizes downtime and water use for fines removal.

A concern by NKWD was raised concerning an increase in GAC particle breakup due to the increased turbulence associated with air scour. Based on discussion with Professor Vern Snoeyink, GAC particle breakup and mass transfer zone disturbances are not anticipated. In fact, the use of air scour was recommended by Professor Snoeyink based on extensive use in Europe with deep beds. The air scour cleaning is often followed by a water only backwash step to re-stratify the media and the garnet layer.

Typical air flow rates are:

$$\text{Air} = 2\ \text{scfm/ft}^2 \text{ with simultaneous water} = 3 \text{ to } 6\ \text{gpm/ft}^2$$

Positive displacement blowers are typically used because of their ability to maintain a relatively constant air flow rate against changing discharge pressure conditions. A separate room is typically provided for the blowers to minimize noise. Air piping is generally type 304 stainless steel, with adequate provision for thermal expansion of the piping. Carbon steel and ductile iron may also be used for air scour piping, but require additional maintenance due to temperature and moisture conditions. Air temperature at the discharge of positive displacement blowers approaches or exceeds 200 degrees F, therefore any piping within 8 feet of the finished floor will be insulated for health and safety reasons.

When the blowers are located at a lower elevation than the filter high water level, care must be taken to avoid the potential for water to siphon down the air piping to the blowers. For this project, a high loop will be incorporated into the air piping to allow for the decrease in air volume as it cools to ambient conditions from the blower discharge pressure.

A new air scour blower system will be added at each plant. FTTP currently does not have an air scour system for the sand filters but the design of a new air scour system is underway by others. The new blower at FTTP is planned to be placed on the north side of the existing Filter Building which is a considerable distance from the Advanced Treatment Building. An air scour system is in place for the existing filters at MPTP which may be able to serve as a back-up to the new blower to be provided in the project. It may not be necessary to include air scour in every backwash event and therefore a single new blower will be provided at each location. Information on the blowers is as follows:

FTTP

- Number of blowers : 1
- Capacity:1760 scfm.
- Blower Discharge Pressure: 9.1psi, final value to be determined in final design.
- Blower Type: Positive Displacement.
- Horsepower: 100 HP, final value to be determined in final design.

MPTP:

- Number of blowers : 1
- Capacity: 1,224 scfm.
- Blower Discharge Pressure: 7.4psi, final value to be determined in final design.
- Blower Type: Positive Displacement.
- Horsepower: 50 HP, final value to be determined in final design.

5.2.6 GAC Loading and Unloading Systems

GAC media is often supplied in bulk truckloads of approximately 20,000 or 40,000 pounds. Partial truckloads will increase the cost per unit weight of GAC. Other delivery options include flat-bed trucks with GAC super sacks (e.g., 1,000-lb or 2,000 lb sacks) and tanker trucks. From discussions with GAC suppliers, tanker trucks are most expensive to use, and consequently, they are typically only used with pressurized GAC vessels.

Exhibit 5-22 lists the design criteria pertaining to GAC procurement for the FTTP. Note that the physical elements that will be designed at each treatment plant to accommodate GAC loading and unloading are shown on Exhibits presented in Section 8.

EXHIBIT 5-22
GAC Contactor Design Criteria for FTTP

Total number of contactors	8
Individual contactor area, sq ft	880
GAC media depth, feet	12.0
Each contactor media volume, cu ft	10,560
Apparent Density of GAC (dry), lb/cu ft	32.5
Dry GAC media per contactor, lbs	343,200
Number of 40,000 lb truckloads per contactor	9 (results in 360,000 lbs of GAC)
Number of 1,000 lb super sacks per contactor	344

Exhibit 5-23 lists the design criteria pertaining to GAC procurement for the MPTP.

EXHIBIT 5-23
GAC Contactor Design Criteria for MPTP

Total number of contactors, initial construction	5
Individual contactor area, sq ft	612
GAC media depth, feet	10.0
Each contactor media volume, cu ft	6,120
Apparent Density of GAC (dry), lb/cu ft	32.5
Dry GAC media per contactor, lbs	198,900
Number of 40,000 lb truckloads per contactor	5 (results in 200,000 lbs of GAC)
Number of 1,000 lb super sacks per contactor	199

5.2.6.1 GAC Loading Procedures

There are various methods used to move virgin GAC to an empty contactor. The method used to load media often depends on the supplier's preference, although specific requirements (e.g., such as those imposed by plant physical constraints) can be defined in the GAC specification. From discussions with the GAC media suppliers, they view any method involving loading the GAC to contactors as a slurry as similar. Their identification of exactly which method to use will be based on the specification requirements and their own economic considerations at the time of delivery to the project site.

GAC loading methods are described in Exhibit 5-24, and the corresponding physical requirements for each method are listed in Exhibit 5-25. Media loading by eduction of GAC from an open-bed truck is illustrated in Exhibit 5-26. Loading from super sacks is illustrated in Exhibit 5-27.

The number of supersacks required for the NKWD facilities is significant. It is estimated that 199 1,000-lb super sacks would be required to load a single contactor at MPTP, and approximately 344 1,000-lb super sacks would be required to load each contactor at FTTP. Given the site limitations at the FTTP, it is recommended that GAC suppliers be encouraged to deliver media from open-bed trucks (Method 4 as outlined in Exhibit 5-24). However a prohibition of super-sacks may slightly increase the cost for GAC media. The facility design will be able to accommodate either approach, although delivery from open-bed trucks is preferred.

EXHIBIT 5-24
Summary of GAC Loading Procedures

Method	Description	Process Description
1	Empty GAC super sacks directly into contactor	GAC would be delivered to the site in super sacks using flatbed trucks. Super sacks, about one cubic yard (3 ft x 3 ft x 3 ft) and typically ½ ton (1,000 lbs) by weight, would be stored on-site until installation. A small crane would be mobilized and used to pick and drop the super sacks into the contactor where the GAC is released from its bag. A water depth 2 ft above the media will be maintained for dust control.
2	Slurry GAC from hopper and super sacks	Similar to above, GAC would be delivered and stored on the site in super sacks. In this case, GAC would be released into a hopper apparatus provided by the GAC supplier using a forklift. Using service water as the motive fluid, GAC would slurry into the contactor bed through portable hoses.
3	Slurry GAC from tanker trucks	Water is added to a self-contained tanker truck to saturate the GAC and form a GAC slurry. Compressed air is then used to pressurize the truck and facilitate GAC transfer to the contactor through a flexible hose. The excess water transferred from the truck to a contactor is removed by backwashing or via contactor to waste. This is the method used for GAC loading to pressurized vessels.
4	Slurry GAC from open bed dump trucks	Dump trucks are emptied into a hopper apparatus or by using an eductor wand with service water as the motive fluid. The GAC slurry is transferred from the eductor system to the contactor through portable hoses.

EXHIBIT 5-25
GAC Loading Requirements

Description	Method	Value
Slurry Water Supply Flow, gpm	2, 3, 4	100-200
Slurry Water Pressure, psi	2, 3, 4	90-110
Compressed Air Supply, scfm	3	14
Compressed Air Pressure, psi	3	13-14
Delivery Truck Capacity, lbs	1, 2, 3, 4	40,000
Approximate total duration to load GAC in 1 contactor including backwashes, hrs	1, 2, 3, 4	24-40
Approximate service water used to load GAC in 1 contactor, gal	2, 3, 4	30,000 to 60,000 per truckload
Approximate backwash waste volume generated following loading GAC in 1 contactor, gal	1, 2, 3, 4	FTTP: 540,000 to 1,000,000 MPTP: 375,000 to 800,000

EXHIBIT 5-26
Media Installation by Eduction from Open-Bed Truck (Provided by Calgon Carbon Corporation)

EXHIBIT 5-27
Media Installation by Eduction from Super Sacks (Provided by Calgon Carbon Corporation

5.2.6.2 GAC Removal Procedures

There are two main procedures for media removal from the NKWD contactors: 1) eduction with high pressure water (either to an open trailer or super sacks), or a 2) vacuum system. A summary of these GAC removal options is provided in Exhibit 5-28.

EXHIBIT 5-28
Summary of GAC Removal Procedures

Method	Description	Process
1A	Eduction of GAC Slurry to Truck	GAC slurry (media + water) is conveyed from the contactor using an eductor (wand or fixed) connected to a motive water supply. The GAC slurry is conveyed to an open bed or tanker truck. Excess water is continuously drained from truck from a single drain point and sometimes aided by the use of a vactor truck with screening to remove water at a high rate but exclude media loss. Drain water would be routed by temporary piping to empty in the backwash waste equalization basin.
1B	Eduction of GAC Slurry to Super Sacks	Same procedure as above, except the GAC slurry is conveyed to a holding container where the excess water is drained. The drain water would be routed to the backwash waste equalization basin. GAC is then loaded into super sacks for storage at the site and further draining. Once GAC is relatively dry, GAC will be transported to custom regeneration facility or disposal.
2	Vactor Truck	GAC slurry (media + water) is vacuumed from contactor using a vactor truck. Vactor trucks are significantly smaller than open trailers (500-2,000 gallons) so the vactor truck would transfer the media into an open trailer truck.

Media removal by eduction of the GAC slurry (method 1A) to an open bed truck is illustrated in Exhibit 5-29. It should be noted that, even after a period of draining, the spent (i.e., wet) GAC weighs approximately twice the amount of dry GAC. Therefore, twice the number of trucks are needed to haul the same volume of spent GAC away as to deliver dry GAC. Drying spent GAC through permeable super sacks allows a contractor to haul away similar quantities per truck as that delivered. From discussions with the Calgon Carbon Corporation, they have patented a method to drain the spent GAC prior to putting it in super sacks. Media removal by eduction of the GAC slurry to super sacks by this proprietary method is shown in Exhibit 5-30.

EXHIBIT 5-29
Media Removal by Eduction to Open-Bed Truck (Provided by Calgon Carbon Corporation)

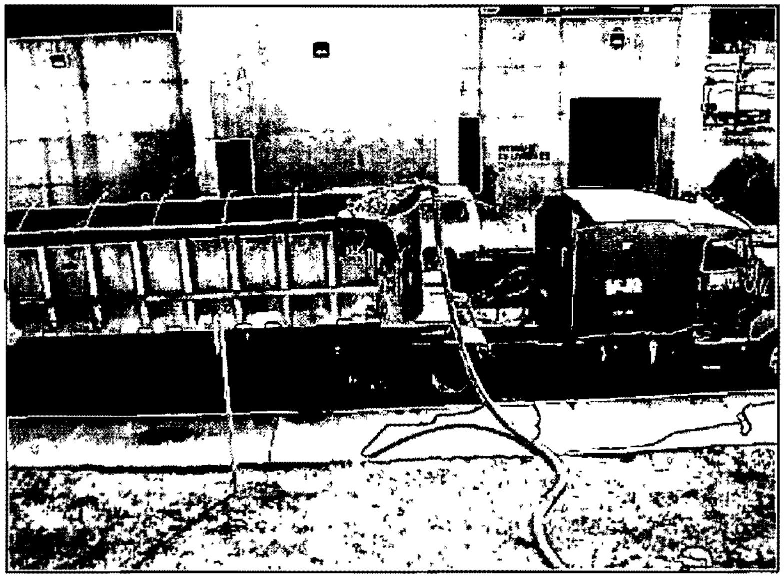


EXHIBIT 5-30
Media Removal by Eduction to Super Sacks (Provided by Calgon Carbon Corporation)

Exhibit 5-31 lists the GAC media removal requirements. The GAC specification section for the purchase order of GAC will specify constraints that the NKWD may elect to impose on media removal methods. The use of Method 1A is expected to have the least impacts on the FTTP site, although Method 1B can also be accommodated.

EXHIBIT 5-31
GAC Removal Requirements

Description	Method	Value
Slurry Water Supply Flow, gpm	1A, 1B, 2	100
Slurry Water Pressure, psi	1A, 1B, 2	90-110
Approximate total time duration to remove GAC from 1 contactor, hrs	1A, 1B, 2	16-40
Approximate drain water used to remove GAC from 1 contactor, gal	1A, 1B, 2	100,000-400,000

5.2.7 On-Site GAC Storage

The PD Report, March 2008, did not include any on-site storage for GAC. The provision of on-site GAC storage would offer a buffer for issues associated with GAC availability or transportation restrictions/issues, and would provide flexibility at each treatment plant. However, providing GAC storage would also take up limited space at each site, potentially increase construction cost, and GAC storage time would need to be carefully managed to ensure that no deterioration of carbon occurred.

Three options were identified to provide GAC storage, as follows:

1. Storage Tanks or Silos:

   Provide storage for 10,560 cu ft (1 contactor) minimum for Fort Thomas.

2. Increase Size of Contactors:

   Increase contactor size to provide 20 min. EBCT with 7 Contactors @ 44 mgd.

   Add approximately 1,005 cu ft of additional contactor area (at 44 mgd).

   Increase building length by 24 ft or width by 6 ft.

3. Super Sack Storage:

   Provide inside storage for 344 +/- super sacks.

   Based upon stacking super sacks 4 high, approximately 1500 cu ft required.

   UOSA used 2000-lb Super Sacks, so approximately 162 per contactor.

After considering these options, the NKWD elected to consider the 8th contactor as GAC storage. This will result in no change in system operation, but because the daily average flowrate has not exceeded 40 mgd, effectively there is system storage available. If it becomes necessary to leave a contactor full of exhausted GAC in place for some period of time, the FTTP can operate with 7 contactors in use, and the EBCT will still be 20 minutes or longer for flowrates of 38.5 mgd or less. Similarly, the capacity at the MPTP facilitates this same approach to GAC storage on-site.

5.2.8 Backwash Supply

The best criteria for backwash effectiveness are the quality of the filtered water and the long-term absence of dirty media and mud ball formation. Typical fluidized bed expansions are 20 to 30 percent, and fluidization also provides water flow to stratify the bed. Since temperature affects viscosity of water, flow rates for water-only backwash have to be adjusted for significant variations of summer and winter temperatures. Each degree Celsius increase in water temperature requires approximately a 2 percent increase in wash rate. Typical backwash rates for silica sand, anthracite coal, and dual media are 15 to 23 gpm/sq ft, but lower rates are required for deep bed monomedia GAC filters. Discussions with GAC suppliers indicate that a 30% bed expansion is adequate to backwash even without air scour. A range of 6 to 12 gpm/sq ft is recommended for the design of the GAC contactors.

The anticipated volume of each GAC contactor backwash at the FTTP is approximately 180,000 gallons. The anticipated volume of each GAC contactor backwash at the MPTP is approximately 125,000 gallons. These volumes were determined based on 30 percent bed expansion, at maximum water temperature (minimum viscosity), and based on contactor sizing at each facility.

At FTTP the backwash supply for the GAC contactors (and for the existing filters) will be pumped from the GAC influent pump station wet well, located beneath the GAC Building. Thus, the backwash supply will consist of filtered water. Because the NKWD pre-chlorinates, a chlorine residual concentration of 0.2 to 0.5 mg/L is typically present in the filtered water. It is recommended that NKWD evaluate pre-chlorination needs and applied doses as a means of reducing disinfection by-products, sodium bisulfite use and possibly GAC replacement frequency.

At MPTP, the backwash pumps draw supply from the finished water clearwell. The chlorine residual at that location is typically in the range of 1.9 to 2.2 mg/l.

5.2.9 Backwash Waste

For each treatment plant, backwash equalization and waste disposal facilities will be provided. At the FTTP, backwash waste equalization will be provided beneath the GAC contactors. Backwash waste will be collected and pumped to the South Reservoir. At the MPTP, backwash waste from the contactors will flow by gravity to the North Reservoir.

The backwash waste handling facilities have been sized to accommodate backwash waste from GAC loading, installation, and unloading. In addition, the equalization basin will accommodate the anticipated volume of each GAC contactor backwash (approximately 180,000 gallons at the FTTP and approximately 125,000 gallons at the MPTP). In addition, the backwash waste facilities were also sized to accommodate

15 minutes of contactor-to-waste flows. NKWD currently adds powdered activated carbon to the reservoirs for taste and odor control so it was concluded that returning carbon fines from backwash and filter to waste operations would provide some , beneficial reuse of the carbon fines.

5.2.10 Analytical Requirements

Each GAC contactor will be equipped with an effluent flowmeter, and a flowmeter will also be provided for backwash supply. Each GAC contactor will be equipped with differential pressure sensors to allow monitoring of headloss accumulation. A level indicator will be provided at each contactor as well.

At each treatment plant, one turbidimeter will be provided on the combined GAC effluent. Each GAC contactor will be piped and spare controls wiring run so that an individual turbidimeter can be added in the future. The NKWD has contacted KDOW about turbidity reporting requirements, and relevant findings will be incorporated into project detailed design. The NKWD plans to continue to use turbidity monitoring on individual conventional filters as the turbidity point of compliance. This practice is consistent with many facilities with operating post-filter GAC contactors. Particle counters will not be installed for the GAC contactors.

To monitor organic concentrations in the GAC effluent, the NKWD will implement grab sampling for total organic carbon (TOC) in the GAC influent and effluent, including the effluent from each contactor. UV absorbance at 254 nm (and UV transmittance at 254 nm, which can be calculated from UV absorbance and vice versa) also provide key information on organic levels that are present. UV absorbance typically correlates well with TOC. Additional grab sampling to monitor UV absorbance is also recommended.

For on-line TOC analyzers, the NKWD checked into Hach, Sievers/GE and S::CAN at the AWWA Water Quality Technical Conference exhibition held in Cincinnati in November, 2008. Based on observations from NKWD staff, the Hach analyzer requires a high degree of maintenance, whereas the Sievers/GE analyzer is reported to work better. The NKWD was impressed with the S::CAN analyzer because of minimal maintenance requirements and simple calibration. The S::CAN TOC analyzer is expected to cost about $1,300. In the coming months, the NKWD plans to demo a few online TOC analyzers. Thus, the detailed design will leave space and provisions (plumbing, power, and controls) for future TOC analyzers to be located on the combined GAC effluent, not on individual contactors, at each facility.

At each facility, the UV absorbance in the combined effluent will be measured as part of the UV disinfection process. Each UV disinfection equipment system will be equipped with a UV transmittance (UVT) analyzer. If not currently available, a bench-top UVT analyzer will need to be provided to the laboratory at both plants for calibration purposes. The on-line UVT analyzer for UV disinfection will require weekly calibration checks versus the bench-top unit at each facility.

At each treatment plant, sample piping from the GAC influent, each individual contactor, and the combined GAC effluent will be routed to a central area with a sample sink.

Based on the site visits, and project discussion at workshops, additional analytical requirements include the following:

- Fines analysis by a 0.45-micron grab sample filter test upon installation of new GAC.
- SCADA will be programmed to compile bed volumes per contactor based on flowrate per contactor and contactor on/off time.

The UV disinfection systems will include the following analytical elements:

- UV intensity sensors – 1 per lamp for medium-pressure UV systems. Note that the UV intensity sensors will require monthly calibration checks versus reference intensity sensors.
- Flowmeter and flow control valve per UV "train".
- Other equipment provided by UV manufacturer, including:
    - Level Sensors.
    - Temperature Sensors.

5.3 Storage and Pumping

5.3.1 Fort Thomas Treatment Plant (FTTP)

Additional pumping facilities will be installed to support the addition of Advanced Treatment facilities within the existing gravity flow configuration of the plant. A GAC Pump Station will be added to lift the water to the GAC contactors and provide sufficient head to drive the flow through the GAC and UV systems. Pump systems will also be constructed to provide backwash water for the contactors, slurry water for conveying clean and spent GAC from the contactors, and for pumping the residuals streams from Advanced Treatment back to the raw water reservoirs.

5.3.1.1 GAC Pump Station

The GAC Feed pumps will be sized to feed the GAC Contactors and match the production rate for the water treatment plant. These pumps will take suction from the proposed GAC Pump Well and discharge into the contactor influent channel. The pumps will be provided with variable frequency drives to control the flows.

Three pumps will be provided, each with a maximum rate capacity of 22 mgd to provide a firm capacity of 44 mgd. Each pump will be sized to develop an approximate TDH of 60 feet.

The PD Report, March 2008 identified both submersible and vertical turbine pumps as appropriate for this application. The NKWD personnel are familiar with the operation and maintenance of the vertical turbine pumps, but do not currently have large submersible pumps in the system. These pumps will operate continuously and are critical to the operation of the Advanced Treatment facility. Based upon the experience of NKWD personnel with operations and maintenance of vertical turbine pumps, the superior operational efficiency available, and accessibility of the pumps for O&M functions, vertical turbine pumps are recommended for this application.

The GAC feed pumps will therefore be as follows:

- Number of pumps: 3, 2 duty, 1 standby.
- Capacity: 22 mgd, each.
- Head: 60 ft, TDH, final value to be determined in final design.
- Drive: Variable speed.
- Pump Type: Vertical Turbine.
- Horsepower: 250 HP (approximate, final value to be determined.

5.3.1.2 GAC Contactor Backwash Pump

The GAC Contactor Backwash Pumps will be sized to provide the flow required to develop a 30% bed expansion. The maximum flow identified by the PD Report, March 2008 was 13,200 gpm based upon a backwash rate of 15 gpm per square foot at an approximate TDH of 65 feet. Discussions with suppliers for the selected GAC indicate that, at a temperature of 85 degrees F, a backwash rate of 11.8 gpm per square foot of contactor bed area will provide 30% bed expansion. On this basis, the contactor backwash pump will be designed to provide a rate of 12 gpm/sf or a total flow rate of 10,560 gpm at an approximate TDH of 65 feet. The PD Report, March 2008 identified both submersible and vertical turbine pumps as appropriate for this application. The GAC Backwash Pump will not operate on a continuous basis, but will take suction from the pump well and be located in the GAC Pump Station adjacent to the GAC Feed Pumps. Based upon the use of vertical turbine pumps for the GAC Feed Pumps, the facility layout, hydraulics and consistency, it is recommended that vertical turbine pumps be utilized for the backwash pumps.

The GAC backwash pumps will therefore be as follows

- Number of pumps: 1, with backup provided by Filter Backwash Pump.
- Capacity: 15.2 mgd. 10,555 gpm
- Head : 65 ft, TDH, final value to be determined in final design.
- Drive: Variable Speed Pump.
- Type: Vertical Turbine.
- Horsepower: 250 HP (approximate).

5.3.1.3 Filter Backwash Pumps

The existing sand filters are currently backwashed taking supply from a buried, 200,000 gallon backwash tank located in the hillside above the plant near the south reservoir. This tank is filled with drinking water taken from a distribution system main supplied by the Route 27 Pump Station. Before the finished water supply line was installed, the tank was filled by drawing water from the clearwells. The original backwash pumps for filling this tank are located in the basement of the filter building and have not been used for several years due to excessive vibration in the entire building and a power dip that occurred whenever the pumps were started.

Replacement of the original backwash pumps was included in the scope of the Advanced Treatment project. The existing sand filters are currently scheduled for rehabilitation including, at a minimum, the replacement of the existing media. The filter improvement project is in design by another engineering firm and bidding of the project will be completed before the Advance Treatment bidding. The filter media replacement will likely require additional backwash flow which cannot be easily provided by the existing backwash tank system. This need for additional flow and replacement of the backwash pumps when combined with the condition of the existing backwash tank (scheduled for rehabilitation in separate capital project) support the installation of a backwash pump system which can be utilized to backwash the sand filters directly (i.e., without use of the backwash tank). The backwash rate for the new filters has not been determined. In accordance with the latest version of Ten State Standards, the rate should be a minimum of 20 gpm per square foot.

The preliminary sizing analysis provided in this report was completed to determine whether the pump capacity requirement for backwashing the GAC contactors would likely equal or exceed that needed for the sand filters. This preliminary analysis has reached that conclusion. The final capacity and head of the filter backwash pumps should be selected based on the characteristics of the filter media and underdrain system. CH2M HILL requests that NKWD provide this information.

The initial sizing of this pump will provide 20 gpm per square foot to the filters. Based upon the 560 square feet area of the existing filters, the total flow rate will be 11,200 gpm at an approximate TDH of 70 feet will be required. The Filter Backwash Pump will be located in the GAC Pump Station adjacent to the GAC Feed Pumps and the GAC Backwash Pump. Similar to the GAC Feed Pumps and GAC Backwash Pumps, vertical turbine pumps will be utilized for this application.

The flow and head characteristics for the GAC Backwash Pumps and Filter Backwash Pumps are similar enough that the pumps will be utilized as backup pumps for the other application. The pumps will be provided with variable frequency drives, flow meters, and flow control valves sufficient to control the flows and heads for the two applications.

The filter backwash pumps will therefore be as follows

- Number of pumps: 1, with backup provided by GAC Backwash Pump.
- Capacity: 16.1 mgd. 11,181 gpm
- Head: 70 ft, TDH, final value to be determined in final design.
- Drive: Variable speed.
- Pump Type: Vertical Turbine.
- Horsepower: 250 HP (approximate).

5.3.1.4 Slurry Water Pump System

A slurry water supply system is needed to support the installation and removal of the GAC from the contactors. This slurry water stream requires flow of at least 100 gpm per contactor feed line and a head of at least 100psi. Site visits by the project team confirmed that a slurry stream of this capacity and pressure is required to efficiently install and remove the GAC. Contacts with carbon vendors revealed that the ability to operate 2 eductor driven GAC supply/removal lines concurrently would be a valuable asset for exchanging carbon in the beds.

The PD Report, March 2008 determined that the slurry water system would be provided with a hydropneumatic tank to stabilize pressures in the system. Discussions with manufacturers indicate that a large tank (1,000 gallons minimum) would be required for this application and that the relatively infrequent use of the system at full capacity (only during GAC replacement) would result in operational problems. In lieu of the hydropneumatic tank system, a system of vertical pumps with variable frequency drives will be provided. This system will provide additional operational flexibility, reduce maintenance, and avoid the stagnant water that would result from the use of the hydropneumatic tanks. The system will consist of two large pumps capable of providing the flows and pressures required for GAC transfer operations and a smaller, vertical pump with variable frequency drive for routine daily washdown in the facility. The system will be designed to allow operation of both of the large pumps if the GAC replacement contractor needs the additional flow for multiple trucks or removal from multiple contactors concurrently.

The slurry water pumps will therefore be as follows

- Number of pumps: 2.
- Capacity: 100 gpm, each.
- Head: 110 ft, TDH, final value to be determined in final design.
- Drive: Variable speed.
- Pump Type: Vertical Turbine.
- Horsepower: 15 HP (approximate).

5.3.1.5 GAC Pump Well

The operation of the GAC and Filter Backwash Pumps requires a well to avoid system drawdown and significant operational problems. Discussions with NKWD personnel confirmed that the existing clearwells are not adequate for this use. This GAC Pump well will serve as the source for several discharges including the following:

- GAC Feed (Pump to GAC Contactors).
- GAC Backwash Supply.
- Filter Backwash Supply.
- Slurry Water Supply.

The GAC Feed will be a continuous flow and will match the water treatment plant flow in most instances. As such, only minor storage capacity is required for this application, primarily during pump startup.

The remainder of the flows will occur on a periodic basis with the Filter Backwash being the most frequent. In order to minimize the size of the pump well, the NKWD has determined that the filters and the contactors will not be backwashed concurrently. The well was sized to backwash all of the filters in a single day or to backwash two (2) contactors and four (4) filters in a single day. The tank was sized to provide sufficient storage to allow either of the backwash pump systems to operate through a full backwash cycle without increasing the raw water flow to the plant or decrease the GAC Feed rate to the active contactors. This operational flexibility allows the NKWD to complete the required backwash and replenish the storage at the most appropriate time. On this basis, the minimum size required is 371,000 gallons of usable storage. A storage tank of 400,000 gallons is recommended.

The pump well will be divided into two, relatively equal parts to allow for inspection, maintenance, and cleaning without interrupting operation of the system. The interior tank walls will be connected using slide gates which will normally be in the open position. The pump well will be provided with an overflow which will be routed to the EQ Basin. When a tank compartment is to be isolated for maintenance activities the water level can be drawn down by the GAC feed pumps. Each of the two tank sections will also be outfitted with a submersible sump pump to facilitate dewatering of the tanks section.

The sump pumps will therefore be as follows:

- Number of pumps: 3.
- Capacity: 100 gpm, each.
- Head: 25 ft, TDH, final value to be determined in final design.
- Drive : constant speed.
- Pump Type: submersible.

5.3.1.6 Equalization (EQ) Basin

5.3.1.6.1 EQ Basin Size

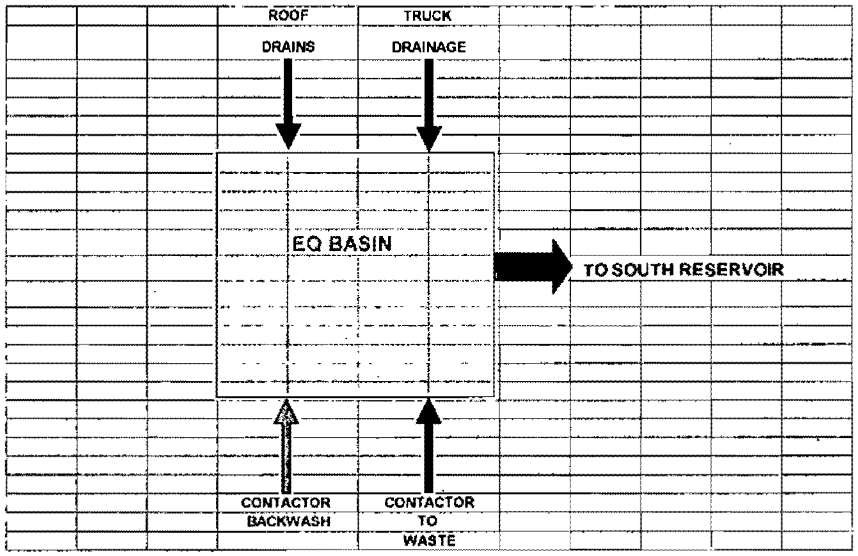
Backwashing the GAC Contactors produces a large volume of waste water which requires disposal. The PD Report, March 2008 identified the total volume of backwash water as 400,000 gallons based upon a backwash period of 30 minutes at a rate of 15 gpm per square foot. This volume does not include the contactor to waste flow proposed after the contactor backwash. The Kentucky Division of Water verified that disposal of the Contactor Backwash water will not be considered recycle flows as regulated by the Filter Backwash Recycle Rule. Therefore the backwash and contactor to waste water will be of suitable quality to be pumped to the South reservoir for disposal at a rate that optimizes the sizing of the tank and pumps.

In addition, the removal of the spent GAC from the contactors and installation of new GAC in the contactors will require the use of slurry water for transport and will require wasting and disposal of these flows. The waste slurry water will contain varying amounts of GAC fines and must be contained and disposed of properly. The facility will include provisions for containing this water and routing it to the EQ Basin for disposal. NKWD currently adds powdered activated carbon to the raw water reservoirs at times for taste and odor control; therefore returning the carbon fines to the reservoirs may be beneficial.

The roof structure for the Advanced Treatment building is intended to include a vegetated green roof over the contactor basins and a pitched metal roof over the pump station and UV room. The storm water from the metal roof will be routed to the EQ Basin for pumping to the south reservoir. The Kentucky Division of Water has agreed to this disposal method provided certain conditions are met (see Section 10).

Exhibit 5-32 summarizes the flows to the EQ Basin. The original analyses and tank sizing included the filter to waste flows from the existing sand filters. It was determined that separating these flows from other backwash to waste flows and routing these flows to the new EQ Basin by gravity would be extremely difficult, if possible, and involve significant construction costs relative to the flows involved. It was determined that the filter to waste flows would continue to be treated in the existing system at this time. In addition, overflows from the GAC Pump Well and the contactor influent channel will be routed to the EQ Basin.

EXHIBIT 5-32
EQ Basin Flows



The size of the EQ Basin is controlled by the total volume of water routed to the basin, the pumping rate from the basin to the South reservoir and the operation of the facility. Three (3) options were evaluated to determine the optimum size of the EQ Basin including the following:

- Pump Rate = 0 gpm.
- Pump Rate = 3,300 gpm.
- Pump Rate = 6,600 gpm.

The tanks sizes for these options ranged from 210,000 gallons for the largest pump rate to over 515,000 gallons for option with no pumping during the tank filling cycle. A review of the lifecycle costs for the three options indicated that a pump rate of 3,300 gpm and a storage tank size of 333,000 gallons resulted in the lowest cost option by approximately 10% of the total costs. On this basis, it is recommended that an EQ Basin with a total volume of approximately 350,000 gallons and a pump station with a firm capacity of 3,300 gpm be constructed.

The EQ Basin will be divided into two, relatively equal parts to allow for inspection, maintenance, and cleaning. The tank sections will be connected using slide gates which will normally be in the open position. When a tank compartment is to be isolated for maintenance activities the water level can be drawn down by the EQ basin pumps. Each of the two tank sections will also be outfitted with a submersible sump pump with capacity sufficient to empty the tank and handle wash down water. During detailed design, consideration will be given to sloping the basin floors and/or filleting the basin corners as a means of enhancing removal of GAC fines.

The sump pumps will therefore be as follows

- Number of pumps: 2, 1 per compartment.
- Capacity: 0.14 mgd, each.
- Head: 25 ft, TDH, final value to be determined in final design.
- Drive: Constant speed.
- Pump Type: Submersible.

5.3.1.6.2 EQ Pump

The PD Report, March 2008 identified submersible pumps or vertical turbine pumps for use in this application. These pumps will be operated primarily when the GAC Contactors are backwashed and for shorter periods of time during other operations. The pumps will be required to pump significant GAC fines after each GAC replacement event with the potential for some GAC fines during each backwash. Submersible pumps have greater solids handling capability and have broader tolerances in the bowl area making them less subject to abrasion from handling carbon fines. It is intended that the tank be emptied after each backwash or contactor to waste event. The use of vertical turbine pumps in this location would require the construction of deeper well in the area of the pumps to maintain submergence at all times whereas submersible pumps require only minimal submergence. On the basis of the intended use and the frequency of use it is recommended that the submersible pumps be utilized for this application. Each pump will be provided with a means for removal from the well for maintenance and removal from the building for servicing. NKWD expressed a concern with inaccessibility of the pumps for routine inspection and maintenance and has requested that highest quality submersible pumps be provided.

The EQ pumps will therefore be as follows:

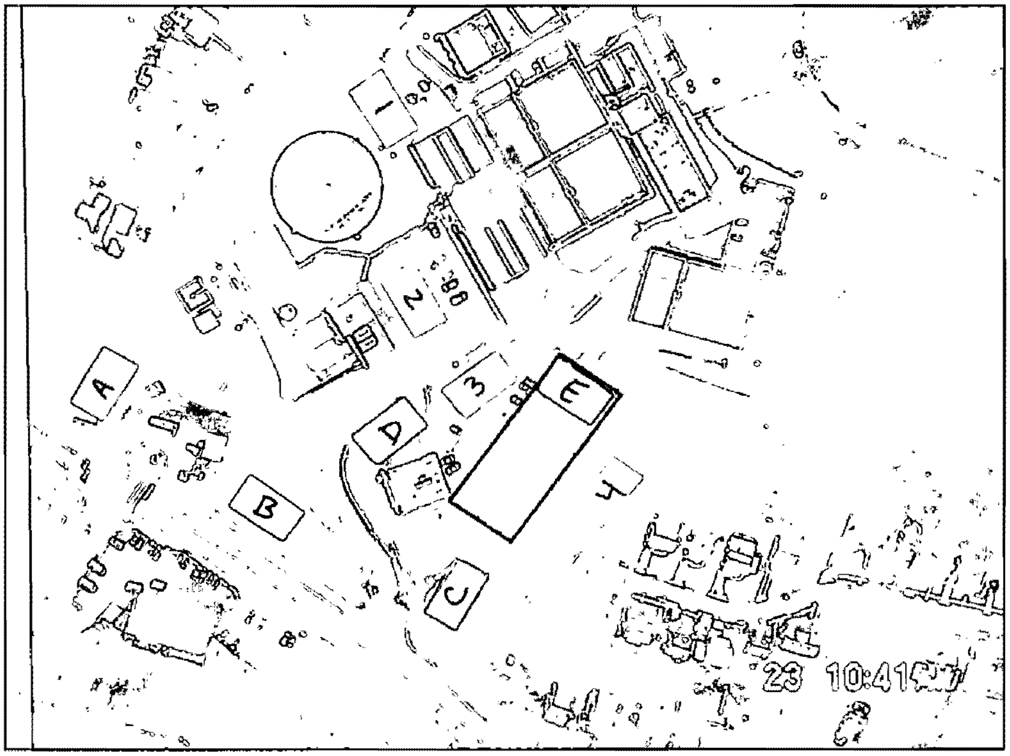
- Number of pumps: 2, 1 per compartment.
- Capacity: 4.75 mgd, each.
- Head: 70 ft, TDH, final value to be determined in final design.
- Drive: Constant speed.
- Pump Type: Submersible.
- Horsepower: 100 HP (approximate).

5.3.1.6.3 Location of Facilities

The FTTP site is extremely limited in space and, accordingly, the location of the proposed EQ Basin and GAC Pump Well with the associated pumping facilities on the site is critical. Numerous factors, both economic and non economic, have a significant impact on the final locations.

NKWD selected four (4) potential locations for each of the tanks/pumping facilities as shown in Exhibit 5-33. The letters show potential locations for the EQ Basins and numbers indicate potential GAC Pump Well locations. In addition, based upon the initial evaluations and discussions with the project team, the potential of locating the tanks at a common location was also evaluated and sites E and 2 selected as the most appropriate sites for combined tanks.

EXHIBIT 5-33
Potential Tank Locations



The evaluation of the alternative locations consisted of a review of the potential construction advantages and disadvantages, discussions related to operational advantages and disadvantages, comparative constructions cost analyses, and a review of non-economic factors. Exhibits 5-34 and 5-35 include the construction review and Exhibit 5-35 includes a summary of the non-economic factors.

EXHIBIT 5-34
EQ Basin Site Construction Evaluation

EQ BASIN	1	2	3	4
SITE OPTIONS			OUT	OUT
			USE E	LOC/ROCK
Site access and operations	No impact	Sheeting for Road	Sheeting--minor	No impact
Laboratory operations	No impact	No impact	Access limited	No impact
			Blasting	
Existing piping	Some relocation	Some relocation	Minor	Minor
Proposed piping	Long discharge	Shortest--influent		Deep, rock, long
	route			influent
Access for O & M				
Operations costs				
Sheeting/shoring/Bracing	Protect Filter/pipe/elec/	Protect Solids Bldg.		Min--rock
	pipe/electrical/hypo	Road and Parking		
	Design Critical	**Design Critical**		
Rock excavation	4-12 ft	Least		Major--hard
	unweathered			
Foundation requirements	On rock	Drilled Shafts		Rock
		plus rock		
Risk to other buildings	Solids	Solids/Park/Road/		Blast near Lab
		Tunnel		Blast near BW
Risk to adjacent property				Blast near houses
Geotechnical investigation	Addn'l Borings req'd	Addn'l Borings req'd		Add'l borings req'd
Future Site use	Filter Bldg Exp	Restricts Solids Bldg		Future BW Tank?
Positives		>Min rock & blast	**USE E INSTEAD**	
		>Access	>No advan to separat	
		>Impact on Ops	>Combine sheeting	
Negatives				
		>Tight Const		>Rock exc
		>Rock Varies		>BW tank
		>10' below solids		>Houses
		>Shore 4 sides		>Depth for Pipe
		>Future solids		
		>Foundation		

EXHIBIT 5-35
GAC Pump Well Site Construction Evaluation

PUMP WELL	A	B	C	D	E
SITE OPTIONS	OUT USE B		OUT-ROCK	OUT SPACE/ROCK	
Site access and operations	No impact	No impact	Close to entrance-- work area, hold hill	Close to road	Close to road to Residential-alt. access avalble
Laboratory operations	No impact	No impact	Access	Access/blast	Blasting
Existing piping	Pipe tunnel/exist station	Minor	Minor	Minor	Minor
Proposed piping	Longest required--in & out	Longest required-- Influent & Outlet	Long Run Influent & Outlet		
Access for O & M			Access difficult	Drive on tank	with GAC
Operations costs	Highest pump head	Highest pump head			
Sheeting/shoring/Bracing	Critical to Protect adjacent				
Rock excavation	Partial	Partial	Major	Major	Above 765-Weathered Below 765-hard!
Foundation requirements	Drilled Shafts + Rock	Drilled Shafts + Rock	On rock	On rock	On rock
Risk to other buildings					Blast near lab Blast near BW tank
Risk to adjacent property	Prop Line--close Rt 27	Rt 27			Blast near houses
Geotechnical investigation	Addn'l Borings req'd	Addn'l Borings req'd			
Future Site use	No impact	No impact			
Positives		**Better than A-** >No property line problems >No buildings to protect >No demo			Combine sheeting w/ GAC bldg const
Negatives	Demo Exist Station Property Line Reduce size to sheet Rt. 27	Rt 27 Foundation	50 ft of cut Approach el. 800 35 ft Weathered Rk 15 ft hard rock	No space for 50x100 20-32 ft of cut Lower than 1st Floor of Lab	To 765--weather rock < 765--rock

EXHIBIT 5-36
Non-Economic Tank Location Factors

	Site Access	Lab Access & Operations	Exist Pipe & Duct	Proposed Pipe	Risk to Adj Prop & Bldg	Future Site Use	Future Bldg Expansion	Community Acceptance	
EQ SITE B	⇨	⇧	⇩	⇩	⇧	⇧	⇩	⇩	
EQ SITE E	⇧	⇩	⇧	⇧	⇩	⇧	⇩	⇩	
PUMP SITE 1	⇧	⇧	⇩	⇨	⇩	⇩	⇩	⇨	
PUMP SITE 2	⇨	⇧	⇩	⇨	⇩	⇩	⇧	⇧	
COMBINED SITE 2	⇨	⇧	⇩	⇨	⇩	⇩	⇧	⇧	
COMBINED SITE E	⇧	⇩	⇨	⇧	⇩	⇧	⇩	⇩	

On the basis of the site construction evaluation for each of the alternatives, the following sites were selected for further evaluation.

- GAC Pump Well----Sites 1 and 2.
- EQ Basin----Sites B and E.
- Combined Tanks----Site 2 or E.

A comparative construction cost estimate was completed for each of the alternatives. On the basis of these estimates, the following was identified:

- Pump Well----Site 2 more economical (25%).
- EQ Basin----Site E more economical (8%).
- Either Combined Site~ 20% more economical than separate sites.
- Combined Sites---Site E more economical (2%).

On the basis of the evaluations and the potential future expansions of the site, it was determined that Site E would be utilized for a combined tank site, under the GAC building.

The EQ Basin will be provided with an overflow which will be routed to the existing backwash holding tank.

5.3.2 Memorial Parkway Treatment Plant (MPTP)

5.3.2.1 Purpose

The installation of granular activated carbon contactors and ultraviolet (UV) disinfection at MPTP will require the addition of pumping and storage facilities for proper operation. At MPTP, these facilities will be installed after filtration and prior to post-chlorination and clearwell storage. The facilities include a GAC influent pumping station, GAC Contactors, and UV reactors together with related piping and valves. In addition, the installation of GAC and UV at MPTP will require modifications to existing piping and facilities. The primary purpose of this section is to identify the pumping and storage facilities that are required and the design criteria associated with them.

5.3.2.2 Design Criteria

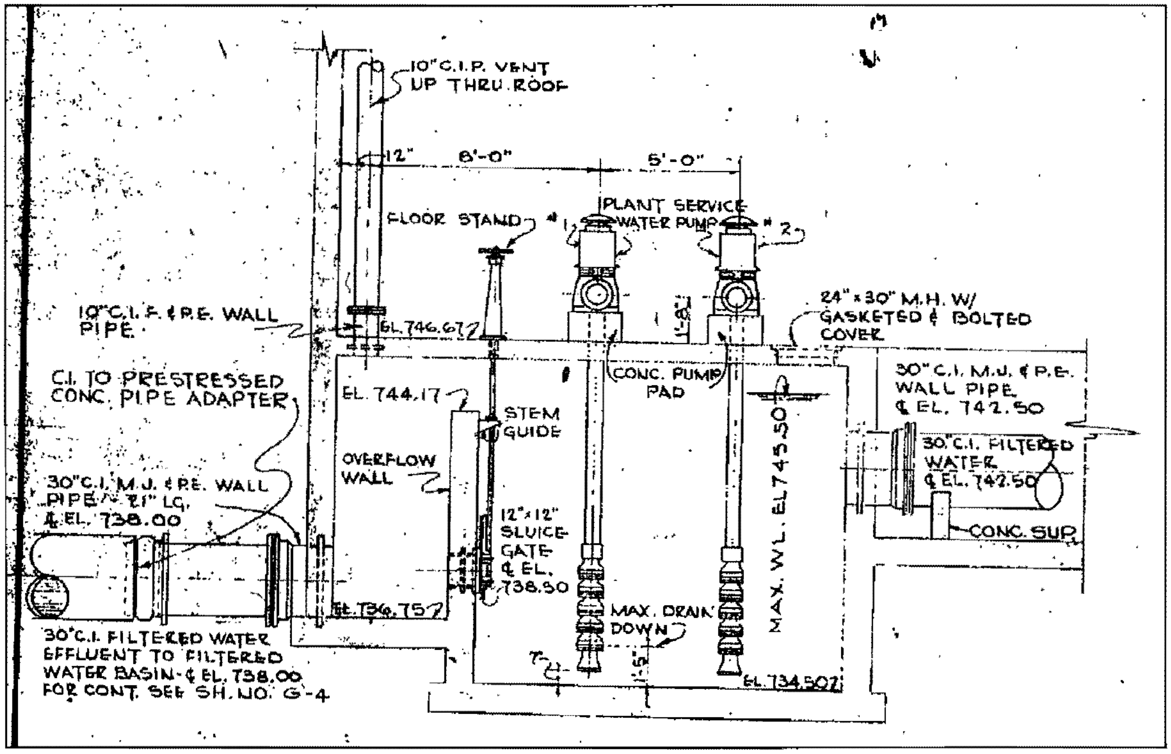
The installation of the GAC contactors at MPTP will be a retrofit and will require a pumping station to provide influent flow to the contactors. The pump station will lift the water to the GAC contactors and provide sufficient head to drive the flow through the GAC and UV systems. The preliminary design details associated with each element of the GAC influent pump station are provided below.

5.3.2.2.1 GAC Pump Station Wet Well

The GAC pump station wetwell at MPTP will be located adjacent to the existing filter building near the lower access door as shown on the Site Plan presented in Section 8. The flow from the filters presently is routed to a 3,000 gallon "pit" as shown below in Exhibit 5-37 prior to exiting the Filter Building. This "pit" has previously served as a supply pump station for a hydro-pneumatic system that supplied service water to the WTP. This pump station is no longer in service but the "pit" has a control weir on the entrance that serves as a seal weir for the filters. The entire pit will be removed and the combined filter effluent pipe will be extended to the GAC influent pump station. The weir will not be needed as the high level in the GAC influent pump station will be equal to the water surface elevation in the conventional gravity filters. Additional details of the GAC influent pump station include the following:

- Operating Floor Elevation – 760.0.
- Bottom of Wetwell Elevation – 735.0.
- Wall Thickness - 18" minimum.
- An existing drain line runs under proposed pump station location. This line will be placed in a trench through the bottom of the pump station which has an impact on available volume.

EXHIBIT 5-37
Pit Layout



The usable volume has been determined based on a review of the expected loss of head through the gravity filters, piping and appurtenances. Those estimated values are provided below:

- 8.0' max LOH (NKWD trigger for backwashing filter).
- 0.5' effluent valve loss at open position.
- 1.0' minor losses for piping.

Based on this information, the terminal head loss through the existing filters is approximately 9.5 ft. Therefore, if the water surface elevation is maintained at approximately 758.0, the level in the GAC influent pump well should be around 748.5. This results in a usable wet well volume of about 75,000 gallons with about 13 ft of water depth. This volume will provide a buffer for the pumps during start-up or change of flow events as well as during media handling periods while the filter rate-of-flow controllers are responding to the change. The pumps will have variable frequency drives (VFDs) to help slow the instantaneous demands associated with a change of flow event. The pump station will be fitted with an overflow pipe discharging to the North Reservoir to prevent the water from backing up in the filters in the event of a pump failure.

The wet well will be divided into two, relatively equal parts to allow for inspection, maintenance, and cleaning without interrupting operation of the system. The interior tank walls will be connected using slide gates which will normally be in the open position. When a tank compartment is to be isolated for maintenance activities the water level can be drawn down by the GAC feed pumps. Each of the two tank sections will also be outfitted with either a submersible sump pump or a valved gravity drain assembly to facilitate removal of sediment and fluid from the tank section prior to a maintenance event.

5.3.2.2.2 GAC Influent Pumps

The GAC pump station will include 4 influent pumps, check valves, isolation valves along a single flowmeter and related appurtenances. All of the proposed pumps are to be vertical turbine and will be provided with VFDs to accommodate the wide flow ranges seen at MPTP. Additional details for the pumps are provided below in Exhibit 5-38.

EXHIBIT 5-38
MPTP GAC Influent Pump Details
NKWD Advanced Treatment Project

Item	Pump 1	Pump 2	Pump 3	Pump 4
Flow (GPM)	3,500	3,500	7,000	7,000
Total Discharge Head (Feet)	50	50	55	55
Minimum Efficiency	78%	78%	78%	78%
Horsepower	75	75	125	125
Maximum Speed (RPM)	1800	1800	1200	1200
Pump Control	VFD	VFD	VFD	VFD
Minimum Floor Clearance	14″	14″	16″	16″
Minimum Submergence	48″	48″	60″	60″

The pumps are sized to provide for efficient operations at the current typical flow rate of 5 mgd as well as projected future flows of 10 - 15 mgd.

5.3.2.2.3 Slurry Water Pumps

In addition to the GAC influent pumps, two vertical turbine slurry water pumps will be included in the GAC pump station. The purpose of these pumps is to provide motive water for the delivery and removal of the GAC media from the contactors. The materials handling will be done with eductors which require high pressure water to produce a vacuum. The vacuum will enable the GAC to be removed or installed in a wet slurry. Some of the details associated with the slurry pumps are provided below in Exhibit 5-39.

EXHIBIT 5-39
MPTP Slurry Pump Details
NKWD Advanced Treatment Project

Item	Pump 1	Pump 2
Flow (GPM)	100	100
Total Discharge Head (Feet)	250	250
Minimum Efficiency	75%	75%
Horsepower	15	15
Maximum Speed (RPM)	3600	3600
Pump Control	Constant Speed	Constant Speed
Minimum Floor Clearance	14″	14″
Minimum Submergence	48″	48″

5.3.2.2.4 Backwash Pumps

A replacement of the existing backwash pumps at MPTP is expected. MPTP currently has two backwash pumps that supply the existing filters. Fortunately, the size and expected backwash rate of the existing filters is comparable with the new GAC contactors. As such, the existing backwash facilities are of acceptable size and capacity to supply the GAC contactors as well. Therefore, the existing backwash pumps will be replaced with new pumps and VFDs added to assure smooth operations between the two facilities. The design criteria for the replacement backwash pumps is provided below in Exhibit 5-40.

EXHIBIT 5-40
MPTP Replacement Backwash Pumps
NKWD Advanced Treatment Project

Item	Pump 1	Pump 2
Flow (GPM)	11,000	11,000
Total Discharge Head (Feet)	65	65
Minimum Efficiency	80%	80%
Horsepower	250	250
Maximum Speed (RPM)	1800	1800
Pump Control	VFD	VFD
Pump Type	Vertical Turbine	Vertical Turbine

5.4 Ancillary Systems

5.4.1 Dechlorination

The RSSCTs conducted for NKWD were all conducted with chlorine feed to filters turned off. There is a limited amount of data available on the impacts of chlorinated influent to GAC contactors. Anecdotal information suggests chlorinated influent may result in a decrease in adsorptive performance (leading to more rapid carbon exhaustion and more frequent replacement), as well as potential negative impacts on GAC media characteristics over time. For these reasons, the NKWD plans to dechlorinate the GAC influent.

The potential concerns associated with a chlorinated backwash supply were carefully considered. The potential negative effects of a chlorinated backwash supply that were identified include damage to any established biology in the GAC contactors, potential reduction in adsorption efficiency, and increased carbon friability. On the other hand, the benefits of a chlorinated backwash supply include the availability on site and the provision of a disinfectant residual for storage.

There have been mixed findings regarding the impacts of free chlorine applied to the GAC media as backwash supply water. One study by Liu et al.1 demonstrated that a concentration of 0.5 mg/L free chlorine in the backwash water had essentially no effect on the GAC's biological activity. CH2M HILL has evaluated this issue at both pilot-scale and full-scale treatment facilities, and empirical findings from the majority of these evaluations indicate that backwash supply water with a free chlorine residual concentration of 0.5 to 1.0 mg/L is not expected to negatively impact biological filtration performance.

Consultation with Professor Vern Snoeyink of the University of Illinois indicated that a key parameter to consider with respect to chlorinated backwash supply is the mass of free chlorine per gram of GAC carbon. Based on backwash volumes, and an average free chlorine concentration leaving the filters of approximately 0.5 mg/L, the total chlorine loading is approximately 1 mg chlorine per gram of GAC, or less than 0.1 percent. Professor Snoeyink, one of the world's foremost experts on activated carbon, indicated in discussion that this chlorine loading from filter backwashing is not likely to have a detrimental effect on GAC performance in terms of biological activity or adsorption performance.

It is recommended that the NKWD collect empirical data during the initial period of plant operations. As described in a later section, dechlorination facilities are planned for the treatment plants. It is recommended that a dedicated dechlorination chemical feed pump and feed piping also be provided for the backwash supply in the event the NKWD determines that it is beneficial to dechlorinate the backwash supply. Once the system is in operation, it is recommended that NKWD review operation of the pre-chlorination and dechorination systems to assess benefits versus costs.

5.4.1.1 Dechlorination Options

Currently, sulfur-based chemicals including sodium bisulfite, sodium metabisulfite, and sodium thiosulfate are most frequently used by water utilities for dechlorination. Other options include hydrogen peroxide, sodium thiosulfate, calcium thiosulfate, ascorbic

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[1] Liu, X., et. al., 2001, "Factors Affecting Drinking Water Biofiltration," *Journal American Water Works Association*, Vol. 93, No. 12, pp. 90-101

acid, and sodium ascorbate. The choice of a particular dechlorination chemical depends on site-specific issues such as chemical preferences, strength of chlorine or chloramines, and site constraints.

Sodium bisulfite is used by many utilities due to its lower cost and higher rate of dechlorination. Sodium thiosulfate is also used for dechlorination since it is less hazardous and consumes less oxygen than sodium bisulfite. Ascorbic acid and sodium ascorbate are used because they do not impact dissolved oxygen concentrations.

Sodium bisulfite is available as a white powder, granule or clear liquid solution. It is highly soluble in water and generally purchased as a solution in strengths of approximately 40 percent. Currently, many industries and wastewater utilities use sodium bisulfite solution for dechlorination. It is usually metered as a dechlorinating agent by diaphragm-type pumps.

Sodium bisulfite reacts very rapidly with residual chlorine, both free and combined forms, and contact times are very short. Dechlorination control is very simple because it is specific to chlorine and has a very low environmental and toxicity impact. Careful dosage control is necessary because any excess over that required for residual chlorine will deplete dissolved oxygen in water and could have a negative impact on chlorine residual in the clearwell. Sodium bisulfite undergoes the following reaction with chlorine:

$$\underset{\text{Sodium Bisulfite}}{NaHSO_3} + \underset{\text{Hypochlorous acid}}{HOCl} + H_2O \rightarrow \underset{\text{Sodium bisulfate}}{NaHSO_4} + \underset{\text{Hydrochloric acid}}{HCl}$$

On a weight-to-weight basis, approximately 1.45 parts of sodium bisulfite are required to dechlorinate 1 part of chlorine. Many facilities overfeed slightly (e.g., 1.6:1 ratio of sodium bisulfite to residual chlorine on a weight basis). The usual solution strength is 40 percent, which has a specific gravity of 1.3. Thus, the bulk density of active chemical is 4.34 lbs per gallon. For each part chlorine removed, 1.38 parts of alkalinity as CaCO3 will be consumed.

Sodium bisulfite can cause skin, eye and respiratory tract irritation. It is highly corrosive and must be stored in a containment area. It can be handled wet in stainless steel, PVC, or fiberglass tanks. Because it may crystallize at room temperatures, a heating system will be necessary.

For the NKWD, sodium bisulfite systems have been designed to dechlorinate, as follows:

GAC Influent:

- 44 mgd maximum flow at FTTP.
- 20 mgd maximum flow at MPTP.
- Minimum sodium bisulfite dose of 0.32 mg/L (for chlorine residual of 0.2 mg/L).
- Average sodium bisulfite dose of 0.80 mg/L (for chlorine residual of 0.5 mg/L).
- Maximum sodium bisulfite dose of 3.2 mg/L (for chlorine residual of 1.0 mg/L).

Backwash Supply:

- Sized for maximum backwash supply flow rate (15 gpm/sf for one contactor).
- Minimum, average, and maximum sodium bisulfite doses as noted above.

A storage tank with capacity of approximately 6,000-gallons will be provided to provide capacity for a full tanker truck delivery and to provide more than 30 days storage at average flow and dose conditions. A total of three feed pumps will also be provided, with dedicated feed pumps for: 1) GAC influent dechlorination, 2) backwash supply dechlorination, and 3) a shared standby pump.

NKWD has elected to defer installation of dechlorination facilities at MPTP. The impact of dechlorination at FTTP will be observed during the early period of operation and the discussion of whether to add dechlorination at MPTP will be made based on the observations.

5.4.2 General Equipment and Systems

Standards for mechanical, electrical and controls equipment and systems have been developed using insights gained during the plant tours, from prior experience of the designers and from the experience of NKWD with vendors and types of equipment. GAC is transported to and from the contact beds in a slurry form through hoses and pipes. Consistent feedback was provided that an ample volumetric flow rate and pressure of the slurry water is essential and that even with a good slurry water supply, plugging of conveyance piping will sometimes occur. Durable 316 stainless steel pipe is recommended for carbon slurry and cleanouts are to be provided at all bends and frequently in long runs of pipe.

Graphite (carbon) is nearly at the top (Cathodic end) of the Galvanic Series of Metals and can cause galvanic corrosion of most metals. In addition, GAC granules and the fines that are created when the granules break down are gritty products that tend to erode surfaces through which they pass. Therefore careful selection of materials and equipment types is required for piping and pumping systems that handle GAC slurry, spent backwash water, and contactor to waste flows.

Exhibit 5-41 located at the end of this Section provides a summary of the standards to be used in selecting and specifying equipment and systems to be used on the Advanced Treatment projects. The standards are intended as a guide for the selection of cost effective components in the detailed design process. The cost effectiveness goal includes selection of durable materials suitable for long term service in the service environment and also identification, where possible of items that are available through multiple sources so as to promote competitive bidding on the projects.

5.5 Electrical System

The purpose of evaluating the electrical system for FTTP and MPTP in the Basis of Design report is five fold:

- Develop design standards to be implemented at each plant.
- Provide an assessment of the condition and capacity of the existing electrical distribution system at each plant to determine if it is suitable to support the proposed improvements related to the additional facilities for Advanced Treatment.
- Develop alternatives to upgrade or replace the existing electrical distribution system to ensure long-term operational reliability for Advanced Treatment at each facility.
- Develop alternatives for adequate back-up power to keep each facility operational during a power outage. Review the existing backup power capabilities at both facilities to determine their capacity for additional loads.
- Recommend specific improvements to be implemented.

5.5.1 Design Standards

The objective of the design is to provide a safe, reliable and maintainable electrical distribution system. In general, the following basic criteria shall apply:

- All electrical components, including transformers, conductors, and overcurrent devices will be sized for the existing, new and known future loads per NEC.
- The fault current will be calculated at any specific point on the system and equipment will be rated for that fault current.
- Reliability is the ability of equipment to perform its function for its service life. For electrical equipment, reliability is established by several factors, including surrounding conditions, maintenance, and operating the equipment within its ratings.
- Maintenance and operation will be considered during design. This includes standardizing the type of equipment specified to ease operations, minimize maintenance time, and minimize maintenance parts; providing equipment and design that is safe, operable, and easily maintainable; and minimizing capital, operations, and maintenance costs.
- The applicable standards and codes include the following:
  - National Electric Code (NEC).
  - Kentucky Building Code (KBC).
  - Life Safety Code (NFPA 101).
  - National Electrical Safety Code (NESC).
  - National Fire Protection Association (NFPA).
  - Insulated Cable Engineers Association (ICEA).
  - National Electrical Manufacturers Association (NEMA).

  - Institute of Electrical and Electronic Engineers (IEEE).
  - American National Standards Institute (ANSI).
  - The Occupational Safety and Health Act (OSHA).
  - American Society for Testing and Materials (ASTM).
  - Underwriters Laboratory (UL).
- Exposed conduit in chemical areas will be PVC Schedule 80. Other areas including exterior locations will be aluminum. Underground conduit shall be PVC Schedule 40, concrete encased. Final connections to motors, valves and vibrating equipment will be with flexible conduit.
- Provide spare conduits where appropriate for future use.
- Conductors will be NEC Type THHN/THWN for sizes #14 through #1 AWG; NEC Type XHHN for sizes #2 and larger.
- System voltage will be 208Y/120 volt, three-phase for lighting and miscellaneous small loads; 480Y/277 volt, three-phase for motors and feeder circuits.
- NEMA 1, gasketed enclosures will be used in locations where the area is relatively dry and clean; NEMA 4X stainless steel or plastic enclosures for electrical equipment outside and in corrosive areas; NEMA 7/9 enclosures for any hazardous areas.
- Surge/Lightning protection will be provided at main switchgears, loadcenters, VFDs and MCCs. For control and power distribution panels, follow the principle of "single point grounding" within each enclosure.
- Motors will be energy efficient type. For motors used with variable frequency drives, inverter duty motors in accordance with NEMA MG 1, Part 31 will be utilized.
- In any space within the building, adequate lighting levels will be maintained. The footcandle level for maintained illumination will be as recommended by IES, Lighting.
- Provide night lighting that stays on continuously in corridors, stairways and critical areas.
- Provide emergency lighting and exit lights in areas required by the current KBC.
- Lightning protection systems shall be provided for each building. Each system shall comply with the latest version of Lightning Protection Institute (LIP) and HFPA.

5.5.2 FTTP

5.5.2.1 Existing System

Currently the facilities at FTTP have four separate services from Duke Power:

- The main feed to the plant which includes the Administration/Filter Building, Sludge Building, Belt Press Building, Sodium Hypo Building and Chemical Building.
- Lab.
- US 27 Pump Station.
- Pretreatment Building and Carbon Silo.

The focus of this report will be on the main feeder at the plant.

FTTP receives power at 12,470 volt from a Duke overhead, three-phase circuit that runs along Military Parkway on the north side of the plant. The supply runs from the overhead circuit underground on the plant property to an outdoor metal-clad enclosure containing a 15 kV draw-out main breaker. The main breaker feeds outdoor, pad-mounted 15 kV switchgear with three sub-feed disconnect switches:

- Switch No. 1 feeds a 225 kVA step down transformer to 480 volt which serves a main switchboard SB-1 at the Sodium Hypo facility. SB-1 also has a sub-feed for the Chemical Building.
- Switch No. 2 feeds three pad mounted transformers:
  - 500 kVA step down transformer to 480 volt which serves MCC-C in the Administration/Filter Building.
  - 225 kVA step down transformer to 480 volt which serves MCC-A in the Sludge Building Pump Room.
  - 225 kVA step down transformer to 480 volt which serves the Belt Press Building.
- Switch No. 3 is spare.

The 15 kV main breaker also functions as a tie-breaker with the generator breaker. In the event of a power failure, the automatic transfer controller will start the generator, open the main breaker and then close the generator breaker to provide back-up power to the facilities.

A 175 kW diesel generator set in an outdoor enclosure located adjacent to the main breaker provides power in the event of a power failure. Because the generator is not large enough for the entire plant, operations must be selective regarding what can run during an outage.

For additional information regarding the existing distribution system at FTTP, refer to the One-Line diagram on Exhibit5-42 located at the end of this Section.

5.5.2.2 Existing Loads

Each facility was evaluated based on the past 10 month demand history provided by Duke Energy as shown on Exhibit 5-43. This information is necessary in order to evaluate the existing capacity of the electrical service as well as the existing generator.

EXHIBIT 5-43
FTTP Demand

Month/Year	Demand (kW)	
	Actual	Billed
December 2007	198.0	198.0
January 2008	192.0	198.0
February 2008	186.0	186.0
March 2008	180.0	180.0
April 2008	162.0	168.3
May 2008	156.0	168.3
June 2008	168.0	168.3
July 2008	198.0	198.0
August 2008	180.0	180.0

Exhibit 5-44 summarizes the existing load and new loads for FTTP and provides an evaluation of potential generator sizes for the new loads and new/existing combined.

EXHIBIT 5-44
FTTP Load Data Summary

ITEM	Quantity	HP	FTTP (KW)
Existing Loads			
1. Existing Plant Peak Demand (Dec/07)			198.0
2. + 25%			49.5
Subtotal Existing Loads			247.5
New Loads			
1. GAC Pumps (2 Duty, 1 Standby)	3	250	400.0
2. Backwash Pump (1 Duty, 1 Standby)	2	250	200.0
3. EQ Pump (1 Duty, 1 Standby)	2	100	80.0
4. Blower	1	100	80.0
5. Misc Pumps		50	40.0
6. UV	3		90.0

EXHIBIT 5-44
FTTP Load Data Summary

ITEM	Quantity	HP	FTTP (KW)
7. Misc Bldg Loads			100.0
Subtotal New Loads			990.0
Generator Size Based New Loads Only			1250.0
TOTAL LOADS			1237.5
Generator Size Based on Total Loads			1500.0

5.5.2.3 Recommendations

After consideration of existing and projected demands along with items identified by NKWD as critical to plant operations, the following is recommended at FTTP:

- Provide a new 480 volt, three-phase, 1600 amp service for the Advanced Treatment facilities.
- Install a new primary 12,470 volt feeder from the existing pad mount switchgear to a new 1000 kVA pad mount transformer.
- Since the existing generator at 175 kVA is too small for anything at the plant except lighting and miscellaneous loads, it is recommended that it be removed and replaced with one large enough to service the existing facilities as well as new. The new generator will be 1500 kW.
- Provide a UPS for the UV System. For a detailed discussion on the UPS, refer to Section 5.1.4.4, Power Quality Equipment.

For additional information regarding the modified distribution system at FTTP, refer to the One-Line diagram on Exhibit 5-45 located at the end of this Section.

5.5.3 MPTP

5.5.3.1 Existing System

Currently the facilities at MPTP have three separate services from Duke Power:

- The main feeder to the plant which includes the Filter Building, New Chemical Building, Old Chemical Building, Wash Water Pump Station, Actiflo Facilities, and PAC.
- Raw Water Transfer Station (RWTS) and Solids Building.
- Water Works Road Pump Station.

The focus of this report will be on the main feeder at the plant.

MPTP receives power at 12,470 volt from a Duke overhead, three-phase circuit that runs along Water Works Road on the southeast side of the plant. The supply runs from the overhead circuit underground on the plant property to an outdoor metal-clad walk-in enclosure that contains two sub-feed draw-out breakers:

- Breaker No. 1 serves as a back-up feed to the RWTS. The feeder runs underground to a 300 kVA pad mounted transformer that steps the voltage down to 480 volt. The secondary of the transformer is tied to a manual transfer switch that can be utilized to provide an alternate source of power to RWTS.
- Breaker No. 2 feeds a 750 kVA step down transformer to 480 volt which feeds 1200 amp switchgear in the walk-in enclosure. The switchgear has seven sub-feed breakers that serve the following areas:
  - Breaker No. 1 is a 200 amp breaker that feeds the Filter Building. The feeder is connected to the generator via an automatic transfer switch.
  - Breaker No. 2 is 300 amp breaker that feeds the old Chemical Building.
  - Breaker No. 3 is a 600 amp breaker that feeds the Wash Water Pump Station.
  - Breaker No. 4 is a 450 amp breaker that feeds Actiflo.
  - Breaker No. 5 is a 250 amp breaker that feeds the blower.
  - Breaker No. 6 is a 60 amp breaker that feeds a 30 kVA step down transformer to 208Y/120 volt.
  - Breaker No. 7 is a 400 amp breaker that feeds the new Chemical Building and Carbon Silo. This feeder is connected to the generator via an automatic transfer switch.

A 250 kW diesel generator set in an outdoor enclosure provides limited power to the Filter Building, new Chemical Building and Powdered Activated Carbon Building.

For additional information regarding the existing distribution system at MPTP, refer to the One-Line diagram on Exhibit 5-46 located at the end of this Section.

5.5.3.2 Existing Load

MPTP was evaluated based on the past 10 month demand history provided by Duke Energy as shown in Exhibit 5-47.

EXHIBIT 5-47
MPTP/RWTS Demand

	MPTP Demand (kW)			RWTS Demand (kW)	
	Actual			Actual	
Month/Year	Peak	Off-Peak	Billed	Peak	Billed
December 2007	60.0	60.0	163.2	75.0	127.5
January 2008	54.0	54.0	163.2	21.0	127.5
February 2008	222.0	222.0	216.0	21.0	127.5
March 2008	240.0	240.0	210.0	66.0	127.5

EXHIBIT 5-47
MPTP/RWTS Demand

Month/Year	MPTP Demand (kW)			RWTS Demand (kW)	
	Actual			Actual	
	Peak	Off-Peak	Billed	Peak	Billed
April 2008	156.0	156.0	168.0	66.0	127.5
May 2008	162.0	162.0	162.0	66.0	127.5
June 2008	186.0	186.0	192.0	69.0	127.5
July 2008	168.0	168.0	186.0	66.0	124.95
August 2008	210.0	210.0	192.0	147.0	-
September 2008	186.0	186.0	168.0	84.0	124.95

Exhibit 5-48 summarizes the existing load and new loads for MPTP and provides an evaluation of potential generator sizes for the new loads and new/existing combined.

EXHIBIT 5-48
MPTP Load Data Summary

ITEM	Qty	HP	MPTP (KW)	RWTS (kW)	COMBINED
Existing Loads					
1. Existing Plant Peak Demand (Mar/08)			222.0		222.0
2. Raw Water Transfer Station (Aug/08)				147.0	147.0
3. + 25%			55.5	36.8	92.3
Subtotal Existing Loads			277.5	183.8	461.3
New Loads					
1. GAC Pumps (Large size)	2	125	200.0		200.0
2. GAC Pumps (Small size)	2	75	120.0		120.0
3. Backwash Pump	1	250	200.0		200.0
4. Blower	1	100	80.0		80.0
5. Misc Pumps		50	40.0		40.0
6. UV	2		20.0		20.0
7. Misc Bldg Loads			100.0		100.0
Subtotal New Loads			760.0		760.0
Generator Size Based New Loads Only			820.0		
TOTAL LOADS			1037.5	183.8	1221.3
Generator Size Based on Total Loads			1250.0	300.0	1500.0

5.5.3.3 Recommendations

After consideration of existing and projected demands along with items identified by NKWD as critical to plant operations, the following is recommended at MPTP:

- Provide a new 480 volt, three-phase, 1200 amp service for the Advanced Treatment facilities.
- Re-route the existing primary service through a new automatic transfer switch and primary switchgear. The new switchgear will have two feeder breakers. One breaker will feed the existing switchgear and the other will feed a new 750 kW pad mount transformer.
- Since the existing generator at 250 kW is too small for the loads considered critical, it is recommended that it be removed and replaced with one large enough to service the existing facilities as well as new. The new generator will be 1500 kW.
- Provide a UPS for the UV System. For a detailed discussion on the UPS, refer to Section 5.1.4.4, Power Quality Equipment.

For additional information regarding the modified distribution system at MPTP, refer to the One-Line diagram on Exhibit 5-49 located at the end of this Section.

5.6 Control Systems

The purpose of evaluating the control systems for FTTP and MPTP is:

- Develop design standards to be implemented at each plant.
- Provide a new control system that is compatible with the existing SCADA system at each plant.
- Develop alternatives to modify the existing SCADA system to connect the new Advanced Treatment facilities to the existing data network.
- Develop preliminary control strategies for each process that accommodates manual and automated system controls.
- Develop a basis of design for a new access control system that will interface with the existing system.
- Recommend SCADA and access control improvements at each facility.

5.6.1 Design Standards

5.6.1.1 Existing System Standards

Currently the SCADA system at both plants utilizes the following key components:

- Allen-Bradley Control Logix PLCs for the more recent upgrades at both plants. Some areas at FTTP still utilize Allen-Bradley PLC5 and SLC500 series PLCs while MPTP still uses Allen-Bradley SLC500 series PLCs for Filter 4-6 and Actiflo.
- Ethernet network and switches.
- Fiber optic cable network with patch panels and media converters.

- View nodes for operator/staff interface throughout the facilities.
- Wonderware HMI software.
- Radio communications to remote pumping stations and tank sites.

The existing access control system at each plant utilizes a proximity card and PIN codes for access inside each building. Each building is hard wired to a master controller. For additional information regarding the existing SCADA network at FTTP, refer to the Network Diagram on Exhibit 5-50 located at the end of this Section. For additional information regarding the existing SCADA network at MPTP, refer to the Network Diagram on Exhibit 5-51 located at the end of this Section.

The existing Wonderware HMI system for NKWD consists of the following:

- The current Wonderware software is Version 8.0 for FTTP, MPTP and TMTP. It was upgraded in 2005.
- Wonderware InTouch currently is licensed up to 60K tags for each plant. Capacity is not an issue.
- The current Wonderware ActiveFactory reporting software is Version8.5. NKWD is licensed for up to five concurrent users per server.
- The current Wonderware InSQL Server is Version 8.0 with 5000 tags.
- The tag count for each facility is:
  - FTTP: 6K tags.
  - MPTP: 3K tags.
  - TMTP: 4K tags.

NKWD has decided to upgrade the existing Wonderware Version 8.0 HMI software to Version 10.0 in a separate capital project. The transition will occur in 2009 and therefore, an analysis of a Wonderware upgrade will not be necessary in this report. The Advanced Treatment design documents will need only to indicate that the contract must include the cost of additional licenses for view nodes added in the project.

5.6.1.2 Proposed Standards - SCADA

The objective of the design is to provide a SCADA system that is fully compatible with the existing system at each facility. In general, the following basic design criteria shall apply to both plants:

- The new Advanced Treatment facility at each plant shall be equipped with an Allen-Bradley Control Logix PLC for interfacing with the new equipment. It is anticipated that any pump VFD will have a data connection between the VFD and PLC. All other components will have inputs/outputs hardwired to the PLC.
- The new PLC will communicate with the existing network via fiber optic cables. Spare or dark fibers will be included for future us.

- View nodes will be installed in the GAC Contactor area on the second floor for access during backwash. Laptop access ports will be provided in the electrical/control room and pipe gallery of each facility.
- Any new computers shall be Dell, IBM or HP.
- Provide empty conduits with pull wire for telephones. NKWD will contract separately to have telephone wire installed for connecting to each plant.
- SCADA tag names must be consistent with NKWD's existing system. Each tag must include a reference to each individual plant. Where appropriate, add tags for industrial SQL for the data base server.
- All data collection, programs and alarms would reside in the new PLC.
- New HMI screens will be developed for each process and some existing ones will need to be updated.
- Status/Alarms for such items as ambient temperature, flooding, fire, and unauthorized entry would be installed and brought to the PLC for SCADA access.
- Provide audio and visual alarms for chemical bulk tank fill stations to identify full tanks. Alarm to be common with high tank level. Include alarm in SCADA and do not provide a driver re-set.
- Provide temper water for all eyewash/shower facilities with a flow switch for SCADA alarm.
- All pumps shall be equipped with vibration monitoring equipment and shall include SCADA interface.
- The SCADA PLC will be sized to accommodate 25% spare I/O including two spare I/Os per contactor for future instrument/analyzer.

New equipment at each plant will have both manual and automated control options. Typical control strategies for pumps/motors will include:

- Local disconnect switch.
- Local HAND-OFF-REMOTE selector switch. In HAND the pump is energized. In OFF the pump cannot be started from anywhere including the MCC, VFD or SCADA. In REMOTE the pump is control from the MCC or VFD.
- MCC or VFD mounted HAND-OFF-REMOTE selector switch. This switch only controls the pump when the local HOR is in the REMOTE position. In HAND the pump is energized. In OFF the pump can only be started at the local HOR. In REMOTE the pump is controlled via SCADA.

New motor operated valves will have 480 volt, three-phase actuators. Each valve will have the following key control features:

- Integral mounted disconnect switch.

- Integral mounted LOCAL-REMOTE selector switch. In LOCAL the valve is operated via the integral mounted OPEN-STOP-CLOSE pushbuttons. In REMOTE the valve is controlled remotely via SCADA. The valve will have provisions for the following input/output signals with SCADA:
  - Valve in remote.
  - Valve open.
  - Valve closed.
  - Valve open command from SCADA.
  - Valve close command from SCADA.
  - Valve stop command from SCADA for valves requiring flow control.
- Valves that are designated as modulating shall have provisions for an additional analog input signal to SCADA for valve position.

5.6.1.3 Proposed Standards - Access Control System

The following access control standards will apply to both plants:

- All exterior doors shall have a keypad with proximity reader for building access.
- Access control will be provided for each new electrical/control room.
- Overhead doors that are not near a pedestrian door will be operated from the outside with keyed access similar to pedestrian door access.
- Panic hardware on the doors need to be push bar type and not paddle type or motion sensors.
- Provide spare conduits where appropriate for future use (CCTV).

5.6.2 FTTP

The modified SCADA network at FTTP is presented on the FTTP Network Diagram on Exhibit 5-52 located at the end of this Section. The process and instrumentation layouts for FTTP are presented in P&ID Exhibits 8-11 through 8-15. Exhibit 5-53 presents electrical design features for the major equipment items at FTTP.

5.6.3 MPTP

The modified SCADA network at MPTP can be found on the MPTP Network Diagram on Exhibit 5-54 located at the end of this Section and the process instrumentation layouts for MPTP are presented in P&ID Exhibits 8-24 through 8-28. Exhibit 5-55 presents electrical design features for the major equipment items at MPTP.

EXHIBIT 5-53
FTTP New Electrical Loads

New Electrical Loads										
Description	ID No.	Quantity	Horsepower/KVA	Volts	Current @ 460V	Ph.	Controller	Fed From	Control Features	
FTTP										
GAC Influent Pumps	FT-GAC-P-1, 2, 3	3	*250 HP ea*	460	*312*	3	VFD	MDP-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. High discharge pressure, high pump/motor temperature or vibration will shutdown the pump and alarm SCADA.	Vertical Turbine P alone, NEMA 1G \
Contactor/Filter Backwash Pumps	FT-GAC-BW-1, 2	2	*250 HP ea*	460	*312*	3	VFD	MDP-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. Pump operates in conjunction with discharge control valve. High discharge pressure, high pump/motor temperature or vibration will shutdown the pump and alarm SCADA.	Vertical Turbine P alone, NEMA 1G \
Slurry Water Pumps	FT-SW-P-1, 2, 3	3	*15 HP ea*	460	*14*	3	VFD	MCC-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. Pump operates in conjunction with suction/discharge valves.	MCC mounted, 6-
UV Reactors	FT-UV-1, 2, 3	3	*40 kVA total*	460	*48*	3		MDP-GAC		Custom control pa
Air Scour Blower	FT-GAC-B-1	1	100 HP	460	124	3	RVSS	MCC-GAC	Local HOR selector switch. HOA selector switch with pilot lights in front of starter.	MCC mounted, re
EQ Pumps	FT-EQ-P-1, 2	2	*100 HP ea*	460	*124*	3	RVSS	MCC-GAC	Local HOR selector switch. HOA selector switch with pilot lights in front of starter.	MCC mounted, re

EXHIBIT 5-55
MPTP New Electrical Loads

New Electrical Loads										
Description	ID No.	Quantity	Horsepower/KVA	Volts	Current @ 460V	Ph.	Controller	Fed From	Control Features	
MPTP										
GAC Influent Pumps	MP-GAC-P-1, 2	2	*125 HP ea*	460	*312*	3	VFD	MDP-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. High discharge pressure, high pump/motor temperature or vibration will shutdown the pump and alarm SCADA.	Vertical Turbine F VFD. Generator I
GAC Influent Pumps	MP-GAC-P-3, 4	2	*75 HP ea*	460	96	3	VFD	MDP-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. High discharge pressure, high pump/motor temperature or vibration will shutdown the pump and alarm SCADA.	Vertical Turbine F VFD. Generator I
Contactor Backwash Pump	MP-GAC-BW-1, 2	2	*250 HP ea*	460	*312*	3	VFD	MDP-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. Pump operates in conjunction with discharge control valve. High discharge pressure, high pump/motor temperature or vibration will shutdown the pump and alarm SCADA.	Vertical Turbine F Generator load s
Slurry Water Pumps	MP-SW-P-1, 2	2	*15 HP ea*	460	*14*	3	VFD	MCC-GAC	Local HOR selector switch. Keypad with LED readout in front of VFD. Pump operates in conjunction with suction/discharge valves.	MCC mounted, 6
UV Reactors	MP-UV-1, 2	2	*20 kVA total*	460	*24*	3		MDP-GAC		Custom control p
Air Scour Blower	MP-GAC-B-1	1	100 HP	460	124*	3	RVSS	MCC-GAC	Local HOR selector switch. HOA selector switch with pilot lights in front of starter.	MCC mounted, r

5.7 Architectural

A new Advanced Treatment Building will be constructed at each plant. At FTTP the AT Building will be constructed into a hillside east of the existing Water Quality Laboratory with a connection to the laboratory only by a breezeway. At MPTP the AT Building will be constructed largely within an area occupied by abandoned Sedimentation Basins 5 and 6 and an abandoned flocculation basin. A pump station structure will be under separate roof and constructed adjacent to Sedimentation Basins 5 and 6.

New building structures for the NKWD will be designed to blend with existing facilities and be practical and functional with emphasis on long service life with minimum maintenance requirements.

5.7.1 Design Codes and Standards

Building design will comply with the latest edition of codes and industry standards referenced herein:

- Kentucky Building Code.
- National Fire Protection Association (NFPA) standards, including:
  - NFPA 101 Life Safety Code.
  - ADAAG 1999 Accessibility Code.
  - International Fire Code.

5.7.1.1 Building Code Classification

All facilities will be designed in accordance with applicable codes for life safety, fire protection, and occupational health and safety. Where applicable, facilities will be designed in accordance with Building Code requirements for accessibility by persons with disabilities.

Both AT buildings have been classified as Industrial Moderate Hazard F1. The classification is based on building use, building area, number of stories and building content. GAC has been classified as a combustible solid according to the MSDS (Material Safety Date Sheet). The International Fire Code (IFC) defines maximum allowable quantities within a building as 125cu ft. Areas exceeding the allowable amount should be classified as H3 High hazard. Both AT Buildings have a quantity of GAC in excess of 125cu ft, however under typical operating conditions the GAC will be fully submerged in water and will not create any fire hazard. Additionally the GAC is expected to be placed and removed from the basins using a slurry water system. Special procedures will have to be observed when GAC will be left exposed. The Operations and Maintenance manual will indicate the GAC should be left in a submerged condition whenever basins are out of service. This practice is recommended by GAC vendors.

Signage for the top floor of the AT building will also be considered. The Proposed building classification approach will require review by the local Authorities Having Jurisdiction.

Building structural components will be concrete walls and floor slabs with double Tee precast concrete roof slabs. These materials allow classification of the building construction according to IBC as Noncombustible Unprotected IIB or Noncombustible Protected IIA.

Combustible protected construction will require fire rating of structural elements, but in return allows larger building area and additional stories in building height. The Fort Thomas GAC building area is over the limit for IIB classification and therefore the construction type will be noncombustible protected. Given the nature of concrete construction, rating of structural elements can be achieved by maintaining proper concrete cover for steel reinforcement and additional concrete topping over the precast roof. The Memorial Parkway AT Building has smaller building area and could be classified as IIB (Noncombustible unprotected).

5.7.1.2 Exterior Treatment and Materials

Structure exteriors will be designed to be practical and functional with emphasis on long service life with minimum maintenance requirements and to blend with existing structures. Priority will be given to the use of local construction materials and techniques where practical and complementary to the existing structures.

5.7.1.3 Exterior Walls

Exterior-facing walls will be designed of face brick. Exterior materials will be selected to minimize maintenance requirements. Exterior wall assemblies will be designed to achieve an R =10 value.

5.7.1.4 Roofs

The design arrangements of roofs, canopies, fascias, parapets, overhangs, or other roof elements will be in harmony with the massing and materials of the structures and to control runoff and direct drainage away from equipment, doorways, sidewalks, ramps, or other occupied areas. Sloped roof with metal roofing system on pre engineered metal framing will be provided at MPTP and on the lower portion of the FTTP AT Building over the Pump Room and UV room. The portion of the FTTP roof over the GAC facilities will include a flat vegetated (green) roof. Runoff from the metal roofs will be directed to the gutters (sloped roofs) and drains (flat roofs). Access to the green roof will be provided by both the stairs and the elevator to provide for public viewing of the roof. As a surface runoff mitigation measure and sustainability approach, the runoff will be discharged to the EQ tank at FTTP and pumped back to the South Reservoir for reuse whereas at MPTP the roof drainage can flow by gravity to the North Reservoir. The Roof assemblies will be designed to achieve a minimum R =20 value.

5.7.1.5 Exterior Doors, Windows, and Louvers

Exterior doors, windows, and louvers will be designed of extruded aluminum sections with factory-applied protective coatings. Sills, thresholds, flashing, and trim will be provided to prevent water penetration to the interior of the building. All doors, windows, and louvers will be provided with corrosion-resistant hardware, accessories, fasteners, and operating mechanisms. Exterior window glazing will be tinted insulated glass. Exterior door glazing to be tinted insulated tempered glass.

The interior space of the operating floor of each AT Building where top of the GAC basins are exposed will be kept dimly lit except when required for a personnel access. This approach will limit growth of algae in the basins. Natural light will be limited and electric lights should be switched to be extinguished when GAC space is not occupied.

A curtain wall will be constructed on the operating floor of each AT building to contain the humid atmosphere but to allow sufficient space for personnel access with ladders into the GAC contactors for placing and removing the GAC media. The type of ladder access will be investigated during detailed design to identify a system that provides access to the bottom of the contactor while meeting safety code issues with landings, cage or cable system, etc. Besides isolating the moist atmosphere, the curtain wall will serve to block natural light from exterior windows from penetrating into the contactor area but allow the light to illuminate the walkways or conference rooms. At FTTP the curtain wall will also provide separation between the process area and the public area to allow conference activities and operations and maintenance activities to be conducted concurrently without disruption.

Door units and hardware will be designed for heavy-duty usage. Locksets, security system and keying arrangement acceptable to the Owner will be provided. Security access card readers will be provided on all exterior doors and any doors to the electrical rooms.

Where applicable, equipment and vehicle doors for motorized operation will be provided and controlled from an interior control panel. Doors with manual backup for emergency hand operation will be provided.

Louver assemblies will be designed complete with bird screens, filters, dampers, blank-off panels, acoustical treatment, or other required features. Louver assemblies will be designed to prevent infiltration of rain and provide positive drainage to the exterior.

5.7.1.6 Interior Treatment and Materials

Structure interiors will be designed to be practical and functional with emphasis on long service life with minimum maintenance requirements. Priority will be given to the use of local construction materials and techniques, where practical and final selection will be made during detailed design. Interior components and finishes will be designed of non-combustible materials with minimum flammability and smoke developed characteristics.

Interior walls in process areas will be designed of concrete masonry units or concrete. Conference room walls will have gypsum dry wall surface. Where required for fire separations, walls will be designed in accordance with recognized tested UL assemblies.

Floor and base materials designed for long service life with minimum maintenance requirements will be provided. Hard surface seamless flooring material will be provided for areas subject to splashes, spills, or wet exposure. Bases of suitable material and height to protect wall finishes will be provided. Floors, ramps, and steps will be designed with non-slip finishes and abrasive nosing inserts for safety.

Interior doors, frames, sidelights, transoms, and windows will be designed of steel or aluminum to the Owner's Standard and final selection will be made during detailed design. Where required for fire or smoke separations, steel doors and frames, window frames, and appropriately sized glass units with labels from appropriate testing agencies will be provided.

All doors will be designed with appropriate corrosion-resistant hardware. Locksets and keying system acceptable to the Owner will be provided. Clear tempered glazing will be provided for all interiors glazing not required to be labeled as a fire separation.

Ceilings will be designed to be integrated with the building services and lighting systems. Ceiling materials and finishes that enhance the acoustic properties of the spaces will be provided. Appropriate access will be provided to equipment concealed in the ceiling spaces.

Where practical, the design will include factory finishes of interior items. Field-applied finishes and protective coatings will be provided to all other building elements that are not supplied with factory-applied protective coatings. The use of factory- or field-applied coatings that provide long-term service use with minimum maintenance will be considered wherever possible.

Chemical resistant coating systems will be designed to provide a minimum of 48-hour immersion protection against spills or leaks of stored chemicals in secondary containment areas. Coating systems will include primer, fiberglass mat, saturant, and two trowel -applied coats of vinyl ester resin with silica filler. Non slip finish will be provided on all horizontal surfaces.

Public use spaces such as the conference room and entry foyer at FTTP will have durable finishes suitable for the industrial setting but also provide an attractive appearance.

Areas subject to elevated noise level will be provided with acoustical treatment.

5.7.2 FTTP

The proposed AT Building will house a pipe gallery, UV area and Pumping Station at lower level (769). The first floor will house a chemical storage room, blower and HVAC room and Wash and Janitor rooms, an Electrical Room and an elevated walkway over the UV and Pump Rooms. The second floor, termed the GAC operating floor will be placed at level 802 and will extend over the GAC contactors and adjacent areas but not over the UV or Pump Rooms. A conference room with kitchenette will be constructed on this floor level. Due to the existing site constrains and grade configurations, the eastern portion of the building will be recessed into existing hillside. This approach will partially screen the building and make it less intrusive to the adjacent residential neighborhood. All of the mentioned areas (GAC, UV, Pumping Station, Blower room and chemical storage area) will be considered as one building for the building code classification. Access to the building will be provided from North/West side through stair No 1 and Stair No 2. See Architectural Exhibits in Section 8.

The classification of the Fort Thomas AT building is outlined in the Exhibit 5-56.

EXHIBIT 5-56
Fort Thomas AT Building

Building Classified Under IBC 2006	
Construction Type:	Noncombustible protected -IIA
Occupancy Type:	Industrial Moderate Hazard F-1
Number of Stories:	3
Building Area:	21,812 SF(max allowed 25,000SF)
Building Height:	39 ft (max allowed 4 stories, 65 Feet)
Occupant Load:	Unoccupied
Fire Rated Separation Required Between Following Areas and the Remainder of the Building:	
1HR	Stairs
1HR	Vestibules
1HR	Electrical Room
1HR	Basement and Ground Floor
Fire Protection Requirements:	
Sprinklers (IBC Section 903.2.3):	Not Required
Fire Alarm System (IBC Section 907.2.4):	Not Required
Portable Fire Extinguishers (IBC) Section 906.1):	Required

5.7.3 MPTP

The new GAC facility will be located adjacent to the existing Filter Building at the Memorial Parkway Water Treatment Plant and constructed largely within existing abandoned process tankage and galleries. The proposed structure will house a Pipe Gallery at level 745.00 connecting on one side to lower level of existing Filter Building and also providing access to existing Service Tunnel on the South –East side. The UV area will be located at the lower level, adjacent to the existing Service Tunnel. The Pump

Station will be placed adjacent to existing Filter Building with Pump Room floor at level 760, which is the First Floor. Also at this level a walkway/loading area will be constructed for the full length of the building to allow for walking access between the Filter Building and the proposed UV room through the proposed AT Building. A GAC operating floor will be located at level 772.00. All of the mentioned areas (GAC, UV and Pumping Station) will be considered as one building for the building code classification. Access to the ground from all levels will be provided through stair No 1 and No 2. See Architectural Exhibits in Section 8.

The classification of the MPTP AT building is outlined in the Exhibit 5-57.

EXHIBIT 5-57
Memorial Parkway AT Building

Building Classified Under IBC 2006	
Construction Type:	Noncombustible unprotected -IIB
Occupancy Type:	Industrial Moderate Hazard F-1
Number of Stories:	3
Building Area:	11,030 SF (max allowed 15.500SF)
Building Height:	24 (max allowed 2 stories, 55 Feet)
Occupant Load:	Unoccupied
Fire Rated Separation Required Between Following Areas and the Remainder of the Building:	
1HR	Stairs
1HR	Vestibules
1HR	Electrical Room
1HR	Basement and Ground Floor
Fire Protection Requirements:	
Sprinklers (IBC Section 903.2.3):	Not Required
Fire Alarm System (IBC Section 907.2.4):	Not Required
Portable Fire Extinguishers (IBC) Section 906.1):	Required

5.8 Green Elements

The sustainability statement for the project that is included in Section 1 will be the guiding statement for sustainability/green project elements throughout the design, construction and startup. The statement goes beyond the initial construction to address the entire service life of the project. Accordingly the design will incorporate features such as SCADA controls that will enable NKWD operations staff to optimize operations of pumps and chemical feed equipment and provide for energy efficiency.

5.8.1 Sustainability Initiatives

A common measure of sustainability is the Leadership in Energy and Environmental Design (LEED) certification program. The program establishes standards that are primarily applicable to residential and commercial structures and provides for certification at various levels of energy efficiency and environmental stewardship. LEED certification is not intended to be sought for the Advanced Treatment facilities at FTTP and MPTP but the LEED sustainable initiatives will provide additional guidance to the AT teams in the execution of the design, construction and startup. The primary LEED initiatives are:

- Sustainable sites.
- Water efficiency.
- Energy and atmosphere.
- Materials and resources.
- Indoor environmental quality (IEQ).
- Innovation and design process.

Project elements that have been adopted to implement these initiatives are described herein.

5.8.1.1 Sustainable Sites

- Erosion and Sediment Control- site erosion, sediment control and air quality (dust) control plant will be integrated into the construction activities as prescribed in the bidding documents.
- Site Selection – Use of existing plant sites for the structures at both plants will minimize the disruption of the projects on surrounding neighborhoods.
- Reduced Site Disturbance – Constructing the AT Building at FTTP into the hillside with a covered breezeway to the laboratory and constructing the MPTP AT Building within the footprint of existing abandoned structures reduced disturbance to the existing plant sites and preserves space for future additions.
- Stormwater Management – The facilities are designed to return the residual water streams including much of the stormwater from the roofs to the raw water reservoirs and a green roof is proposed for FTTP. A green roof will also be investigated for MPTP. These measures counteract the effect of increasing the impermeable surfaces associated with expanding roadway and vehicle areas. The primary concerns with stormwater quality are GAC fines, chemical spills and vehicle fluid leaks and the AT Building aprons at both plants will include provisions for containment of these stormwater threats.

- Site Greening – The green roof on a majority of the AT Building and vegetative restoration of the surrounding hillside at FTTP will be compatible with the green features on the existing terraced hillside.
- Heat Island Effect – The high degree of incorporation of the facilities both at FTTP into the hillside and at MPTP into existing structures minimizes the increase in heat absorptive spaces. Additionally the use of a green roof and light colored, high-albedo masonry at FTTP will further reduce heat absorption.
- Light Pollution Reduction – Containing the access to the FTTP AT Building to the surface of the building facing inward towards the existing plant facilities will result in lighting the access areas in a manner that shields the neighborhood behind the building from additional lighting.

5.8.1.2 Water Efficiency

- Water Use Reduction- Returning the residual water streams to the raw water reservoir retains the beneficial use of the streams while minimizing offsite discharge of the water.
- Water Use Reduction-Use of low flow plumbing fixtures will minimize water use.

5.8.1.3 Energy and Atmosphere

- Minimum Energy Performance – Several provisions in equipment specifications will be made including NEMA "Premium Efficiency" Motors on process equipment and use of energy efficient lighting.
- Minimum Energy Performance – Constructing the FTTP AT Building into the hillside will provide natural insulation and moderate heating and cooling requirements for the building.
- Minimum Energy Performance – Providing air conditioning only in electrical/controls rooms and conference rooms will minimize cooling energy requirements.
- CFC Reduction in HVAC and R Equipment and Elimination of Halons- Use of ozone friendly refrigerants.
- Optimize Energy Performance-Variable frequency drives will be used on the largest motors and all equipment items where cost effective to minimize energy use.

5.8.1.4 Materials and Resources

- Building Reuce- The MPTP AT Building will be constructed with existing facilities using existing channel walls and galleries.

- Building Reuse- Several systems at MPTP including the sodium bisulfite system, the air scour blower, and the backwash pumps will be installed within existing buildings to replace aged equipment or take advantage of space allocations provided in prior construction.
- Durable Building- Emphasis will be placed on designing all of the structures using long lasting durable materials, prolonging the service life of the buildings.

5.8.1.5 Indoor Environmental Quality

- Minimum IAQ Performance- HVAC design will meet current ASHRAE Standards.
- Low-emitting Materials – Low VOC materials will be specified in bidding documents to meet or exceed VOC limits for adhesives, sealants, paints, and composite wood products.
- Indoor Chemical and Pollutant Source Control- Use of separate ventilation systems for chemical storage areas.
- Daylight and Views-Windows and glazing provided on galleries and conference spaces to provide natural light to these spaces. Curtain walls installed to shield GAC contactor surfaces from light.

5.8.1.6 Innovation and Design Process

- Lighting – Where applicable, lights will include motion detectors to automatically turn off lights on un-occupied spaces.
- Reuse of excavated material – Where possible, rock and soil excavated from the site will be used for fill or pavement subgrade to minimize off site hauling and import of fill materials.
- Integration of Operations and Maintenance Staff- The project team includes full participation by NKWD front line operations and maintenance personnel so as to promote user friendly design approaches and to stimulate development of sustainable approaches to long term operations and maintenance of the facilities.
- LEED Certified Design Staff – The lead project Architect, Barbara Kolis-Hupa is a LEED accredited professional.

5.8.2 Stormwater System

The impact of the new advanced treatment buildings on stormwater released from both the FTTP and MPTP sites has been considered in the overall effort to achieve a green design. Each site is uniquely different in the current approach to stormwater management and the impact from the different construction approaches (retrofit versus greenfield) will also differ between sites. Ultimately, review and approval of the design by Sanitation District No. 1 will be required, but the concept was to prevent any increase in the discharge volume from either site. This would be done through the construction of detention facilities or other measures. A brief summary of the proposed stormwater detention facilities or system modifications for each site is provided below.

- FTTP - An existing stormwater infrastructure exists at FTTP with a 30" main discharging storm flow into an unnamed tributary to the Licking River. This main will require a short relocation as part of the advanced treatment project. The construction of a new advanced treatment facility with a footprint of approximately 22,000 square feet into a hillside will have a stormwater management impact. This was an important part of the consideration of the green roof. The incorporation of the green roof reduces 100-year storm flows from 4.2 CFS to 1.2 CFS when considering only the building footprint. Stormwater from the metal roof portion of the building will be collected in the EQ basin beneath the building and pumped to the raw water reservoirs. Collecting and handling the stormwater in this manner keeps the water from the stormwater system and eliminates any system impacts. This results in a detention facility that is reduced by 62%. This is especially important at the FTTP site where space available for detention facilities is not easy to accommodate.
- MPTP – The construction within the footprint of the existing sedimentation and flocculation basins will enable the construction at MPTP to yield no net increase of stormwater from the building construction. The improved access roads and delivery area will increase surface runoff slightly but MPTP captures most of the surface run-off on the north side of the site in the north basin. Therefore, any increase will be detained on-site within a suitable structure. No stormwater improvements are anticipated at MPTP.

SECTION 6

Geotechnical Analysis

The deep excavations and the geotechnical conditions at both FTTP and MPTP will have a significant impact on the overall project cost. Thelen Associates is currently completing the borings and summary report for the advanced treatment project but a significant amount of information already exists that has helped form some conclusions about the geotechnical expectations at both sites. The expected conditions and areas of concern are detailed below.

- FTTP - Three areas exist which will likely require significant geotechnical consultation as part of the final design. Each of the areas identified below will be reviewed in detail with special measures noted either in the geotechnical report or in a subsequent meeting.
  - Hillside adjacent to the laboratory that will be excavated for the advanced treatment building.
  - Clearwell influent pipe corridor between the filter building and Sedimentation Basins 2 & 3.
  - North filter bank effluent pipe route around the northwest side of the building.
- MPTP - Subsurface data from under the existing is available from two previous projects. More data will be gathered as part of the advanced treatment project . The footprint under the new building is the primary area of interest at MPTP.

Based on the available information, it is expected that the new Advanced Treatment facilities at both sites will be founded on rock. In developing the preliminary opinion of probable construction cost, Thelen & Associates has been consulted and contacted local excavation contractors to verify unit costs associated with rock excavation, rock removal and other geotechnical costs.

The geotechnical reports for both plants are provided in Appendix A.

SECTION 7

Hydraulic Analysis

7.1 Introduction

Hydraulic analysis was necessary to establish allowable water surface levels and structural elevations of the Advanced Treatment facilities and the sizing of conveyance piping and channels at both plants. Currently filter effluent from both plants flows by gravity to the clearwells. The proposed configuration requires the introduction of piping and pumping to intercept the filter effluent and lift it to the top of the GAC contactors. The pumping lift must provide adequate head to drive the water through the GAC contactors, the downstream UV reactors, and conveyance facilities to discharge the AT effluent to the clearwells. The GAC pump wet well elevation is established to provide for discharge of the filter effluent into the well while allowing continued operation of the sand filters. These components are common to both FTTP and MPTP. At FTTP, the operating level of the existing and proposed treatment processes is below the level of the raw water reservoirs. Consequently, it is necessary to include an equalization tank and pumping system to return the recycle streams to the reservoirs. The MPTP raw water reservoirs are at a level below the treatment processes which allows the recycle streams from the AT processes to flow by gravity to the raw water reservoirs.

The hydraulic analysis was used to develop the maximum operating level of the GAC contactors at both plants and the maximum operating level of the GAC pump station wet wells. At FTTP an option of discharging the filter to waste flows from the sand filters to the EQ tank was also considered and used to establish the maximum operating level of the tank.

The hydraulic analyses were conducted using the CH2M HILL WINHYDRO (HYDRO) program and best practices. The program uses forms to input data and it provides formatted pages for textual output and a hydraulic profile as graphical output. The HYDRO program computes the energy grade line (EGL) and hydraulic grade line (HGL) elevations on the upstream and downstream sides of hydraulic elements that commonly occur in water treatment plants. It allows elements to be sequenced to simulate the entire plant. HYDRO is based on backwater calculations, i.e., analysis begins at the downstream end and precedes upstream, one element at a time. Hydraulic parameters on the downstream side of each element are equated to the upstream parameters of the downstream element.

7.2 Fort Thomas Treatment Plant

7.2.1 Assumptions

The following assumptions and allowances were made for the hydraulic analysis.

- 44 mgd peak flow.
- Minimum water temperature of 35 degrees F.
- 8 contactors in service.
- Mannings n value for piping = 0.013.
- High water level of 765.0 in the newest clearwell.
- Weir elevation at splitter box set at 774.00 for UV submergence.
- 48-inch pipe from UV discharge header to splitter box.
- 24-inch Trojan MP UV reactor (22 mgd per reactor and headloss of 11.1 inches).
- 24-inch piping for UV trains.
- 48-inch pipe from GAC contactors to UV influent header.
- One foot of headloss across 20-inch flow control valve on GAC effluent at 60% open.
- Leopold Universal Type S underdrains with IMS cap (6-inches of headloss at 4.5 gpm/sf).
- 4-inch sand layer between top of underdrain and GAC in contactors.
- 12 feet of Calgon Filtrasorb 400 GAC with allowance of 6.1 feet of clean bed headloss at 4.5 gpm/sf and 6 feet of headloss for dirty bed.
- 30 percent expansion of GAC media during backwash.
- 6 inches of space between expanded GAC level during backwash and bottom of trough.
- AT effluent passes through splitter box to divide flows equally to both existing clearwells. Splitter box serves to provide for full submergence of UV reactors and functions as a seal weir for the GAC contactors.

Maximum water levels for existing structures were obtained from the Asset Management Program (Black & Veatch, May, 2004). Both Trojan and Calgon are expected to compete for provision of the medium pressure UV reactors. In the 22 mgd capacity range, Trojan would provide a 24 inch reactor while Calgon would provide a 30 inch reactor. Therefore the hydraulic analysis was based on the higher head loss situation of the smaller Trojan reactors to allow adequate head for either reactor to be used. It is not anticipated that Calgon will offer a 24 inch reactor for this flow range.

7.2.2 Hydraulic Profile

The hydraulic profile for the Advanced Treatment facilities FTTP is shown on Exhibit 7-1 at the end of this Chapter. The output file from WINHYDRO provided in Appendix B.

7.2.3 Conclusions

The conclusions of the hydraulic analysis are listed below.

- Operating water elevation of 798.7 in GAC contactors to accommodate full range of flow and temperature, multiple UV and GAC options, and to allow flow by gravity to the existing New Clearwell.
- Maximum water level in EQ tank is 764.0 to allow gravity flow of filter to waste to the tank. Design considerations for the AT Building may require a lower operating level in the tank.
- Maximum water level in GAC wetwell is 762.0 to allow gravity flow and prevent back-up of filter effluent.
- Design considerations for the AT Building may require a lower operating level in the tank.
- GAC contactor-to-waste pipe size permits gravity flow to EQ basin.
- GAC backwash waste channel size permits gravity flow to EQ basin.
- Operating level of EQ basin allows gravity discharge of sand filter FTW to EQ basin.
- A maximum flow of 35 mgd can be delivered through the new 36-inch pipe from splitter box to New Clearwell when the operated at highest operating level.

The hydraulic analysis is in general concurrence with the operating level estimates for the GAC contactors presented in the Preliminary Design report. The hydraulic analysis conducted for this phase of the project are preliminary and will be refined as the full details of the equipment, piping and fittings are developed in the detailed design phase.

7.3 Memorial Parkway Treatment Plant

7.3.1 Assumptions

The following assumptions were made for the hydraulic analysis.

- 20 mgd peak future plant flow.
- Minimum water temperature of 35 degrees F.
- 6 contactors in service at 20 mgd and 5 in service at 15 mgd.
- Mannings n value for piping = 0.013.
- Clearwell high water level of 742.0.

- 36-inch piping between UV discharge header and clearwell.
- Open/close butterfly valves on UV influent and effluent.
- 24-inch gooseneck for UV submergence.
- 24-inch Calgon MP UV reactor (20 mgd per reactor and headloss of 14 inches).
- 24-inch piping for UV trains.
- 36-inch piping between GAC and UV.
- One foot of headloss across 18-inch flow control valve on GAC effluent at 60% open.
- Leopold Universal Type S underdrains with IMS cap (6-inches of headloss at 4.5 gpm/sf).
- 4-inch sand layer.
- 10 feet of Calgon Filtrasorb 400 GAC with allowance of 5.1 feet of clean bed headloss at 4.5 gpm/sf and 5 feet of headloss for dirty bed.
- 30 percent expansion of GAC media during backwash.
- 6 inches of space between expanded GAC level during backwash and bottom of trough.
- 24-inch piping between GAC pump station and GAC contactors.

Maximum water levels for existing structures were obtained from the Asset Management Program (Black & Veatch, May, 2004) A contactor media depth of 10 feet was selected for MPTP because adequate space was available to provide for larger shallower basins which allowed for reducing the height of the contactors and the AT building. The lower profile building fits better into the aesthetic of the plant facilities. Both Trojan and Calgon are expected to compete for provision of the medium pressure UV reactors. In the 20 mgd capacity range, both manufacturers have validated 24 inch reactors. The Calgon unit has more headloss so the hydraulic analysis was based on Calgon reactors to allow adequate head for either reactor to be used.

7.3.2 Hydraulic Profile

The hydraulic profile for MPTP is shown on Exhibit 7-2 at the end of this Chapter. The output file from WINHYDRO is provided in Appendix B.

7.3.3 Conclusions

The conclusions of the hydraulic analysis are listed below.

- Water elevation of 768.7 in GAC contactors to accommodate full range of flow and temperature, multiple UV and GAC options, and contactor to allow flow by gravity to clearwell.

- A maximum water surface of 748.5 in the GAC feed pump wet well can accommodate existing filter operating levels. Design considerations for the AT Building may require a lower operating level in the tank.
- Backwash waste and contactor-to-waste pipes and channels are adequately sized to permit gravity flow to the North Reservoir.

SECTION 8

Schematic Design

This section presents the schematic design which conveys how the systems described in prior chapters will be implemented at FTTP and MPTP. The section addresses implementation issues such as yard piping and site work, constructability and sequencing, project schedule, and estimated drawing lists for the bidding documents at each plant. A combined specific list is provided as the specification sections for each plant are expected to be very similar but the numbers, sizes and quantities of items at MPTP will be less than at FTTP.

The following drawings are presented at the end of this Section:

FTTP:

8-1 Site Plan
8-2 Not Used
8-3 AT Facility Section
8-4 AT Facility West Elevation – Proposal 1
8-5 AT Facility West Elevation – Proposal 2
8-6 AT Facility Lower Basement Plan at EL 769.00
8-7 AT Facility Basement Plan at EL 769.00
8-8 AT Facility First Floor Plan at EL 784.00
8-9 AT Facility Second Floor Plan – Proposal 1 at EL 802.00
8-10 AT Facility Second Floor Plan – Proposal 2 at EL 802.00
8-11 AT Facility GAC Pump Station P&ID
8-12 AT Facility GAC Contactor Overview P&ID
8-13 AT Facility Typical GAC Contactor P&ID
8-14 AT Facility UV P&ID
8-15 AT Facility Air Scour Blower P&ID
8-16 AT Facility Waste (EQ) Basin P&ID

NKWD reviewed the 2 proposals for the west face of the AT Building at FTTP and selected Proposal 1 for implementation.

MPTP:

8-17 Site Plan
8-18 AT Facility Northwest and Southwest Elevation
8-19 AT Facility Lower Level Floor Plan at EL 743.50
8-20 AT Facility Operating Level Floor Plan at EL 760.0
8-21 AT Facility Upper Level Floor Plan at EL 772.0
8-22 AT Facility Sections
8-23 AT Facility Section
8-24 AT Facility GAC Pump Station P&ID

8-25 AT Facility GAC Contactor Overview P&ID
8-26 AT Facility Typical GAC Contactor P&ID
8-27 AT Facility Air Scour P&ID
8-28 AT Facility UV P&ID

8.1 Fort Thomas Treatment Plant

8.1.1 Sitework

The installation of GAC contactors and UV disinfection facilities at FTTP will require extensive sitework. This will be challenging considering that the FTTP site is already nearly built out. The GAC contactors, GAC and backwash pump station and UV facilities are all proposed to be built in a single building. The proposed location of the building is within the terraced hillside northeast of the laboratory and adjacent to the parking area. The placement of the building in this location will require extensive excavation (over 40' deep in some areas) and a significant restoration effort will be required. In addition, the existing access roads and utility lines will need to be modified or relocated to accommodate the building. Details of this work will be provided in the following items and a site plan reflecting the proposed work is provided in Exhibit 8-1.

8.1.2 Access Road

The current access roadways will be impacted by the construction of the new Advanced Treatment Building. The main road will experience higher frequency and heavier than normal loads from construction traffic. In addition, excavation from the work is expected to impact portions of the existing roads due to the deep excavations that will be required. The key design considerations for the access roads are detailed below.

- The main access road into FTTP is expected to experience modest damage from construction traffic. It is expected that subbase repair along with new binder and surfaces courses of pavement will be required from the entrance through the driveway area north of Flocculator #4.
- The parking area in front of the filter building will be significantly impacted from the installation of 36-inch GAC influent pipe and will require sub-base and pavement restoration.
- The northeast laboratory parking area will be temporarily destroyed during excavation of the GAC facilities. This area will be re-constructed with concrete pavement as a GAC delivery/parking area. Concrete pavement is proposed in lieu of asphalt because extensive truck traffic flow and parking will occur when GAC is delivered and removed so an especially durable surface is needed.
- The access road from the lower plant site to the dam will be temporarily closed during construction as excavation will be present in this area. It will be relocated northeast by approximately 50 feet and re-opened later in the project.

- Larger concrete pavement aprons and driveway areas will be added between the filter building and advanced treatment building to improve truck access. This area is identified on the site plan in Exhibit 8-2.

8.1.3 Yard Piping

As detailed on the site plan provided in Exhibit 8-3, there are several significant runs and tie-ins of yard piping that are required for the advanced treatment project. Each of these are described below.

- Two GAC influent lines are required based on the current filter piping arrangement. The 12 gravity filters at FTTP are divided into the north and south filter banks. Each bank has a designated combined filter effluent (CFE)channel beneath the floor of the gallery. In order to accommodate the routes proposed below, some existing utilities may be required to be relocated. Selected potholing (or daylighting) of existing lines has been performed by NKWD to determine the extent of the relocation requirements.
  - The north filter bank 36" CFE is directed out the north wall of the building into the yard where it is routeded to the 3.5 MG cylindrical clearwell known as the new clearwell. This line will be intercepted with a 36" tee (2 valves) in the yard north of the filter building. A new 36" GAC Influent line will be installed from this point around the northwest corner of the filter building, across the front parking area to the Advanced Treatment Building.
  - The south bank CFE discharges into the collection/weir box in the basement of FTTP. This box is the entrance point to the old clearwell under the FTTP filter building. In order to access the filter effluent from the south bank, two new 30" connections will be made with the effluent channels that run under the filter building floor on either side of the gallery. From there, the twin 30" pipes will be combined into a 36" CFE that will exit the south wall of the filter building in a similar manner to the north bank. Once outside the filter building, the new 36" line will be routed southwesterly across the main access road to the advanced treatment facility.

8.1.4 List of Drawings

Based on the preliminary design concept, a preliminary list of expected drawings for the installation of advanced treatment at FTTP is provided in Exhibit 8-29. The drawing list has expanded from prior estimates primarily because of the additional sheets associated with the installation of 3 floors, an elevator, conference rooms and the green roof for the Advanced Treatment Building.

8.1.5 List of Specifications

A preliminary list of specifications for the installation of advanced treatment be found in Exhibit 8-30. This list applies to both the FTTP and MPTP AT projects and includes all disciplines including civil, process, mechanical, architectural, structural, electrical and instrumentation.

8.1.6 Project Schedule

The anticipated project schedule is as follows:

Value Engineering Review:	January 12, 2009 – February 2, 2009
Commence Final Design:	February 9, 2009
50% Review:	March 30, 2009
90% Review(includes constructability review and submittal to KDOW):	June 22, 2009
Submission to NKWD for Final Review:	July 15, 2009
Advertisement for Bids:	August 17, 2009
Bid Opening:	October 5, 2009
Award Construction Contract:	January 4, 2010
Construction Substantial Completion:	June 6, 2011

8.1.7 Construction Sequencing

The FTTP is the largest and most critical production facility owned and operated by NKWD and as a result it is essential that the plant remain in service continuously during the period of construction. Only short duration outages of less than a few hours can be incorporated into the construction plan. A feature of the plant that accommodates construction sequencing is the dual flow path through the filters and clearwells. It is possible to isolate half of the filters and either clearwell while leaving the remaining units in service. Some of the isolation activities and their impacts on yard piping design have been presented previously in this chapter. As the project progresses, it will be beneficial to identify allowable durations of plant shutdowns to accommodate specific construction activities that cannot be handled by isolation of a portion of the plant.

The proposed work associated with the installation of advanced treatment at MPTP will occur entirely within an existing plant site. The new GAC contactors and UV reactors will be constructed within a new building on an unoccupied portion of the site. This will allow construction of the building to occur with minimal disturbance of plant operations. Deep excavation including removal of durable unweathered rock near the Water Quality Laboratory will have an impact on the accessibility of the lab for delivery of materials and will need to be taken into account as the construction plan and schedule are developed.

The construction activities that will require the most consideration for sequencing and coordination will be the tie ins to the filter effluent piping in and around the filter building as described previously. It will be necessary to limit the contractor to working on the piping for only the north or south half of the filters and only one clearwell at any time. Consideration should also be given to the seasonal variation of flows at FTTP as longer outages for tie ins can be accommodated more readily in the cold weather months when the production rate is down.

Besides the piping and structural tie-ins it will be necessary to construct temporary access roadways during construction to provide for the continued delivery of materials and chemicals to the existing chemical and sodium hypochlorite buildings. It will be essential to identify maximum allowable durations of road outages to accommodate chemical delivery traffic as needed. To this end it will be beneficial for the contractor to complete the major excavation for the proposed Advanced Treatment Building before May 1 of 2010 so as to take advantage of reduced chemical delivery during the winter and spring period.

8.2 Memorial Parkway Treatment Plant

The concept for the installation of GAC contactors and UV facilities at MPTP is to intercept the combined filter effluent line in the existing filter building and re-direct the flow to the proposed Advanced Treatment Building. The new contactors fit within the footprint currently occupied by Sedimentation Basins 5 and 6. Additionally, the UV facility will be housed in the existing north flocculation basin. Upon the completion of the additional treatment steps, the finished water will be routed to the finished water piping to the existing clearwell.

The installation of GAC and UV require some supplemental components to be installed. These include a GAC influent pump station, replacement backwash pumps to serve both the filters and the GAC Contactors, and chemical facilities for dechlorination.

8.2.1 Sitework

The installation of GAC contactors and UV disinfection facilities at MPTP will require a significant amount of sitework. However, the location of the proposed facilities are all adjacent to each other so the length of piping runs will be modest. Like FTTP, the contactors, influent pumping station and UV building are all proposed to be built in a single building. The proposed location of the building is within the footprint of existing sedimentation basins 5 and 6 and the existing north flocculator. These structures will be modified or demolished as part of the project. The building in this location will require significant excavation below existing foundation levels and shoring and bracing will be important. In addition, existing access roads and utility piping will need to be modified or relocated to accommodate the building. Details of this work will be provided in the following items and a site plan reflecting the proposed work is provided in Exhibit 8-17.

8.2.2 Access Road

The existing main access roadway (north side of plant) will be significantly impacted by the construction of the new advanced treatment building. MPTP has 2 alternate entrances which can be utilized during the construction phase. The restoration of the main access road will include the re-grade of a portion of the area to create a loading/removal area for the GAC. This will require most of the ground surrounding the advanced treatment building to be re-graded to approximate elevation 757.0 and paved with concrete. This will eliminate the lower level "back door" entry to the filter gallery.

8.2.3 Yard Piping

As detailed on the site plan provided in Exhibit 8-17 there are several significant runs and tie-ins of yard piping that are required for the Advanced Treatment project. Each of these are described below.

- The GAC pump station will be served by the existing 30" combined filter effluent line. This line is currently located within the pump station footprint. Valving and tees will be added to the portion of the line that remains in service while the remainder is cut and abandoned.
- The 36" combined contactor effluent line will be routed outside the footprint of the advanced treatment building for a short distance in order to prevent a piping conflict.
- The 36" UV effluent line is routed outside the building and re-connects to the existing 30"clearwell influent piping.
- The GAC delivery area will have drains to collect any surface water. These drains will be routed to the north reservoir.

8.2.4 List of Drawings

Based on the preliminary design concept, a preliminary list of expected drawings for the installation of advanced treatment at MPTP. This list is found in Exhibit 8-31 and is a composite look at drawings from all disciplines including civil, process, mechanical, architectural, structural, electrical and instrumentation.

8.2.5 List of Specifications

A preliminary list of specifications for the installation of advanced treatment at MPTP can be found in Exhibit 8-32. This list is consistent with the specifications found in the FTTP project and will include all disciplines including civil, process, mechanical, architectural, structural, electrical and instrumentation.

8.2.6 Project Schedule

The anticipated project schedule is as follows:

Commence Final Design:	January 12, 2009
50% Review:	March 30, 2009
90% Review(includes constructability review and submittal to KDOW):	June 22, 2009
Submission to NKWD for Final Review:	July 15, 2009
Advertisement for Bids:	August 17, 2009
Bid Opening:	October 5, 2009
Award Construction Contract:	January 4, 2010
Construction Substantial Completion:	June 6, 2011

8.2.7 Construction Sequencing

A key constructability asset of the MPTP is that at present and for the entire construction period it will be possible to take the plant off line for extended periods of time. Presently the plant is operated only 16 hours a day 7 days a week. Allowing the plant to be taken off line rather than requiring pump around or making hot taps into pipes offers significant cost advantages. As the project progresses, it will be beneficial to identify allowable durations of plant shutdowns to accommodate specific construction activities.

The proposed work associated with the installation of advanced treatment at MPTP will occur entirely within an existing plant site. As previously described, the new GAC contactors and UV reactors will be constructed within the footprint of existing basins which were abandoned when the Actiflo system was installed. As such, the work will need to be coordinated and sequenced in order to minimize the downtime of the facility. Key elements of that sequencing are provided below.

- MPTP does not utilize the sedimentation basins under current operations. Therefore, the demolition of these facilities may occur early in the project without impact on the availability or capacity of the plant.
- The relocation of the drain line from the existing filters must occur early in the project prior to constructing the GAC pump station.
- The demolition of the "pit" area and the associated piping modifications should be performed prior to the construction of the GAC influent pump station.

Aside from these specific elements, the construction of the GAC and UV facilities is expected to occur largely without significant impact on the operations at MPTP. In addition to the specific items listed above, shutdowns may be required for shoring of existing structures to create suitable temporary support. Otherwise, it is expected that chemical delivery traffic through the new Memorial Parkway delivery entrance can be maintained and that normal operations of the Actiflo, filters, clearwell and chemical feed facilities is possible during much of the construction period.

SECTION 9

Cost Estimates

Estimates of the construction cost and annual operations costs have been prepared for the Advanced Treatment systems at FTTP and MPTP. The estimates were prepared using the CH2M HILL Parametric Cost Estimating System (CPES) conceptual cost estimating tool. Inputs to the tool include the facilities and equipment standards presented in Section 5 and the layouts and structure dimensions presented in the drawing exhibits in Section 8. Costs for many of the largest equipment items were input to CPES based on quotes received from equipment vendors. The CPES tool provides allowances for ancillary equipment and systems such as building mechanical, electrical and SCADA based on process design criteria, equipment cost information, where available, and historic construction project data. CPES also generates the operations and maintenance estimates from the same process inputs and unit rates for labor, materials and energy applicable to the local area.

The construction cost estimates presented in this Basis of Design Report are "order-of-magnitude" estimates, as defined by the American National Standards Institute (ANSI) and The Association for the Advancement of Cost Engineering International (AACE International) as "approximate estimates made without detailed engineering data. It is normally expected that estimates of this type will be accurate within plus 50 percent or minus 30 percent." This range implies that there is a high probability that the final project cost will fall within the range.

A 30% contingency has been included in these cost estimates as a provision for unforeseeable, additional costs within the general bounds of the project scope; particularly where previous experience has shown that unforeseeable events that will increase costs are likely to occur. The contingency is used as a means to reduce the risk of possible cost overruns. The contingency in these estimates consists of two components: Bid Contingency and Scope Contingency. Bid Contingency covers the unknown costs associated with constructing a given project scope, such as adverse weather conditions, strikes by material suppliers, geotechnical unknowns, and unfavorable market conditions for a particular project scope. Scope Contingency covers scope changes that invariably occur during final design and implementation.

The cost estimates have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimates. The final cost for the project will depend on such criteria as actual labor and material costs, competitive market conditions, actual site conditions, final project scope, and other variables. As a result, the final project cost will vary from this estimate. The proximity to actual costs will depend on how close the assumptions of this estimate match final project conditions. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help assure proper project evaluation and adequate funding.

One of the largest components of the construction cost and the overwhelming largest operations expenditure is the acquisition of GAC. A uniform message from the GAC facilities that were toured by the project team and from GAC suppliers is that the prices of virgin and regenerated GAC are unstable to the point that purchase contracts with a term exceeding one year are not available. Longer term projections were also not available from suppliers. Many market conditions are in flux including the availability of foreign supplies, energy prices, and demands for water treatment and electrical power plants. A current 2008 price of $1.30 per pound of carbon delivered and placed in the bed by the supplier was used in the cost analysis.

The cost estimates were developed using unit cost information for other materials such as concrete, steel, etc. referenced to January 2008. Then the costs were escalated to the mid point of construction at the end of the 3rd quarter of 2010. The *Engineering News Record* recently posted the regional construction cost index (CCI) for January 2009 and the index exhibited a 5.7 percent increase over the January 2008 index. Accordingly a 6 percent annual escalation factor was applied to the construction estimates to develop the values for the November 2010 mid point of construction.

9.1 FTTP

The cost estimates for FTTP were developed based on facility types as defined in the CPES tool. The major facility types are filtration/contactors, chemical feed systems (sodium bisulfite), UV disinfection, flow splitting structures, and user defined facilities which apply to the engine generator and yard piping. The major pump systems are included in the GAC facility cost.

9.1.1 Construction Cost Estimate

The construction cost estimate is presented in Exhibit 9-1 and the details of each item in the table are presented in Appendix C.

EXHIBIT 9-1
FTTP Construction Cost Estimate

Component	2008 Cost Estimate	Nov 2010 Estimate
GAC Building • Contactors • Air Scour System • GAC Feed Tank & Pumps • EQ Basin Tank & Pumps • Backwash Pumps • Slurry Water Pumps • Conference Room • Green Roof	$ 22,240,734	$ 26,110,600

EXHIBIT 9-1
FTTP Construction Cost Estimate

Component	2008 Cost Estimate	Nov 2010 Estimate
Sodium Bisulfite System	$ 193,953	$ 227,700
UV Disinfection	$ 1,882,864	$ 2,210,500
Flow Splitting Structure	$ 284,355	$ 333,800
Engine Generator	$ 688,681	$ 808,500
Yard Piping	$ 2,659,152	$ 3,121,800
Allowances • Sitework • SCADA • Electrical	$3,353,970	$ 3,937,600
Contractor Markups	$6,659,865	$7,818,700
Contingency	$11,389,073	$13,370,800
Total	$49,352,647	$57,940,000

Excavation of weathered and durable rock and sheeting of the excavation are significant factors in the cost of the Advanced Treatment Building. Thelen and Associates contacted local excavation contractors to assess unit pricing for the work and provided input for the cost analysis. The input resulted in reduction of the unit pricing from rates used in other locations.

9.1.2 Operations and Maintenance Estimate

The CPES model development of operations and maintenance costs includes provisions for long term maintenance and repair of facilities and structures as well as routine operations. As such the estimates include not only purchase of GAC, sodium bisulfite, and electricity and routine maintenance of pumps but also resurfacing of pavement, repainting walls, and replacement of SCADA hardware and other longer term ownership and maintenance items. Annual costs are developed for the current year, then escalated to the first year of operations and each subsequent year in the period of analysis (20 year planning period), and then an annualize net present value for the entire period is calculated as shown in Exhibit 9-2. The O&M costs include a 20 percent contingency. The detailed estimates are presented in Appendix C.

EXHIBIT 9-2
FTTP Operations and Maintenance Cost Estimate

Component	2008 Cost Estimate	20 Year Annual Net Present Value
GAC Building • Contactors • Air Scour System • GAC Feed Tank & Pumps • EQ Basin Tank & Pumps • Backwash Pumps • Slurry Water Pumps • Conference Room • Green Roof	$ 6,086,277	$ 9,215,849
Sodium Bisulfite System	$ 56,964	$ 86,256
UV Disinfection	$ 213,138	$ 320,627
Flow Splitting Structure	$ 9,219	$ 13,960
Engine Generator	$ 9,427	$ 14,275
Yard Piping	$ 0	$ 0
Allowances Items • Sitework • SCADA • Electrical	$201,099	$ 304,504
Staffing – 1 position	$ 67,392	$ 102,046
Total	$ 6,643,516	$ 10,057,517

The estimate assigns equal long term O&M costs over each year of the planning period so that allowances for repainting and pavement resurfacing are included in both the year 1 and year 20 estimates. In reality such long term cost will be incurred toward the back end of the planning period. This method of estimation allows the owner to plan for such costs and regulates annual funding allocations to a uniform level.

The O&M estimate includes budget for a staff position at FTTP which is an allowance to cover the added labor associated with the operations, maintenance, laboratory, management and other activities necessary for ownership and operations of the GAC, pumping, and UV systems. The allowance is not a recommendation to add a single labor position at the plant. The specific staffing needs will be explored in more detail by NKWD based on their current staff size and capabilities.

9.2 MPTP

The cost estimates for MTTP were developed based on facility types as defined in the CPES tool. The major facility types are filtration/contactors, chemical feed systems (sodium bisulfite), UV disinfection, and user defined facilities which apply to the engine generator and yard piping. The major pump systems are included in the GAC cost, however the washwater pumps will be installed in the existing pump station.

9.2.1 Construction Cost Estimate

The construction cost estimate is presented in Exhibit 9-3 and the details of each item in the table are presented in Appendix C.

EXHIBIT 9-3
MPTP Construction Cost Estimate

Component	2008 Cost Estimate	Nov 2010 Estimate
GAC Building • Contactors • Air Scour System • GAC Feed Tank & Pumps • Backwash Pumps • Slurry Water Pumps	$ 9,342,505	$ 10,968,100
Sodium Bisulfite System	$ 160,977	$ 189,000
UV Disinfection	$ 1,004,773	$ 1,179,600
Engine Generator	$ 688,681	$ 808,500
Yard Piping	$ 165,392	$ 194,200
Allowances • Sitework • SCADA • Electrical	$ 1,363,481	$ 1,600,800
Contractor Markups	$ 2,707,417	$ 3,178,500
Contingency	$ 4,629,968	$ 5,435,600
Total	$ 20,063,194	$ 23,554,300

The estimate includes considerably less GAC and excavation than the Fort Thomas estimate but includes costs for demolition of existing facilities in the sedimentation flocculation basin. The allowances, contractor markups and contingency values are based on the same percentages as at FTTP.

At the time of preparation of this Basis of Design Report, there are some cost items that have not yet been finally resolved at MPTP including the potential for a green roof, adding an air scour blower for the GAC system, and the elimination of the sodium bisulfite system. As a result the cost estimate has not been changed from the submittal that was made with the draft report which includes the cost of the sodium bisulfite system but not a green roof of an additional air scour blower. The combined additive and deductive impacts of the potential changes are expected to amount to less than 1 percent of the total construction cost.

9.2.2 Operations and Maintenance Estimate

The development of the O&M costs for MPTP parallels that for FTTP and the estimate is presented in Exhibit 9-4. The detailed estimates are presented in Appendix C.

EXHIBIT 9-4
MPTP Construction Cost Estimate

Component	2008 Cost Estimate	20 Year Annual Net Present Value
GAC Building • Contactors • Air Scour System • GAC Feed Tank & Pumps • Backwash Pumps • Slurry Water Pumps	$ 1,316,037	$ 1,992,745
Sodium Bisulfite System	$ 19,926	$ 30,173
UV Disinfection	$ 92,118	$ 139,486
Engine Generator	$ 9,427	$ 14,275
Yard Piping	$ 0	$ 0
Allowances Items • Sitework • SCADA • Electrical	$ 81,752	$ 123,790
Staffing – 1 position	$ 67,392	$ 102,046
Total	$ 1,586,652	$ 2,402,515

The MPTP O&M estimate also includes an allowance for a staff position for the new facilities. As is the case with FTTP, this allowance is intended to aid in the budgeting process NKWD will complete an assessment of specific staffing needs.

SECTION 10

Kentucky Division of Water Coordination

An important element of the preliminary engineering phase was to establish regular communication with the Kentucky Division of Water in relation to the advanced treatment project at both FTTP and MPTP. This has been accomplished with conference calls and correspondence exchange with key KDOW staff on a variety of subjects related to the project including the following.

- Requested clarification on need for supplementary detention basin after the Actiflo process. This basin (existing Sedimentation Basin #4) will need to have one wall modified as part of the project. Based on Actiflo performance and a previous determination, KDOW will not require the continued use of the basin so this will not create an impact on plant operations.
- Discussed the capture of roof run-off by routing drains to equalization basin to reduce stormwater impact of large new GAC building at FTTP. KDOW was substantially in agreement with this if diversion capabilities were included to account for contaminants during maintenance periods, etc. The KDOW response letter is provided in Appendix D.
- Gained approval of recycling carbon backwash waste water, GAC contactor to waste and carbon motive (slurry) water to the raw water reservoirs at both plants.
- Gained approval of including a bypass around the entire Advanced Treatment system at both plants rather than around GAC and UV processes individually.
- The use of the procedures established in the United States Environmental Protection Agency Guidance Manual for UV Disinfection for establishing a UV dose that achieves the inactivation targets over varying water quality and flow conditions while minimizing energy consumption.
- Discussion on maintaining the turbidity compliance point as the sand filter effluent rather than the GAC contactor effluent. Electronic correspondence has been exchanged with KDOW with no final response as of December 31, 2008.

Case No. 2010-____
Exhibit ____A____

NORTHERN KENTUCKY WATER DISTRICT

Project
Memorial Parkway Treatment Plant
Advanced Treatment Facility

Campbell County
184-0456

Engineer's Opinion Of Probable Construction Cost

MPTP $23.0M

CH2MHILL

FACILITY DETAIL 4 (CSI) Unallocated
PROJECT: Memorial Parkway Treatmen
DESIGN STAGE: .
PROJECT No.:
ESTIMATOR: David Roby
ESTIMATE No.:
REV No./DATE: /

Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
W990			**Memorial Parkway Treatment Plant**				
	02000		**SITEWORK**				
		Plumbing DR Trench	**Trench Drains**				
			18" Wide trench drain with heavy duty grating	150.00 lf	170.00 /lf	25,500	37,837
			Drop box inlet	7.00 ea	3,000.00 /ea	21,000	31,160
			Plumbing DR Trench Trench Drains		/lnft	**46,500**	**68,997**
		Site Concret	**Site Concrete Paving**				
			Base course drainage layers,aggregate base course for roadways and large paved areas,crushed stone base,compacted,crushed 1-1/2"stone base, 8"deep	5,695.00 sy	21.02 /sy	119,718	179,974
			12" Compacted subgrade	5,695.00 sy	10.58 /sy	60,228	90,085
			Concrete Paving 8"	5,695.00 sy	40.99 /sy	233,438	351,228
			Concrete Curb & Gutter 12"	560.00 lf	8.08 /lf	4,523	6,756
			Site Concret Site Concrete Paving		/sqft	**417,906**	**628,043**
		Site Demo	**Site And General Demolition**				
			Demolish, remove pavement, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	4,351.00 sy	7.71 /sy	33,527	48,541
			Area Between Settling Basins And Floc. Basins	9,420.00 sf	16.19 /sf	152,510	220,803
			Settling Basins 5&6	13,247.00 sf	16.19 /sf	214,469	310,507
			North Flocculation Basins	9,576.00 sf	16.19 /sf	155,035	224,460
			Settling Basins 4 Walls	1,225.00 sf	16.19 /sf	19,833	28,714
			Curb	850.00 lf	4.25 /lf	3,613	5,230
			Remove Above Grade Fuel Storage Tank	1.00 ls	5,000.00 /ls	5,000	7,239
			Existing Storage At Chemical Building	1.00 ls	7,000.00 /ls	7,000	10,135
			Pneumatic Tank, pumps, valves, piping, sluice gates, and Miscellaneous At Existing Filter Building	5.00 day	3,500.00 /day	17,500	25,336
			24" Overflow line at Existing Filter Building	1.00 day	3,500.00 /day	3,500	5,067
			24" Concrete Drain Pipe	110.00 lf	31.00 /lf	3,410	4,937
			30" PCCP Filter Effluent Pipe	120.00 lf	40.00 /lf	4,800	6,949
			Concrete Pad With Electric Manhole	2.00 day	3,500.00 /day	7,000	10,135
			8" Storm Sewer	10.00 sf	31.00 /sf	310	449
			3' Wide Concrete Flume	25.00 sy	9.75 /sy	244	353
			2 FRP Storage Tanks, Concrete Pad And guardrail	1.00 ls	10,000.00 /ls	10,000	14,478
			Load Haul And Remove Debris	1.00 ls	60,000.00 /ls	60,000	86,868
			Remove Fire Hydrant	1.00 ls	1,000.00 /ls	1,000	1,448
			Remove existing old chemical building	1.00 ls	27,000.00 /ls	27,000	39,091
			Remove equip. including paddles, gearboxes, & motors & handrail from S Flocculation Basin	1.00 ls	20,000.00 /ls	20,000	28,956
			Infill construction rubble in abandoned South flocculation basin	1.00 ls	12,000.00 /ls	12,000	17,374
			Replacement of Filter Influent & Effluent Valves - Demo existing valves, actuators, Piping	1.00 ls	50,000.00 /ls	50,000	72,390
			Site Demo Site And General Demolition			**807,751**	**1,169,459**
		Site Erosion	**Site Erosion Control**				
			Erosion Control	1.00 ls	50,000.00 /ls	50,000	74,190
			Site Erosion Site Erosion Control		/lnft	**50,000**	**74,190**

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Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		Site Excavate Struct	**Site Structural Excavation**				
			Excavate Unweathered Rock	203.00 CY	70.00 /CY	14,210	20,573
			Excavate Weathered Rock	1,558.00 CY	40.00 /CY	62,320	90,227
			Excavate General	3,525.00 CY	18.00 /CY	63,450	91,863
			Backfill With Imported Select Fill & Compact	8,200.00 CY	17.42 /CY	142,844	213,205
			Haul Excess Excavated Rock Offsite	5,286.00 CY	15.00 /CY	79,290	114,796
			Site Excavate Struct Site Structural Excavation		**/cuyd**	**362,114**	**530,664**
		Site Grading	**Grading**				
			Selective clearing, brush, light clearing, with dozer, ball and chain, excludes removal offsite	0.50 acre	876.28 /acre	438	634
			Dewatering	1.00 LS	30,000.00 /LS	30,000	52,463
			Site Grading Grading		**/cuyd**	**30,438**	**53,097**
		Site Landscape	**Site Landscaping**				
			Landscape complete	1.00 ls	30,000.00 /ls	30,000	44,514
			Site Landscape Site Landscaping		**/sqft**	**30,000**	**44,514**
		Site Manhole	**Miscellaneous Site Structures, Manholes, Vaults**				
			Manholes 4' diameter	3.00 ea	6,793.00 /ea	20,379	30,096
			Manholes 4' diameter	1.00 ea	5,709.00 /ea	5,709	8,421
			Manholes 4' diameter	2.00 ea	11,013.00 /ea	22,026	32,553
			Manholes 5' diameter drain manhole	1.00 ea	10,801.00 /ea	10,801	15,951
			Manholes 6' diameter chemical manhole	1.00 ea	7,562.00 /ea	7,562	11,189
			Chemical feed vault	1.00 ea	10,396.00 /ea	10,396	15,542
			3' Wide concrete channel	66.00 lf	303.00 /lf	19,998	29,674
			Headwalls	1.00 ls	1,500.00 /ls	1,500	2,226
			Concrete retaining wall	1.00 ea	42,000.00 /ea	42,000	62,319
			Static mixer in chemical feed vault	1.00 ea	51,800.00 /ea	51,800	77,216
			Pipe bollards, steel, concrete filled/painted, 8' L x 4' D hole, 8" di	6.00 ea	263.00 /ea	1,578	2,379
			Site Manhole Miscellaneous Site Structures, Manholes, Vaults		**/each**	**193,749**	**287,566**
		Site Pilings	**Site Pilings**				
			Sheet Pile	7,700.00 SF	50.00 /SF	385,000	673,273
			Site Pilings Site Pilings			**385,000**	**673,273**
		Site Retaining Wall	**Miscellaneous Site Concrete Walls And Flumes**				
			Miscellaneous Site Concrete Walls And Flumes	1.00 ls	70,000.00 /ls	70,000	103,026
			Site Retaining Wall Miscellaneous Site Concrete Walls And Flumes			**70,000**	**103,026**
			02000 SITEWORK		**/sqft**	**2,393,458**	**3,632,828**
	03000		**CONCRETE**				
		Con Beam	**Concrete Cast In Place Beam**				
			Concrete Beams	25.00 cuyd	750.00 /cuyd	18,750	27,146
			Con Beam Concrete Cast In Place Beam		**/cuyd**	**18,750**	**27,146**
		Con Column	**Concrete Cast In Place Column**				

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Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		Con Column	**Concrete Cast In Place Column**				
			Concrete Columns	18.00 cuyd	750.00 /cuyd	13,500	19,545
			Con Column Concrete Cast In Place Column		/cuyd	**13,500**	**19,545**
		Con Elev Slab	**Concrete Cast In Place Elevated Slab**				
			Elevated Slab	430.00 cy	1,150.00 / cy	494,500	728,320
			Concrete cap over abandoned South flocculation basin	78.00 cy	550.00 / cy	42,900	62,110
			Con Elev Slab Concrete Cast In Place Elevated Slab		/cuyd	**537,400**	**790,430**
		Con Footing	**Concrete Cast In Place Footing**				
			Foundations	935.00 cuyd	550.00 /cuyd	514,250	744,530
			Con Footing Concrete Cast In Place Footing		/cuyd	**514,250**	**744,530**
		Con Grout	**Concrete Grout**				
			Miscellaneous Concrete Fill, Grout	1.00 LS	800.00 /LS	800	1,206
			Con Grout Concrete Grout		/cuyd	**800**	**1,206**
		Con Precast	**Precast Roof Slabs**				
			Precast tees, double, roof, , 24" x 8' wide, prestressed	14.00 ea	2,942.33 /ea	41,193	61,759
			Slabs, precast prestressed, roof and floor members, 12" thick	5,000.00 sf	8.85 /sf	44,250	66,720
			Con Precast Precast Roof Slabs		/sqft	**85,443**	**128,479**
		Con Wall	**Concrete Wall**				
			Concrete Walls	2,150.00 cuyd	750.00 /cuyd	1,612,500	2,334,572
			Con Wall Concrete Wall		/cuyd	**1,612,500**	**2,334,572**
			03000 CONCRETE		/cuyd	**2,782,643**	**4,045,909**
	04000		**MASONRY**				
		Masonry Brick	**Masonry Brick**				
			Brick Standard Selrct Common 4x2 2/3	11,444.00 SF	12.40 /SF	141,906	209,330
			Soldier Course	675.00 SF	13.10 /SF	8,843	13,031
			Concrete Block Wall Reinforced 8"	3,400.00 SF	6.30 /SF	21,420	31,477
			Concrete Block Wall Reinforced 12"	540.00 SF	8.70 /SF	4,698	6,915
			Concrete Block Backup Reinforced 12"	8,500.00 SF	9.39 /SF	79,815	117,387
			Scaffolding	1.00 LS	45,000.00 /LS	45,000	65,151
			Masonry Brick Masonry Brick		/sqft	**301,681**	**443,291**
			04000 MASONRY		/sqft	**301,681**	**443,291**
	05000		**METALS**				
		Metal Ladder	**Metal Ladder**				
			Vertical ladder, shop fabricated, aluminum	150.00 vlf	147.52 /vlf	22,128	32,946
			Metal Ladder Metal Ladder		/lnft	**22,128**	**32,946**
		Metals Grating	**Metal Grating**				
			Grating frame, aluminum, 1" to 1-1/2" D, field fabricated	4,294.00 lf	16.15 /lf	69,363	102,536
			Grating frame, aluminum, 1" to 1-1/2" D, field fabricated, for each corner, add	36.00 ea	6.45 /ea	232	350
			Floor grating, aluminum,	2,225.00 sf	53.66 /sf	119,393	179,599

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Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
			Metals Grating Metal Grating		**/sqft**	**188,988**	**282,485**
		Metals Handrail	**Metal Handrail**				
			Railing, pipe, aluminum, satin finish, 2 rails, 1-1/2" dia, shop fabricated	1,050.00 lf	44.54 /lf	46,764	69,595
			Railing, pipe, aluminum, wall rail, satin finish, 1-1/2" dia, shop fabricated	155.00 lf	26.67 /lf	4,134	6,131
			Metals Handrail Metal Handrail		**/lnft**	**50,898**	**75,726**
		Metals Misc	**Metal Miscellaneous Metal Fabrications**				
			Open web trusses, factory fabricated WT chords, average cost	3.00 ton	5,547.52 /ton	16,643	24,986
			Floor plate, steel checkered plate, 1/4" & 3/8" T, 2000 to 5000 S.F., field fabricated	4,584.00 lb	1.68 /lb	7,709	11,403
			Coping, aluminum II	600.00 lf	13.19 /lf	7,914	11,740
			Metals Misc Metal Miscellaneous Metal Fabrications			**32,265**	**48,129**
		Roof Metal	**Roofing Standing Seam Metal**				
			Metal decking, steel, open type, wide rib, galvanized, over 500 Sq, 1-1/2" D, 22 ga	100.00 sf	1.62 /sf	162	241
			Metal Standing Seam Roof Complete	100.00 sf	20.03 /sf	2,003	2,989
			Roof Metal Roofing Standing Seam Metal		**/sqft**	**2,164**	**3,230**
			05000 METALS		**/sqft**	**296,443**	**442,516**
	07000		**THERMAL & MOISTURE PROTECTION**				
		Roof BuiltUp	**Roofing Built Up**				
			vapor barrier,	12,800.00 sf	0.17 /sf	2,210	3,242
			Roof Deck Insulation, perlite, tapered for drainage	2,400.00 bf	1.23 /bf	2,946	4,369
			Polyisocyanurate Insulation, for roof decks, 2" thick	12,800.00 sf	1.20 /sf	15,346	22,855
			Modified Bitumen Roofing, base sheet,	256.00 sq	26.53 /sq	6,791	10,000
			Modified Bitumen Roofing, Cap Sheet	12,800.00 sf	1.57 /sf	20,106	29,555
			Roof BuiltUp Roofing Built Up		**/sqft**	**47,398**	**70,021**
		Wall Ext	**Exterior Wall Insulation**				
			Wall Insulation, Rigid, expanded polystyrene, 2" thick, R7.69	10,900.00 sf	1.20 /sf	13,100	19,366
			Wall Ext Exterior Wall Insulation		**/sqft**	**13,100**	**19,366**
			07000 THERMAL & MOISTURE PROTECTION		**/sqft**	**60,498**	**89,386**
	08000		**DOORS & WINDOWS**				
		Door HM	**Doors/Frames Hollow Metal**				
			Aluminum Entrance Doors Including Finish Hardware	12.00 ea	3,250.00 /ea	39,000	58,264
			Doors, commercial, steel, flush, full panel,	16.00 ea	3,250.00 /ea	52,000	77,685
			Door HM Doors/Frames Hollow Metal		**/each**	**91,000**	**135,950**
		Door OH	**Overhead/Rolling Door**				
			Aluminum Bi-Fold door	1.00 ea	6,500.00 /ea	6,500	9,711
			Over Hesd Rolling Door	1.00 ea	13,000.00 /ea	13,000	19,421
			Door OH Overhead/Rolling Door		**/each**	**19,500**	**29,132**
		Window HM	**Window Hollow Metal**				
			Metal Spandrel Panels	1,000.00 sf	7.00 /sf	7,004	10,404

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Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		Window HM	**Window Hollow Metal**				
			Windows, aluminum sash, stock, grade C, fixed casement, excl. glazing and trim	1,000.00 sf	18.17 /sf	18,167	27,058
			Insulating Glass, Tinted	1,000.00 sf	27.70 /sf	27,702	41,118
			Window HM Window Hollow Metal		/each	**52,873**	**78,580**
			08000 DOORS & WINDOWS		/sqft	**163,373**	**243,662**
	09000		**FINISHES**				
		Floor Fluid Applied	**Finishes**				
			Floor, Wall And Ceiling Finishes	1.00 ls	70,000.00 /ls	70,000	103,746
			Waterproofing	1.00 ls	20,000.00 /ls	20,000	29,676
			Floor Fluid Applied Finishes		/sqft	**90,000**	**133,422**
			09000 FINISHES		/sqft	**90,000**	**133,422**
	11000		**EQUIPMENT**				
		Equip GAC	**Equipment Gravity Actived Carbon Filter**				
			UV Reactors	2.00 EA	231,000.00 /EA	462,000	686,882
			Wash Troughs and Supports	1.00 LS	225,600.00 /LS	225,600	336,283
			Underdrains With MS Cap	1.00 LS	588,000.00 /LS	588,000	876,505
			Air Header Pipe SS	1.00 LS	93,355.00 /LS	93,355	139,158
			GAC Media	595,614.00 lbs	1.80 /lbs	1,072,105	1,552,191
			Sand layer between the media and the underdrains	1.00 ls	16,000.00 /ls	16,000	23,165
			Equip GAC Equipment Gravity Actived Carbon Filter			**2,457,060**	**3,614,183**
		Equip Pump Submers	**Equipment Submersible Pump**				
			Submersible Pumps	2.00 EA	4,200.00 /EA	8,400	12,521
			Equip Pump Submers Equipment Submersible Pump			**8,400**	**12,521**
		Equip Pump Turbine	**Equipment Vertical Turbine Pump**				
			GAC Feed Pumps 10 mgd	2.00 EA	104,630.00 /EA	209,260	311,922
			GAC Feed Pumps 5 mgd	2.00 EA	74,109.00 /EA	148,218	220,939
			Backwash Pumps	2.00 EA	140,000.00 /EA	280,000	417,383
			Slurry Pumps	2.00 EA	17,500.00 /EA	35,000	52,173
			Equip Pump Turbine Equipment Vertical Turbine Pump			**672,478**	**1,002,416**
			11000 EQUIPMENT		/sqft	**3,137,938**	**4,629,121**
	13000		**SPECIAL CONSTRUCTION**				
		I&C Instruments	**I&C Instruments**				
			Instrument and Control/General and Functional Requirements	1.00 ls	50,000.00 /ls	50,000	74,790
			Instruments and Controls	1.00 ls	269,500.00 /ls	269,500	399,421
			Installation of Primary Sensors and Field Instruments	1.00 ls	40,000.00 /ls	40,000	59,712
			Control Consoles, Panels and Enclosures	1.00 ls	25,000.00 /ls	25,000	37,095
			Programmable logic controllers (PLC)	1.00 ls	15,000.00 /ls	15,000	22,317
			Plant control system (SCADA)	1.00 ls	40,000.00 /ls	40,000	59,412

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Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		I&C Instruments	**I&C Instruments**				
			Plant control system (SCADA)/I&C Replacement of filter and effluent valves Filters 4,5,6	1.00 ls	33,000.00 /ls	33,000	49,247
			I&C Instruments I&C Instruments			**472,500**	**701,994**
			13000 SPECIAL CONSTRUCTION		/sqft	**472,500**	**701,994**
	14000		**CONVEYING SYSTEMS**				
		Crane Mono	**Monorail Hoist**				
			UV Bridgecrane	1.00 ls	38,100.00 /ls	38,100	56,661
			GAC Pump Station Bridge Crane	1.00 ls	27,900.00 /ls	27,900	41,678
			Monorail Crane	1.00 ls	5,500.00 /ls	5,500	8,215
			Crane Mono Monorail Hoist			**71,500**	**106,553**
			14000 CONVEYING SYSTEMS		/sqft	**71,500**	**106,553**
	15000		**MECHANICAL**				
		Equip GAC	**Equipment Gravity Actived Carbon Filter**				
			4" Butterfly Valves With Motor Actuator	6.00 ea	4,758.00 /ea	28,548	42,649
			12" Butterfly Valves With Motor Actuator	11.00 ea	6,920.00 /ea	76,120	113,717
			18" Butterfly Valves With Motor Actuator	2.00 ea	9,390.00 /ea	18,780	28,052
			24" Butterfly Valves With Motor Actuator	15.00 ea	13,650.00 /ea	204,750	305,886
			14" Butterfly Valves With Motor Actuator	2.00 ea	8,100.00 /ea	16,200	24,198
			30" Butterfly Valves With Motor Actuator	6.00 ea	20,700.00 /ea	124,200	185,540
			36" Butterfly Valves With Motor Actuator	4.00 ea	24,250.00 /ea	97,000	144,912
			24" Butterfly Valves With Manual	1.00 ea	7,150.00 /ea	7,150	10,682
			8" Butterfly Valves With Manual	1.00 ea	4,680.00 /ea	4,680	6,992
			24" Butterfly Valves With Motor Actuator Replacement of Filter Influent Valves	3.00 ea	13,650.00 /ea	40,950	61,177
			20" Butterfly Valves With Motor Actuator Replacement of Filter Backwash Influent Valves Valves	3.00 ea	11,499.00 /ea	34,497	51,537
			12" Butterfly Valves With Motor Actuator Replacement of Individual Filter Effluent Valves	3.00 ea	6,920.00 /ea	20,760	31,014
			6" Butterfly Valves With Motor Actuator Replacement of Filter-to-Waste/Drain Valves	3.00 ea	13,650.00 /ea	40,950	61,177
			24" Butterfly Valves With Motor Actuator Replacement of Filter Backwash Drain Valves	3.00 ea	13,650.00 /ea	40,950	61,177
			8" Air Valves Replacement of Filter Valves	3.00 ea	16,250.00 /ea	48,750	72,830
			4" Check Valves	4.00 ea	1,430.00 /ea	5,720	8,545
			14" Check Valves	2.00 ea	9,581.00 /ea	19,162	28,627
			18" Check Valves	2.00 ea	17,160.00 /ea	34,320	51,272
			Air Release Valves	7.00 ea	495.00 /ea	3,465	5,214
			16" Insert Flowmeter	1.00 ea	1,035.00 /ea	1,035	1,556
			24" Insert Flowmeter	2.00 ea	1,395.00 /ea	2,790	4,195
			6" Gate valve	2.00 ea	870.00 /ea	1,740	2,541
			4" Gate valve	1.00 ea	785.00 /ea	785	1,148
			Equip GAC Equipment Gravity Actived Carbon Filter			**873,302**	**1,304,642**
		Mech Duct	**HVAC**				
			Air handlers/AC/Wall heaters/Electric heat	1.00 ls	78,650.00 /ls	78,650	117,499
			Louvers and dampers	1.00 ls	6,687.00 /ls	6,687	9,990
			Exhaust Fans	1.00 ls	10,564.00 /ls	10,564	15,782
			Ductwork, grilles, access doors, accessoeies, supports and hangers	1.00 ls	108,699.00 /ls	108,699	161,287

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Facility	CSI	Proc/Systm	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		Mech Duct	**HVAC**				
			Refrigerent piping and condensate drains	1.00 ls	3,000.00 /ls	3,000	4,451
			Mech Duct HVAC		/lnft	**207,600**	**309,010**
		Pipe C	**Carbon Slurry**				
			4" Stainless Steel Pipe	310.00 lf	116.38 /lf	36,079	53,965
			4" Stainless Steel 90 Degree Elbow	12.00 ea	317.38 /ea	3,809	5,590
			4" Loading/UnloadingStainless Steel Pipe	6.00 ea	362.39 /ea	2,174	3,202
			8" Stainless Steel Pipe	80.00 lf	158.88 /lf	12,711	18,969
			8" Stainless Steel 90 Degree Elbow	10.00 ea	1,242.38 /ea	12,424	18,356
			8" Stainless Steel Tee	1.00 ea	1,137.38 /ea	1,137	1,677
			Pipe C Carbon Slurry		/lnft	**68,334**	**101,759**
		Pipe FTW	**Filter to Waste**				
			Replacement of filter influent and effluent valves - Miscellaneous piping	1.00 ls	50,000.00 /ls	50,000	74,190
			Pipe FTW Filter to Waste		/lnft	**50,000**	**74,190**
		Pipe FW	**Underground Piping**				
			8" PVC Sanitary sewer	425.00 lf	133.16 /lf	56,595	82,238
			12" DIP Underground Piping	570.00 lf	125.00 /lf	71,250	104,866
			24" DIP Underground Piping	1,114.00 lf	225.00 /lf	250,650	369,574
			36" DIP Underground Piping	411.00 lf	340.00 /lf	139,740	206,754
			36" MJ 22 1/2 Degree Elbow	2.00 ea	4,480.00 /ea	8,960	13,356
			36" MJ 45 Degree Elbow	1.00 ea	8,960.00 /ea	8,960	13,356
			36" MJ 90 Degree Elbow	3.00 ea	22,820.00 /ea	68,460	102,050
			36" MJ 36x30	1.00 ea	38,800.00 /ea	38,800	57,153
			6" MJ DIP Waterline	247.00 lf	44.12 /lf	10,898	16,075
			4" MJ DIP Waterline	42.00 lf	29.37 /lf	1,234	1,831
			Allowance For Small bore Piping	1.00 ea	50,000.00 /ea	50,000	74,250
			6x6x4 MJ DIP 90 tee	1.00 ea	578.00 /ea	578	863
			6 MJ DIP 90 degree elbow	3.00 ea	387.50 /ea	1,163	1,736
			6 MJ DIP tee	1.00 ea	578.00 /ea	578	863
			10" DI Drain	239.00 lf	80.15 /lf	19,156	28,192
			6" DI Sludge decant	25.00 lf	58.34 /lf	1,459	2,136
			6" DI Drain	70.00 lf	58.34 /lf	4,084	5,981
			Pipe FW Underground Piping		/lnft	**732,562**	**1,081,273**
		Pipe SS	**Storm Sewer**				
			Public Storm Utility Drainage Piping, non-reinforced concrete pipe 4" diameter	40.00 lf	84.11 /lf	3,364	4,883
			Public Storm Utility Drainage Piping, reinforced concrete pipe (RCP), 30" diameter,	25.00 lf	180.00 /lf	4,500	6,590
			Public Storm Utility Drainage Piping, reinforced concrete pipe (RCP) 15" diameter	65.00 lf	93.75 /lf	6,094	8,878
			Miscellaneous Connections, And Fittings	1.00 ls	15,000.00 /ls	15,000	21,717
			Pipe SS Storm Sewer		/lnft	**28,958**	**42,067**
		Pipe UD	**Slurry Water Supply**				
			4" DIP	300.00 LF	44.00 /LF	13,200	19,669
			4" 90 Degree Elbow	12.00 EA	154.00 /EA	1,848	2,755
			4" Tee	8.00 EA	221.00 /EA	1,768	2,636
			12" DIP	70.00 LF	108.00 /LF	7,560	11,269
			12" 90 Degree Elbow	8.00 EA	742.00 /EA	5,936	8,849
			12" Tee	6.00 EA	1,183.00 /EA	7,098	10,581
			14" DIP	10.00 LF	148.00 /LF	1,480	2,206
			14 Coupling	2.00 EA	1,414.00 /EA	2,828	4,216
			16" DIP	105.00 LF	175.00 /LF	18,375	27,391

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Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		Pipe UD	**Slurry Water Supply**				
			16x12 Reducer	12.00 EA	2,702.00 /EA	32,424	48,333
			18' DIP	9.00 LF	197.00 /LF	1,773	2,643
			18" Coupling	2.00 EA	2,117.00 /EA	4,234	6,311
			30x18x30 Tee	2.00 EA	7,729.00 /EA	15,458	23,043
			24" DIP	383.00 LF	293.00 /LF	112,219	167,250
			24" 90 Degree Elbow	10.00 EA	4,857.00 /EA	48,570	72,401
			24" Tee	12.00 EA	7,103.00 /EA	85,236	127,057
			24x16 Reducer	2.00 EA	2,839.00 /EA	5,678	8,464
			24" 45 Degree Elbow	4.00 EA	3,528.00 /EA	14,112	21,036
			24x14 LR Elbow	2.00 EA	10,990.00 /EA	21,980	32,765
			24x14x24 Tee	1.00 EA	4,763.00 /EA	4,763	7,100
			24x30	1.00 EA	4,545.00 /EA	4,545	6,792
			20' DIP	185.00 LF	228.00 /LF	42,180	62,877
			20" 90 Degree Elbow	18.00 EA	2,639.00 /EA	47,502	70,809
			20" Tee	8.00 EA	3,958.00 /EA	31,664	47,200
			30x20 Side-Outlet Elbow	8.00 EA	3,500.00 /EA	28,000	41,738
			30" DIP	120.00 LF	504.00 /LF	60,480	90,155
			30" 90 Degree Elbow	4.00 EA	7,119.00 /EA	28,476	42,448
			30x24x30 Tee	1.00 EA	10,331.00 /EA	10,331	15,400
			30x36 Tee	1.00 EA	7,855.00 /EA	7,855	11,709
			30 Coupling	1.00 EA	7,714.00 /EA	7,714	11,499
			30x8x30 Tee	1.00 EA	10,279.00 /EA	10,279	15,322
			36" DIP	175.00 LF	728.00 /LF	127,400	189,909
			36" 90 Degree Elbow	9.00 EA	39,685.00 /EA	357,165	521,388
			36" 45 Degree Elbow	1.00 EA	8,953.00 /EA	8,953	13,346
			36" Tee	4.00 EA	16,037.00 /EA	64,148	95,622
			36" Blind Flange	2.00 EA	4,031.00 /EA	8,062	12,018
			36x12x36 Tee	6.00 EA	16,265.00 /EA	97,590	145,473
			36x16x36 Tee	6.00 EA	11,147.00 /EA	66,882	99,698
			36x24 Eccentric Reducer	2.00 EA	15,346.00 /EA	30,692	45,751
			4" Wall Pipe	5.00 EA	189.00 /EA	945	1,409
			12" Wall Pipe	2.00 EA	518.00 /EA	1,036	1,544
			18" Wall Pipe	2.00 EA	973.00 /EA	1,946	2,901
			24" Wall Pipe	3.00 EA	1,470.00 /EA	4,410	6,574
			30" Wall Pipe	5.00 EA	2,345.00 /EA	11,725	17,478
			36" Wall Pipe	2.00 EA	3,367.00 /EA	6,734	10,038
			Miscellaneous Connections And Fittings	1.00 LS	11,200.00 /LS	11,200	16,695
			24x36	2.00 EA	6,300.00 /EA	12,600	18,782
			24x16x24 Tee	1.00 EA	5,060.00 /EA	5,060	7,560
			Pipe Hangers, Supports, And Restraints	1.00 ls	5,000.00 /ls	5,000	7,419
			Pipe UD Slurry Water Supply		/lnft	**1,507,114**	**2,235,528**
		Plumbing Bldg Serv	**Plumbing Building Services**				
			Sanitary drainage piping	1.00 ls	45,660.00 /ls	45,660	67,506
			Plumbing fixtures	1.00 ls	6,575.00 /ls	6,575	9,716
			Roof drainage piping	1.00 ls	55,915.00 /ls	55,915	82,760
			Roof drains and accessories	1.00 ls	12,390.00 /ls	12,390	18,505
			Potable water piping, valves, trap primers, backflow, and accessories	1.00 ls	49,360.00 /ls	49,360	72,836
			Trench drains	1.00 ls	52,850.00 /ls	52,850	78,166
			Plumbing Bldg Serv Plumbing Building Services		/lnft	**222,750**	**329,489**
			15000 MECHANICAL		/sqft	**3,690,620**	**5,477,958**
	16000		**ELECTRICAL**				
		Elec Systems	**Electrical Systems**				

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CH2MHILL

FACILITY DETAIL 4 (CSI) Unallocated

PROJECT: Memorial Parkway Treatmen | ESTIMATOR: David Roby
DESIGN STAGE: | ESTIMATE No.:
PROJECT No.: | REV No./DATE: /

Facility	CSI	Proc/System	Description	Takeoff Quantity	Total Unit Price	Total Amount	Grand Total
		Elec Systems	**Electrical Systems**				
			Basic Electrical Materials and Methods	1.00 ls	130,000.00 /ls	130,000	193,614
			Wire and Cable Conductors	1.00 ls	205,000.00 /ls	205,000	306,248
			Grounding and Bonding For Electrical Systems	1.00 ls	10,000.00 /ls	10,000	14,928
			Conduit and Fittings/Raceways and Boxes	1.00 ls	268,000.00 /ls	268,000	400,310
			Electrical System Analysis	1.00 ls	25,000.00 /ls	25,000	36,795
			Generator	1.00 ls	350,000.00 /ls	350,000	521,729
			Automatic Transfer Switch	1.00 ls	55,000.00 /ls	55,000	82,029
			Low Voltage Transformer	1.00 ls	114,000.00 /ls	114,000	170,149
			Panelboards	1.00 ls	92,000.00 /ls	92,000	137,337
			Wiring Devices	1.00 ls	13,000.00 /ls	13,000	19,301
			Safety Switches	1.00 ls	120,000.00 /ls	120,000	179,136
			Low-Voltage Adjustable Frequency Drive System	1.00 ls	140,000.00 /ls	140,000	207,492
			Facility Lightning Protection	1.00 ls	10,000.00 /ls	10,000	14,898
			Lighting Fixtures and Outside Lights	1.00 ls	136,000.00 /ls	136,000	202,810
			Switchboards	1.00 ls	200,000.00 /ls	200,000	298,559
			Medium Voltage Circuit Breaker Awitchgear	1.00 ls	125,000.00 /ls	125,000	183,975
			Telephone ans security system including CCTV	1.00 ls	10,000.00 /ls	10,000	14,928
			Replacement of filter influent and effluent valves Filters 4,5,6	1.00 ls	49,100.00 /ls	49,100	73,307
			Elec Systems Electrical Systems			**2,052,100**	**3,057,544**
			16000 ELECTRICAL		/sqft	**2,052,100**	**3,057,544**
			W990 Memorial Parkway Treatment Plant		/sqft	**15,512,754**	**23,004,184**

Estimate Totals

Description	Amount	Totals	
Subcontractor Markups			
		15,512,754	
Sales Tax	444,867		6.00 %
General Conditions	1,551,275		10.00 %
	1,996,142	**17,508,896**	
Overhead	1,750,890		10.00 %
Profit	875,445		5.00 %
Mob/Demob	1,050,534		6.00 %
Insurance	875,445		5.00 %
Bond	118,871		
	4,671,185	**22,180,081**	
Contingency Shown On Bid Form	100,000		
	100,000	**22,280,081**	
Escalation	724,103		3.25 %
	724,103	**23,004,184**	

Construction Total	**23,004,184**

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Case No. 2010-____
Exhibit ____A____

NORTHERN KENTUCKY WATER DISTRICT

Project
Memorial Parkway Treatment Plant
Advanced Treatment Facility

Campbell County
184-0456

Specifications prepared by CH2M Hill and HDR Engineers titled "Advanced Treatment Facility Memorial Parkway Treatment Plant"

Northern Kentucky
Water District

The following items are enclosed separately from this volume.

- Plans prepared by CH2M Hill titled "Advanced Treatment Facility Memorial Parkway Treatment Plant"
- Specifications prepared by CH2M Hill titled "Advanced Treatment Facility Memorial Parkway Treatment Plant"

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