THE ECONOMIC EFFICIENCY OF WATERSHED MANAGEMENT CONCERNING DRINKING WATER SUPPLY IN THE WHITE CLAY CREEK WATERSHED IN PENNSYLVANIA AND DELAWARE

By

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Environmental and Energy Policy

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ABSTRACT

The White Clay Creek watershed in northern Delaware and southeastern Pennsylvania is the drinking water supply to the city of Newark, Delaware. This thesis is an analysis of current and future water quality and land use changes as they relate to the operation of the Curtis Mill Water Treatment Plant that withdraws surface water from the White Clay Creek. The research is based on the interaction of watershed management, water supply operation, and water quality as they pertain to drinking water.

The water quality of the White Clay Creek is currently high, but land use changes known to be detrimental to water quality within the watershed occur at a fast pace. A land use analysis on the Pennsylvania and Delaware sections of the White Clay Creek watershed had found that impervious cover in the watershed increases at a rate of one half percent annually and is currently eleven percent for the area of the watershed that contributes source water to the city of Newark. Land use change is most apparent in the transition from agricultural land to single family residential areas.

The Curtis Mill Water Treatment Plant is technologically sensitive to stream turbidity, and this thesis measures the range of sensitivity and the economic impact that declining water quality will have on the operation of the facility run by the Newark Water Department. The plant currently purchases water from United Water Delaware when stream turbidity in the White Clay Creek surpasses 20 NTU. Given the increase in turbidity frequency and intensity due to estimated impervious cover growth, an upgrade to a 40 NTU operating limit is recommended.

The Curtis Mill Water Treatment Plant can physically and financially upgrade to the 40 NTU operating limit. This thesis has found that it is cheaper for the plant to treat

water with turbidity between 20 NTU and 40 NTU rather than purchase it from United Water Delaware under current high water quality and future poor water quality conditions.

This research has produced three specific recommendations regarding the Newark Water Department.

It is recommended the Newark Water Department remain active in watershed management groups within the White Clay Creek watershed and greater Christina River basin. The Newark Water Department would work with the management groups to slow the rate of land use conversion in Pennsylvania.

The second recommendation advocates the investment by the City of Newark in a real time turbidity meter. The turbidity meter will enable an exact study of the turbidity streamflow relationship that was extrapolated in this research.

The turbidity meter will enable the Newark Water Department to fulfill the third recommendation which is to develop a new chemical dosage schedule for the Curtis Mill Water Treatment Plant that will raise the operating limit from 20 NTU to 40 NTU. A 40 NTU operating limit will expand the range of turbidity the Curtis Mill Water Treatment Plant can technically handle. A higher operating limit will reduce financial losses that accrue to the Newark Water Department because the practice of purchasing water from United Water Delaware is more expensive than treating water during high turbidity.

Chapter 1

INTRODUCTION

1.1 Introduction

The Christina River Basin Watershed Restoration Action Strategy (WRAS) written by the Christina Basin Clean Water Partnership sets the management direction of each sub-watershed within the Christina Basin based on pollution potential (Kauffman 2003). The pollution potential takes into account sediment, impervious cover, land use, stream water quality, and fish consumption advisory. Table 1.1 is the chart used to determine whether a watershed has a low, medium, or high pollution potential.

Watersheds with low pollution potential are to be protected and preserved in order to prevent degradation from occurring. Watersheds with medium and high pollution potential are to be restored and conserved wherever possible to mitigate degradation that has already occurred.

Table 1.1 Watershed Pollution Potential

Watershed Pollution Potential	BMP Implementation Strategies	Goal	TSS Load (lb/ac./ yr.)	% Impervious	% Agriculture	% Wooded	Stream Water Quality
High	Remediation Retrofitting Restoration	Improve Water Quality	>600	>20	>40	0-20	Not supported For life, wildlife, or water supply
Medium	Conservation	Improve Water Quality	401-600	11-20	21-40	21-30	Not supported for swimming, fishing, boating, or water sports
Low	Prevention Preservation Protection	Protect Water Quality	0-400	0-10	0-20	>30	Exceptional recreational or ecological significance, cold water trout fishery

Source: Watershed Restoration Action Strategy Kauffman 2003

The Watershed Restoration Action Strategy lists the White Clay Creek above Newark as a watershed with low pollution potential. The pollution potential is low because the watershed has low impervious cover, sediment load, and a high percentage of wooded area. The Watershed Restoration Action Strategy also gives a watershed grade of B to the White Clay Creek watershed above Newark. The grading system takes into account stream water quality, stream habitat, and watershed health parameters. However, the Newark Source Water Assessment (NSWA), which analyzes the supply and quality of the White Clay Creek as a municipal supply, finds the White Clay Creek above Newark to have a high susceptibility to organic pollution from petroleum hydrocarbons and PCBs, and inorganic pollution from nutrients, pathogens, pesticides, and heavy metals (Wollaston 2002). Both analyses of the White Clay Creek above Newark suggest a management path that emphasizes protection of the resource and deploys conservation measures to maintain the high level of water quality.

What can be inferred from the WRAS and NSWA is that although the pollution potential of the White Clay Creek is currently low, if that status were to change the source water would remain highly susceptible to pollution. The result would be a watershed with a medium to high pollution potential and high susceptibility, placing the source of the drinking water at risk. The main parameter within the pollution potential determination that can shift in future years and force such a change is the land use and impervious cover values.

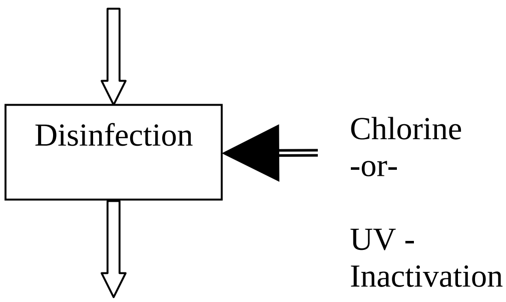
The Center for Watershed Protection describes a sensitive stream with less than 10 percent impervious cover as having stable channels, excellent biodiversity, and excellent water quality. At impervious levels 11-25 percent the channels become unstable and biodiversity and water quality decline (Schueler 2000). The White Clay Creek watershed above the Newark intake is currently eleven percent impervious cover. Water quality degradation with land use change is significant to municipalities that draw water from surface sources because the existing technological capacity and efficiency of water treatment facilities is dependent upon the quality of the water supply.

Depending on the water supply and treatment technology, quality changes could force a municipality to make minor adjustments in operating procedure, or force major and expensive process upgrades. Minor adjustments include an increase in the amount of chemicals necessary, a change in the chemicals used, and possibly the addition of an external pre-sedimentation basin. Depicted below in Figure 1.1 are the major treatment steps involved when the surface water supply is of superior quality.

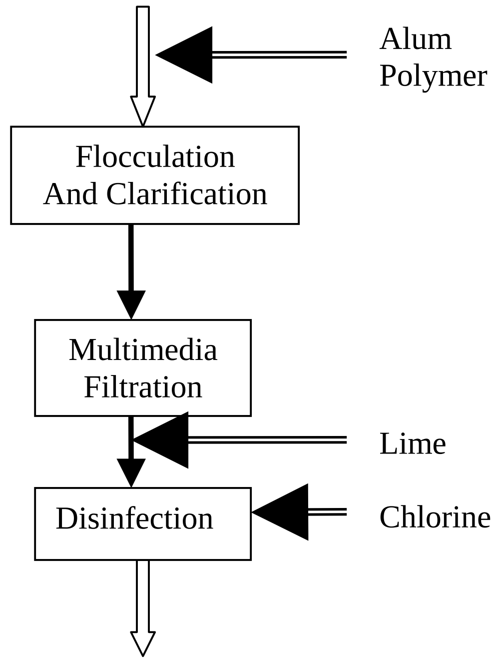
Figure 1.1a is representative of the New York City water system that currently does not need to filter its water because the quality of the source water is superior. New York City has clean source water due to the protected and managed reservoir system in the Catskill Mountains. The treatment process in Figure 1.1a is a one step disinfection process, where the water is of such superior quality that filtration is not required by the Environmental Protection Agency.

Figure 1.1b is the current operating steps used to treat water from the White Clay Creek at the Curtis Mill Water Treatment Plant serving Newark, Delaware. This treatment process is designed to treat high quality surface water withdrawn from a river system. The treatment process at Newark is a four step process that involves combined flocculation and clarification, filtration, and disinfection. With this process alignment, chemical treatments can be adjusted to changing surface water quality (Zimmerman personal communication 2005, USFilter 2005).

Figure 1.1 Treatment Scenarios for Superior and High Quality Source Water



1.1a Superior Water Quality



1.1b High Water Quality

Figure 1.2 Treatment Scenario for Moderate Surface Water Quality

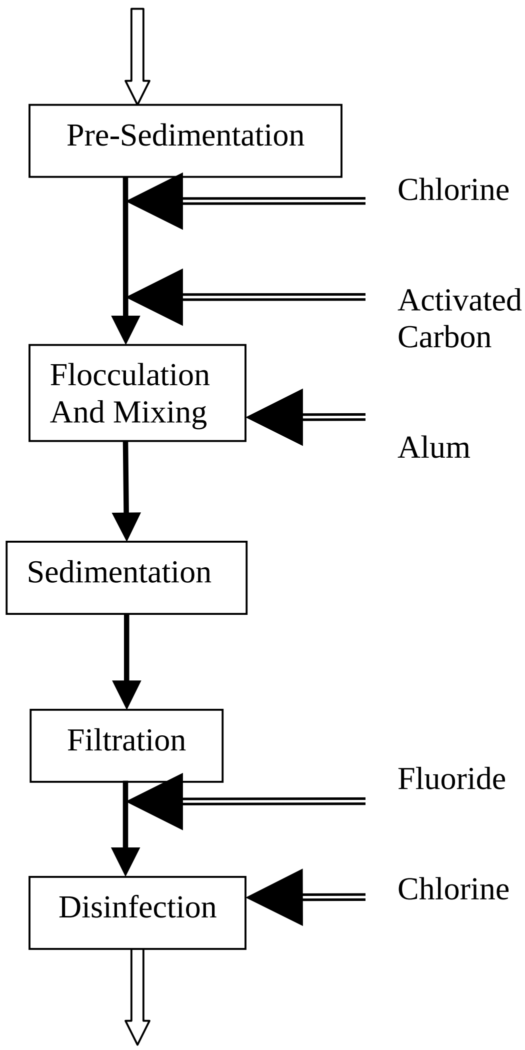


Figure 1.2 is representative of treatment processes necessary for surface water of moderate quality. This five – six step process is similar to that depicted in Figure 1.1b but includes activated carbon to remove turbidity, dual chlorination, and pre-sedimentation. Figure 1.2 is typical of conventional water treatment plants such as the

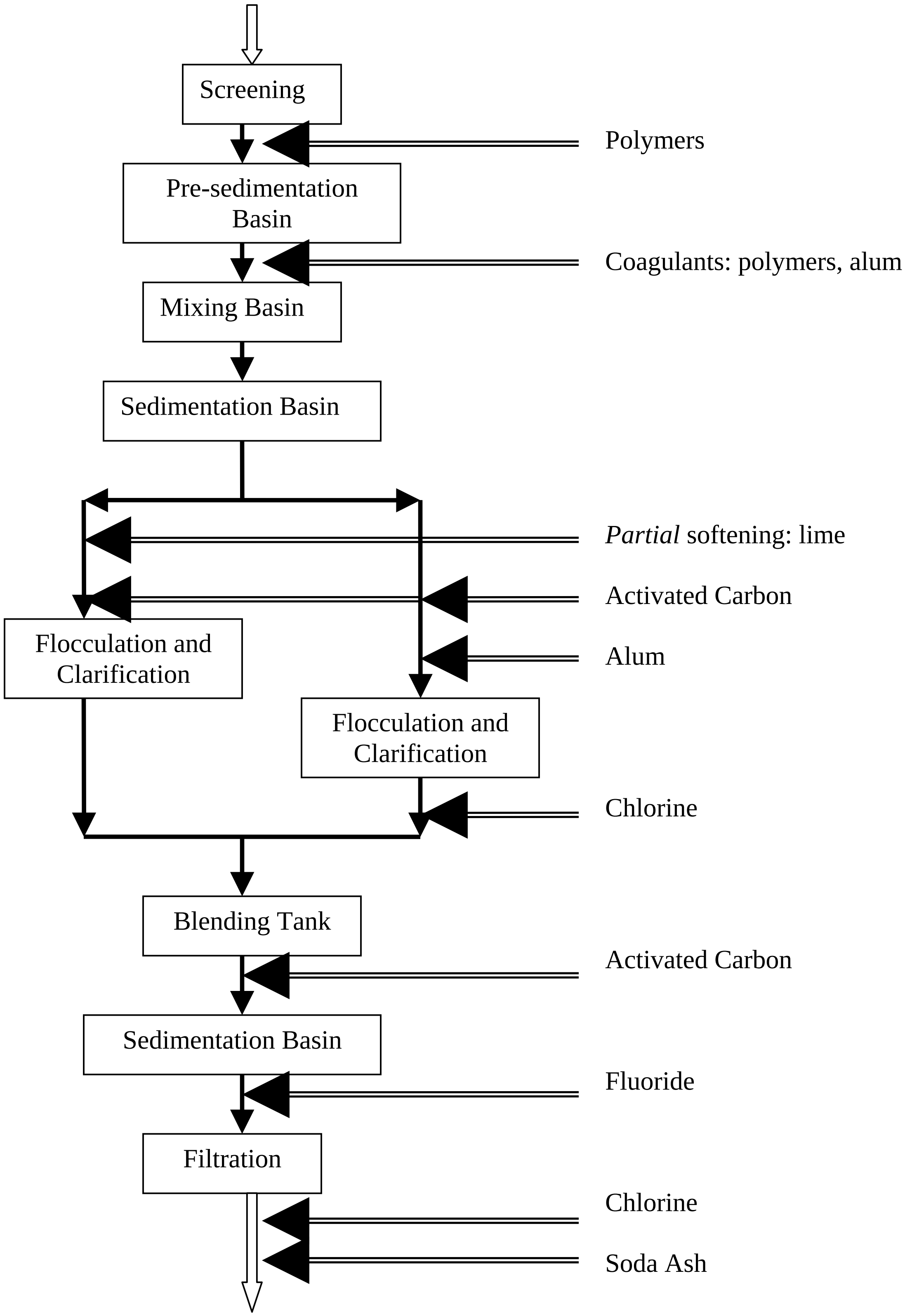
United Water Delaware Water Treatment Plant that uses the White Clay Creek at Stanton, Delaware as a water supply.

Shown on the following page is Figure 1.3, the treatment scenario of surface water with poor water supply quality. This process includes split flocculation and clarification, three sedimentation steps, and dual activated carbon and chlorination steps. The total number of steps used in this treatment process is eight to ten. Large cities such as Philadelphia employ this process because it can handle large demand and poor quality.

The past four figures have shown broad treatment process steps used to treat surface water of varying quality, summarized on Table 1.2. The scenarios range from the New York City, NY example that emphasizes watershed protection to secure a superior quality water supply requiring minimal treatment to the Philadelphia, PA example which is technologically intensive.

Regardless of the number of steps in the treatment process, a water treatment plant is a large capital investment for any town and is designed to operate for several decades. If water quality change is likely, a worse case scenario would be that a treatment plant could be rendered obsolete by technical limitations before the engineered lifetime of the plant has passed. The avoidance of this likelihood should be considered in the watershed management approach.

Figure 1.3 Water Treatment Scenario for Poor Surface Water Quality



If a water treatment facility can make minor adjustments in operating procedure to deal with changing water quality, the watershed management strategy should aim to preserve water quality levels within the current ability of the treatment technology. The technical limitations of the water treatment technology and the potential for water quality change must be determined in order for this relationship to dictate watershed management plans and best management practices that target water quality.

In order to test the hypothesis that the technological limitations of the municipal water treatment process will aid watershed managers, this thesis will examine the White Clay Creek water supply through the current and potential water quality effects on the municipal water treatment process of Newark, Delaware. The research objective is to determine how the water quality could change in the next ten years and if the water treatment technology is capable of dealing with such changes. The analysis will focus on land use change and the water treatment process employed by the City of Newark which is currently reliant on low water turbidity.

The thesis will begin with a description of the White Clay Creek watershed and Newark source water area in the second chapter. The literature review in the third chapter will explain land use and impervious cover influences on water quality. The third chapter will also discuss the specific treatment process used by the City of Newark and its known benefits and limitations. The fourth chapter discusses methodology surrounding the land use determination and anticipated water quality changes. The fourth chapter will also include methodology that will be used to determine how water quality changes can financially impact the Newark Water Department.

The fifth chapter presents the results from a land use and impervious cover analysis, baseflow separation, turbidity extrapolation, and assessment of the cost of turbidity treatment to the Newark Water Department. The results from chapter five provide for a discussion of land use change, water quality, and the capability of the treatment technology to handle projected turbidity scenarios. The fifth chapter will also discuss the range of water quality the treatment technology is capable of operating in. The discussion is followed by a conclusion and recommendation chapter that outlines what management path the White Clay Creek must follow in order to keep water quality within the capabilities of the water treatment technology.

Table 1.2 Water Quality Treatment Scenarios

Treatment Scenario	**Location Example**	**Water Quality**	**Treatment Steps Required**	**Treatment Processes**
1.1a	New York City, NY	Superior	1	Disinfection
1.1b	Newark, DE	High	4	Flocculation Clarification Filtration Disinfection
1.2	Stanton, DE	Moderate	5-6	Pre-Sedimentation Flocculation Sedimentation Filtration Disinfection
1.3	Philadelphia, PA	Poor	8-10	Screening Pre-sedimentation Sedimentation Softening Activated Carbon Flocculation Clarification Sedimentation Filtration Disinfection

1.2 Hypothesis

The hypothesis of this manuscript is that the economic value of stream uses is directly related to the healthy function of the drinking water supply and good watershed health. For instance, if watershed health is poor leading to impaired water quality, the operation of the drinking water treatment facility becomes more costly.

1.3 Research Objective

The objective of this research is to determine what the water quality limitations of the Newark, Delaware Curtis Mill Water Treatment Plant are at current and future water quality conditions in order to aid in the management of the White Clay Creek watershed. The water quality limitations will be used to assess the economic impact of changing White Clay Creek water quality on the Curtis Mill Water Treatment Plant.

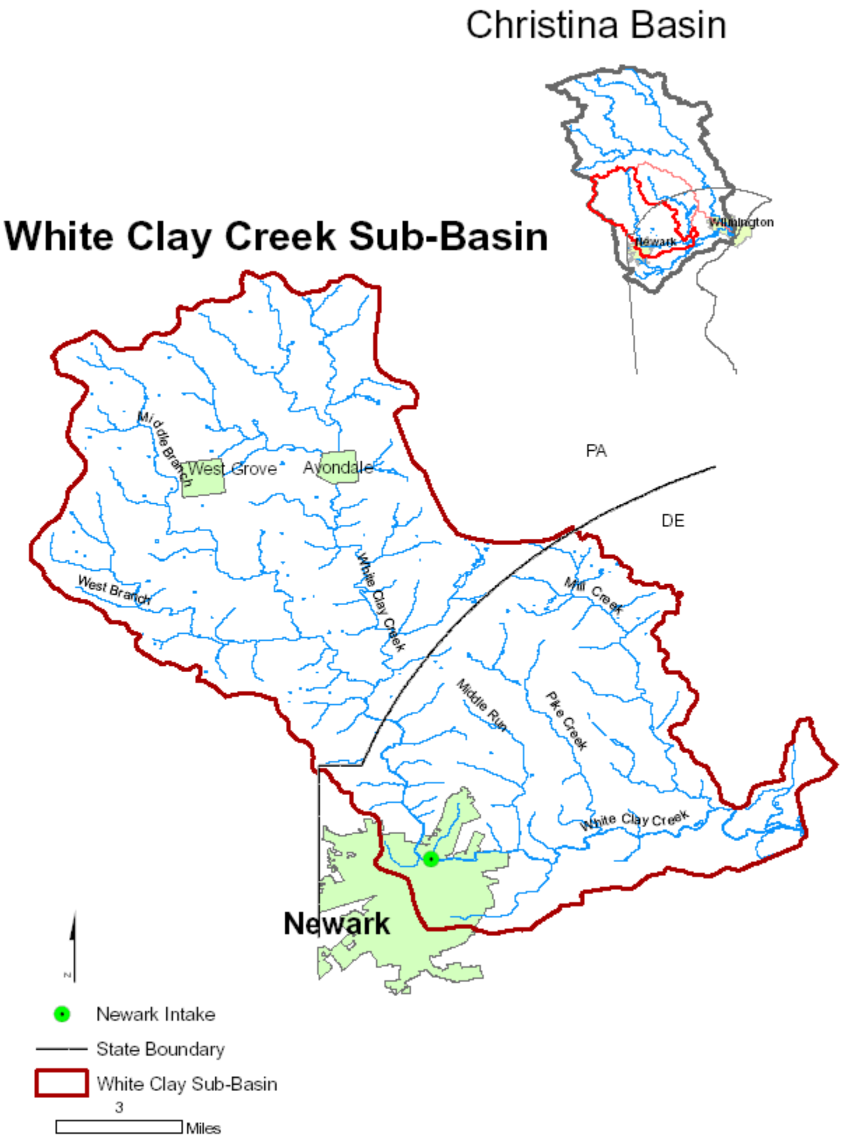
1.4 Research Goals

1. Determine changes in land use in the White Clay Creek watershed above the Newark, Delaware drinking water intake.
2. Estimate the impact of impaired water quality, as measured by turbidity on the operation of the Curtis Mill Water Treatment Plant in Newark, Delaware.
3. Analyze the economic efficiency of the Newark, Delaware Curtis Mill Water Treatment Plant based on stream water quality as measured by turbidity.
4. Determine the benefits of a watershed restoration action strategy to the White Clay Creek.

1.5 Study Area

The area of study is the White Clay Creek watershed within the Christina River Basin located in southeastern Pennsylvania and northern Delaware. The city of Newark uses the White Clay Creek within the Christina River Basin as the drinking water supply. Map 1.1 shows the Christina Basin, the White Clay Creek and its sub-watersheds, and the intake for the surface water treatment facility serving the city of Newark.

Map 1.1 Christina Basin and White Clay Creek Watershed



Chapter 2

STUDY AREA DESCRIPTION

2.1 White Clay Creek Watershed

2.1.1 Geography

The watershed of the White Clay encompasses 107 square miles, with 42 percent in New Castle County, Delaware, 58 percent in Chester County Pennsylvania, and less than one square mile in Cecil County, Maryland (Table 2.1). The White Clay Watershed is a sub-basin within the Christina River Basin of the Delaware River Basin. Map 2.1 shows, the White Clay Creek sub-basin as divisible into 10 watersheds (Table 2.2).

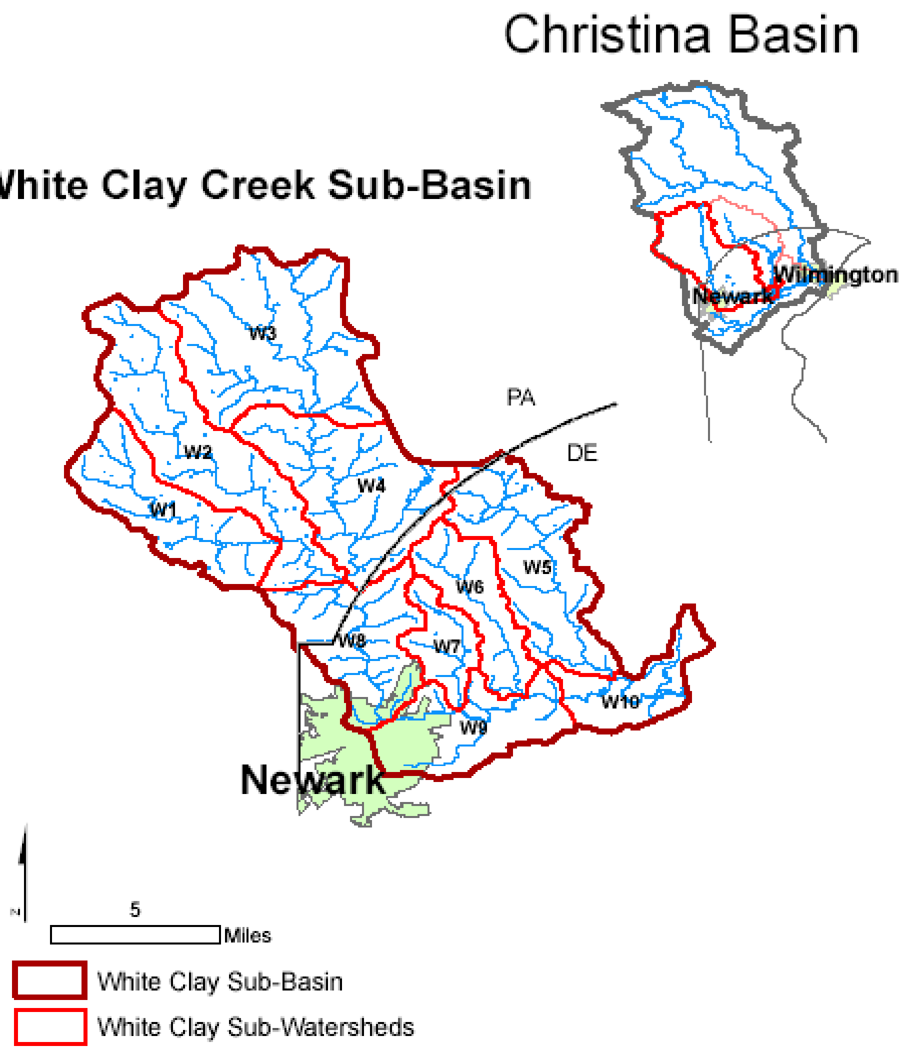
Table 2.1 Areas of the White Clay Creek and Christina River watersheds

Watershed	**PA mi.^{2}**	**DE mi.^{2}**	**MD mi.^{2}**	**Subtotal mi.^{2}**
White Clay Creek Sub-Basin	62	45	<1	107
Christina Basin	396	160	8.	564

Table 2.2 Sub-Watersheds of the White Clay Creek Sub-Basin

Watershed	Area mi.^{2}	DE mi.^{2}	PA mi.^{2}
W1. West Branch	10	0	10
W2. Middle Branch	16	0	16
W3. East Branch above Avondale	19	0	19
W4. East Branch below Avondale	14	1	13
W5. Mill Creek	13	12	1
W6. Pike Creek	7	7	0
W7. Middle Run	4	4	0
W8. Main Stem above Newark	10	7	3
W9. Main Stem above Delaware Park	9	9	0
W10. Main Stem at Churchman's Marsh	6	6	0

Map 2.1 White Clay Creek Sub-Basin



Municipalities within the White Clay Creek Sub-Basin are Newark, Delaware, Avondale, Pennsylvania, and West Grove, Pennsylvania. The White Clay Creek Sub-Basin is also close to the larger cities of Wilmington, Delaware, and Philadelphia, Pennsylvania. Land use with in the White Clay Creek is 18 percent urban/suburban, 50 percent agriculture, and 32 percent wooded/open space.

2.1.2 Geology

The White Clay Creek spans three different physiographic provinces: the Middle Atlantic Coastal Plain, Northern Piedmont, and the South Eastern Plains. These breakdowns are according to EPA Level III regional designations shown on Map 2.2.

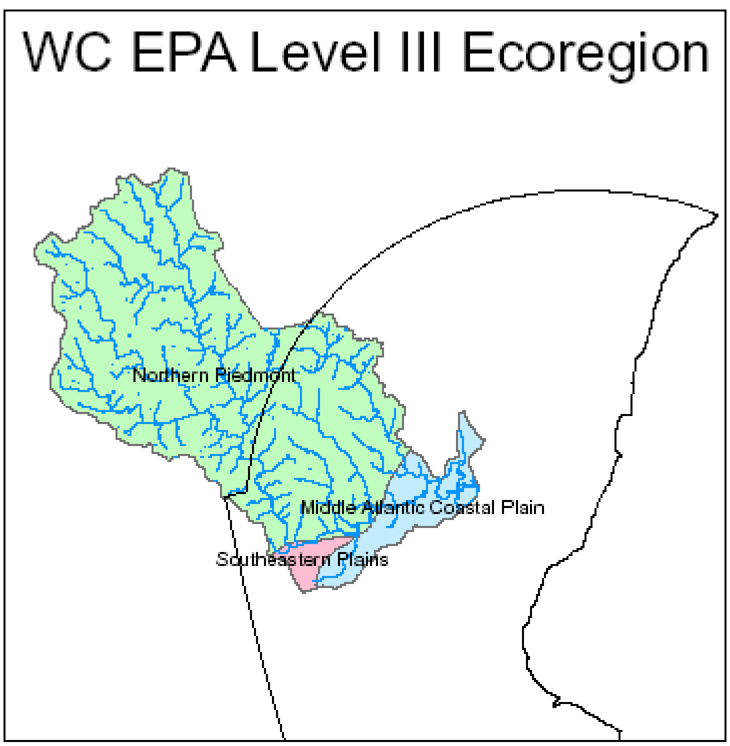
The White Clay Creek watershed is:

87.6 percent Northern Piedmont

10.1 percent Middle Atlantic Coastal Plain

2.3 percent South Eastern Plains.

Map 2.2 U.S. Environmental Protection Agency ecoregion designations



Northern Piedmont

The most dominant region in the White Clay Creek watershed is the Northern Piedmont. The Northern Piedmont is dominated by agriculture, but once contained vast oak forests. The bedrock varies in the Northern Piedmont between sedimentary and igneous metamorphic forms. Soils are fertile utisols and altisols. This region provides the setting for all of the surface water withdrawn in Delaware, and the Wissahickon, Wilmington, and Cockeysville formations provide ground water.

Middle Atlantic Coastal Plain

The Middle Atlantic Coastal Plain is a low elevation ecoregion that contains estuaries, marshes, and other wetlands. Vegetation cover was once dominated by long leaf pine, but is now a combination of oak, gum, and short leaf pine. Soils in the region are unconsolidated, poorly drained, and composed of coarse and fine textured grains. The sand and gravel deposits of this region provide ground water for municipal use in the Christina Basin.

South Eastern Plains

The South Eastern Plains region contains sand, silts, and clays geologically older than formations in the Northern Piedmont. Dominant rock formations are sedimentary. The region is a higher elevation than the Middle Atlantic Coastal Plain but lower than the elevation of the Northern Piedmont. This region comprises the smallest area in the White Clay Creek watershed.

2.1.3 Climate

The White Clay Creek experiences humid continental climate. Winters range from mild to moderately cold, and summers are hot and humid. The average temperature as measured in Newark, Delaware from 1971-2000 is 55 degrees Fahrenheit. Average precipitation as measured in Newark, Delaware between 1971-2000 is 45.35 inches and 49.02 inches in Coatesville, Pennsylvania located in the northern area of the Christina Basin (Senior 2003).

2.1.4 Hydrology

Surface water in the White Clay Creek watershed is supported by precipitation and underlying geology composed of weathered and cracked formations that discharge into the surface water. The geology also supports aquifer formations such as the Cockeysville that acts as a ground water source to the town of Newark, Delaware. Stream gradient in the White Clay Creek watershed varies between 30 feet/mile and 10 feet/mile (Senior 2003).

The past five years of weather in the White Clay Creek watershed included the worst drought on record since the late 1890s in 2002, and three major precipitation events. The one year precipitation value for October 2001-2002 was 69 percent of the average historical values (DNREC 2003). The severity of this drought classifies it as a 100 year drought, with a 1 percent chance of occurrence every 100 years. In September of 1999 Hurricane Floyd brought greater than 10 inches of rain to the White Clay Creek watershed and the river reached a flood stage of 17.3 feet in 10 hours making Hurricane Floyd a 100 year storm. In September of 2003 Tropical Storm Henri brought the flood stage to 16.1 feet in 5 hours and measured as a 500 year storm. Another 100 year storm occurred in September of 2004 when Hurricane Jeanne brought the flood stage up to 17.6 feet in 10 hours (Kauffman 2003, Talley 2004).

2.1.5 Outstanding Recognitions

Wild and Scenic Status

The White Clay Creek was granted Wild and Scenic Status by President Bill Clinton and the U.S. Congress in 2000. The National Park Services recommended this designation, and its approval brought federal money for water quality management, land conservation, education, and public outreach. The White Clay is the only Wild and Scenic River in Delaware and the first in the nation to be protected on a watershed rather than segment basis.

Exceptional Recreational and Ecological Significance (ERES)

The White Clay Creek above Newark is designated an area of ERES by the Delaware Department of Natural Resources and Environmental Control.

USEPA Watershed Initiative

In 2003 the Christina Basin Clean Water Partnership was awarded a one million dollar Watershed Initiative Grant. The money is to be used for agriculture, stormwater, and landscaping best management practice projects within both the Delaware and Pennsylvania sections of the Christina Basin.

2.1.6 Watershed Organizations

The following organizations are just a few whose focus is on the White Clay Creek and the Christina Basin:

UDIPA, Water Resources Agency	White Clay Watershed Association
DGS	Stroud White Clay Creek Laboratory
DNREC	Delaware Nature Society
PADEP	Brandywine Valley Association
DRBC	Brandywine Conservancy
Chester County Conservation District	Red Clay Valley Association

2.2 Newark Municipal Water Supply

The city of Newark is home to 33,000 residents, and the water demand per year is 1.2 billion gallons with a peak demand of 6 million gallons per day. Daily average water demand is 4 million gallons per day (Wollaston 2002). The City of Newark withdraws water from the White Clay Creek, groundwater from the Cockeysville aquifer, and an interconnection with United Water Delaware. The City of Newark withdraws roughly thirty percent of its water supply from each different source. The City of Newark has a minimum purchase contract with United Water Delaware for 21,000,000 gallons per month at a cost of $1.75 per 1,000 gallons (Zimmerman personal communication 2005).

The White Clay Creek became a supply to Newark in 1992 when the Curtis Mill Water Treatment Plant was constructed. Currently in construction is a reservoir with a 318 million gallon storage capacity for 75 days with a 4 million gallon per day demand during a drought situation. The reservoir is expected to cost eight million dollars for land purchase and ten million dollars for construction (DNREC 2003). Recently the city constructed an iron and manganese treatment plant to bring groundwater withdrawn from the Cockeysville formation up to Safe Drinking Water Act standards. The plant cost three million dollars and was completed in 2003, bringing an additional one million gallons per day capacity to the city of Newark. Current total water supply available to the City of Newark is 9.5 million gallons per day.

Chapter 3

LITERATURE REVIEW

3.1 Land Use / Water Quality Relationship

The influence of land use on stream water quality encompasses different land use designations, specific water quality parameters, and the measurement of impervious cover within a watershed. This literature review will cover the recent study of these areas first in a review of research on three broad land use classifications: forested, agricultural, and urban. The second section will take a more detailed look into research that has found specific links between impervious cover percentages, connectivity, and thresholds in relationship to particular biotic and abiotic stream water health and quality parameters. Finally, the literature review will cover recommendations put forth by researchers in science, policy, and planning fields to mitigate and prevent water quality degradation due to land use practices.

3.1.1 Agricultural, Forested, and Urban Influences on Water Quality

Land uses can alter stream health by changing the natural hydrology and water chemistry, to where the macroinvertebrate and fish populations become impacted.

Urban areas affect stream health through the degradation of macroinvertebrate communities, increased transport of sediment, nutrients, heavy metals, man made chemicals, increased water temperature, and increased pH (Coulter 2004, Yuan 2001, Stepanuck 2002, Sheeder 2004).

In comparison to urban effects on water chemistry, agricultural areas transport nutrients such as nitrate and orthophosphate (Coulter 2004, Sheeder 2004), pesticides, herbicides, and heavy metals (Graves 2004), and bacteria depending on the nature of the farm. Higher turbidity levels (16.2 NTU) were also correlated with agricultural land versus wetland and urban land uses (Graves 2004).

Forested catchments are important in riparian and lacustrine environments for their soil stabilization, temperature regulation, and allochthonous carbon contribution. Allochthonous carbon is utilized by zooplankton, bacteria, and in general a stimulant for the microbial loop (Kankaala 1996, Grey and Jones 2001, Hessen 1992, Arvola 1996). Allocthonous carbon inputs into lacustrine ecosystems come from the degradation of leaf litter and vascular plants, and direct input from falling leaves (Meyer 1998, Hessen and Tranvik 1998, Moran and Hodson 1994, Hongve 1999), indicating a change in watershed vegetation will directly affect the carbon inputs into a stream.

A deciduous forest releases the most carbon into a system during the fall, and coniferous stands release carbon more evenly throughout the year (Hongve 1999). Research performed by the United States Geological Survey (USGS) has found that streams with a Hemlock dominated drainage area can support 37 percent more aquatic macroinvertebrate species than a deciduous counterpart (Snyder et al 1999, Snyder 1999).

The USGS also saw lower nitrite concentration and more stable temperature and flow patterns in the hemlock drainage.

Forest conversion to grass and pasture was found to degrade stream quality, while the total imperviousness of the watershed remained low (Booth 2002). Forested catchments also have a lower flow exceedance level and time in exceedance than mixed urban and agricultural catchments with and without stormwater management practices (Booth 2002).

The ability of these land uses to transport water, and any contaminants within, is a function of the runoff coefficient of the pervious surface. Hard surfaces such as gravel and soil have higher runoff coefficients than sod or meadow and therefore transport more water at a higher velocity to the stream (Ross and Dillaha 1993 in Schueler 2000). Cheng and Wang (2002) found the development of a Taiwan watershed over the past thirty years has increased the stream peak flow by 27 percent and decreased the instantaneous time to peak by four hours.

3.1.2 Impervious Cover Influences on Water Quality

The amount of impervious cover in a watershed is the total area of all surfaces such as roads, parking lots, roofs, and sidewalks that repel water. Impervious cover is used as watershed health indicator because it is related to declining biotic and abiotic stream integrity (Schueler 2000). Current research focuses on impervious cover and connected impervious cover, or effective impervious cover. Connected impervious cover is the percentage of impervious cover that directly drains stormwater into the stream, or is connected to a stormwater system with stream discharge. A summary of the biotic and abiotic, or living and non-living, effects and their related impervious cover value is found in Table 3.1 at the end of the literature review.

3.1.2.1 Abiotic Effects of Impervious Cover

Investigators across the country from Washington to Florida are studying the relationship between different impervious cover values and abiotic water quality parameters such as nutrients, sediment transport, and physical stream characteristics.

Impervious cover values above 10 percent are shown to increase dissolved organic carbon, filterable reactive phosphorus, total phosphorus, ammonium, electrical conductivity, chemical contaminants, total suspended solids, and salinity variance (Holland 2004, Hatt 2004, Wu 1998). Concurrent studies by Booth (2002 and 1997) have shown that when impervious cover is >10 percent and when the ten year flood for a forested catchment is equal to the two year flood from an urban catchment stream channels will become unstable. Wang (2001) finds bank erosion increases between 8-12 percent impervious cover. The stream channel and bank effects of impervious cover could be related to research by Cheng (2002) who measured that after thirty years of development in a Taiwanese watershed the peak flow had risen 27 percent and the instantaneous time to peak was decreased by four hours while the total imperviousness was 10.44 percent.

Baseflow hydrology is shown by Wang (2001) to decrease when connected impervious cover in a 50 meter distance of the stream is above 8 percent, and Hatt et al. (2004) found that baseflow pollutant concentration increased when connected imperviousness increased. The baseflow results imply that pollutants from impervious cover can reach streams without transport by runoff, or pollutants in baseflow have a higher retention time than stormwater runoff. More research is needed in this area because the effects of low baseflow volume and high ambient pollutant concentration on stream biota and invertebrates could be responsible for the biotic effects discussed in the following section.

3.1.2.2 Biotic Effects

The biotic effects of impervious cover are measured by a variety of stream health indicators such as the Index of Biotic Integrity (IBI) and species diversity measurements. In tidal ecosystems, increased impervious cover between 20-30 percent is responsible for reduced stress-sensitive taxa, commercially valuable shrimp, altered food webs, and reduced fish and crustacean abundance (Sanger 2004, Holland 2004). Stepanuck (2002) saw the decline of macroinvertebrate communities between 8-12 percent impervious cover, and similarly Miltner (2004) measured a decline in IBI scores when imperviousness reached 13.8 percent. The beginning of IBI decline was found to begin at 4 percent impervious cover (Miltner 2004).

Wang (2001) also found that between 8-12 percent impervious cover minor changes in impervious cover would result in large changes in fish density, IBI score, and species richness. Wang (2001) refers to connected imperviousness and found a stronger relationship between connected imperviousness and degradation than imperviousness and degradation.

3.1.3 Mitigation Options for Impervious Surface Effects on Water Quality

Recent literature recommendations for impervious cover reduction are:

- Low impact urban design that targets the reduction of connected imperviousness (Hatt 2004)
- Riparian buffers and the protection of undeveloped buffer areas (Miltner 2004)
- Impervious cover caps through policy, stormwater detention, unstable slope protection, forest retention, wetland protection and buffer maintenance, and most importantly a policy that advocates protecting watersheds from degradation while the impervious cover is low (Booth 2002)
- Reduction of connected impervious cover through urban development design (Wang et al. 2001)
- Land use regulations regarding zoning, street design, and permeable driveways due to findings that low density residential land use has a high impervious value (Stone 2004)
- Incentive policies targeting impervious cover such as BMP cost sharing and subsidies (Randhir 2003)

Table 3.1 Abiotic and Biotic Impervious Cover Affects on Stream Health and Water Quality

Abiotic	**Impervious Cover**	**Parameter Effect**	**Author**
	10-20%	Altered hydrography Salinity variance Increased chemical contaminants Increased fecal coliform	Holland 2004
	Range of values	Increased: Baseflow DOC FRP, and TP Ammonium Conductivity	Hatt 2004
	>10%	Unstable Channels	Booth 2002
	8-12%	Decreased baseflow Increased bank erosion	Wang 2001
	10.4%	Increased peak flow Decreased instantaneous time to peak	Cheng 2002
	35% Connected IC: 13%	Connected IC is a stronger indicator of urban runoff behavior than IC	Lee 2003
Biotic	8-12%	Macroinvertebrate community sharp decline	Stepanuck 2002
	13.8%	IBI measurement showed significant decline	Miltner 2004
	14%	IBI began to decline	Miltner 2004
	<8%	High IBI and fish species diversity	Wang 2001
	>12%	IBI decline, fish species diversity decline	Wang 2001
	20-30%	Reduced stress-sensitive taxa Loss of commercial shrimp Altered food webs	Holland 2004
	Range	Reduced fish and crustacean abundance	Sanger 2004

3.2 Water Treatment

3.2.1 Package Water Treatment Plant Technology

The technology used to bring surface and ground water sources to Safe Drinking Water Act (SDWA) requirements is a function of cost, population size, and demand. Large and medium service populations greater than 10,000 people use conventional treatment technology that consists of separate coagulation, flocculation, clarification, sedimentation, filtration, and disinfection processes (Viessman 2005). Package plant technology is often used by small and medium populations less than 10,000 people, however multiple package plants can be linked to serve larger demand such is the case in Newark, Delaware. A package plant combines flocculation and sedimentation processes into one adsorption clarifier (Goodrich et al. 1992). Package plants are designed to have reduced operations costs, plant footprint, and construction costs. The package plant arrives to the site directly from the manufacturer and can begin operating once installed.

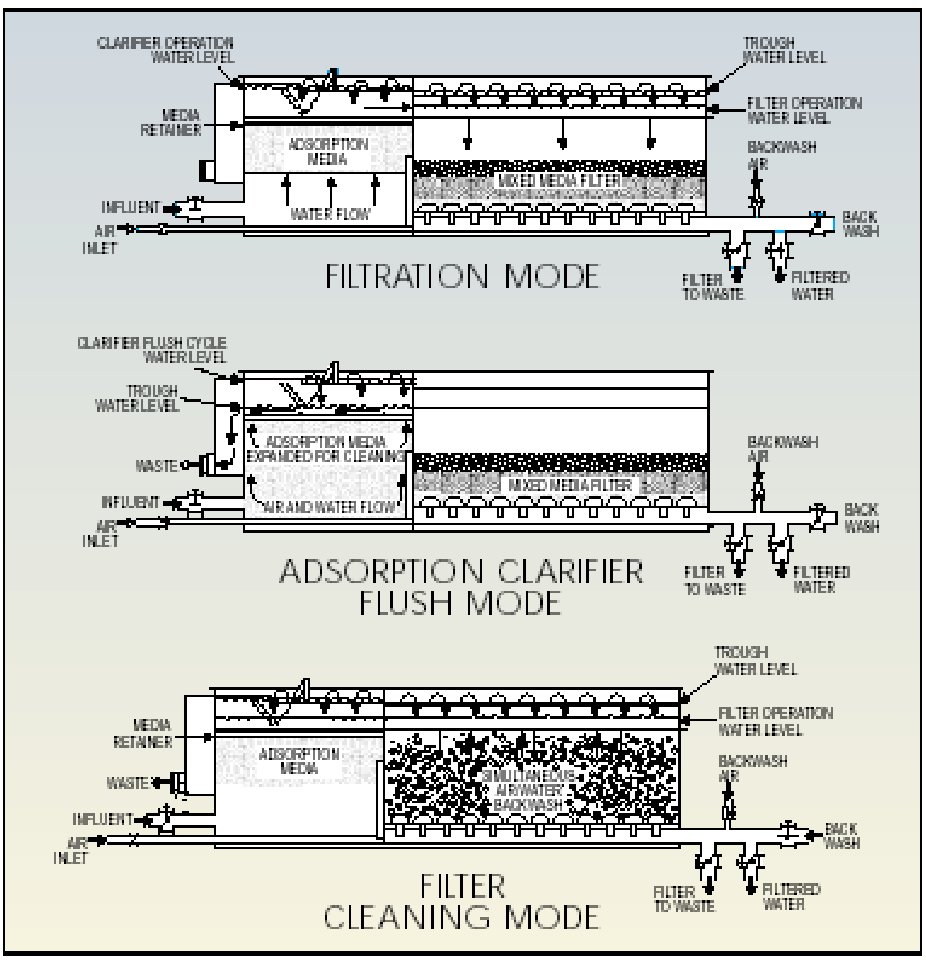
Package plants were introduced as a concept in the early 1980s to meet the economic circumstances faced by small communities trying to attain SDWA quality water (Clark 1981). Smaller communities are financially at a disadvantage compared to larger communities because the water department can not benefit from the economies of scale that larger demand generates (Shanaghar 1994, EPA and AWWA 1997). Package plants are shown to be economically effective in Clark (1981), DeMers (1988), Goodrich (1992), Shanaghar (1994), Pontius (1997), Campbell (1995), and EPA (1997, 1998, and 2002). One cost draw back to package plants is the initial pilot testing required by states and the EPA in order to assure proper treatment requirements are fulfilled. The pilot testing was found to cost up to thirty percent of initial capital costs (Goodrich et al. 1992). The EPA in cooperation with the states has initiated a standardized protocol in order to reduce pilot testing expenses (EPA 1998).

Package plant technology is approved by the EPA for the treatment of surface water and ground water, and appears on the compliance lists for the Surface Water Treatment Rule and non-microbial contaminants (EPA 1997, 1998).

Reviews of package plant technology identify the key role of operators and the need for advanced operator training. Clark and Morand (1981) reviewed package plants operating with less than 100 NTU surface water and found the only violations occurred due to lack of operator attention to varying dosage and the failure to run for long enough periods of time to achieve stable operation. Package plant technology used in Crested Butte, Colorado designed to deal with high winter melt turbidities less than 120 NTU reported turbidity violations when the alum pump clogged and coagulant chemicals were incorrectly applied requiring new chemicals to be used (DeMers 1988). A study of 48 package plants found that overall record keeping was poor, access to and use of training was variable, and capital and operating costs were not documented. These failures led to the lack of long term and contingency planning and the inability to anticipate funding for improvements, expansion, and or loan requests (Campbell 1995). The EPA also noted that the filtration performance is extremely sensitive to coagulation chemistry and that turbidity and microbiological contaminant removal efficiency can decline rapidly within minutes (EPA 1997).

The Newark Water Department owns and operates the Curtis Mill water treatment plant which is composed of three package plants. Curtis Mill uses three 0.5 million gallon per day Microfloc Trident TR-210A Package plants, and has two empty Trident shells that can be filled with media and brought into operation for future demand increases. A rendering of the Trident system is in Figure 3.1, and a table of Trident capacities is shown in Table 3.2.

Figure 3.1 Trident Package Plant from USFilter 2005



Top: Normal operating mode. Middle: Clarifier cleanse mode. Bottom: Filter backwash mode, necessary twice a day.

Table 3.2 Trident Design Capacities from USFilter 2005

MODEL		TR-105A	TR-210A	TR-420A	TR-840A	TR-105-LP	TR-210-LP	TR-420-LP	TR-840-LP
Typical Design Flow	GPM*	350	700	1400	2800	350	700	1400	2800
Dimensions (each tank)	Length	10' 1"	14' 5 1/2"	27' 10"	39' 10"	9' 1"	12' 11 1/2"	24' 9"	35' 6"
	Width	6' 11"	8' 11"	8' 11"	11' 11"	6' 11"	8' 11"	8' 11"	11' 11"
	Height	8' 5"	8' 5"	8' 5"	10' 1"	7' 6"	7' 6"	7' 6"	8' 6"

*Design flow is for a two-tank system. Being modular allows us to provide a (1 1/2) TR-210A to treat 1050 gpm with 3 tanks, or a (2) TR-840A for 5,600 gpm, etc.

Trident systems are manufactured to treat a range of volumes from 175-4200 gallons per minute, and turbidities less than 100 NTU or less than 50 color units (USFilter 2005). The Trident treatment process begins with coagulation by primary and secondary coagulants, commonly polymer and alum. Once coagulants are added, flocculation and clarification occur when the mixture flows upwards through the adsorption/clarifier in the Trident. Particles produced during flocculation adsorb on buoyant plastic media within the adsorption/clarifier. Water is then forced downwards through a multimedia filter with a coarse to fine grade. Media within the filter are anthracite coal, garnet, and sand. Once the water has been filtered, chlorine disinfectant and fluoride is added to finish the water for distribution. The Newark Tridents follow this exact process, and the system was designed to treat up to 40-50 NTU (Zimmerman personal communication 2005).

Chapter 4

METHODOLOGY

The methodology used to determine the relationship between streamflow and turbidity, impervious cover percentage and land use change, and economics of high turbidity are described in this section and summarized below.

1. Geographic Information System (GIS) techniques are used to analyze land use change in the White Clay Creek watershed.
2. Impervious cover analysis based on land use designation is executed using GIS analysis of the White Clay Creek watershed.
3. Baseflow separation is performed on daily average streamflow data from stream gauges above Newark and at the Delaware Park Race Track along the White Clay Creek
4. Turbidity and streamflow regression analyses are calculated on data obtained through baseflow separation calculations.
5. The economics of turbidity treatment and interconnection purchases are analyzed for the Curtis Mill Water Treatment Plant in Newark, Delaware.

4.1 Land Use Analysis

In order to quantify land use changes in the White Clay Creek watershed GIS technology was used to perform the analysis. The University of Delaware, Institute for Public Administration Water Resources Agency (WRA) is in possession of Pennsylvania land use data from 1995 and 2000, and Delaware land use data from 1992, 1997, and 2002. The land use data is divided into thirteen categories for this analysis: single family residential, multi family residential, commercial, industrial, transportation/utility, mixed urban/other, institutional/governmental, recreational, agriculture, rangeland, forestland, water, and wetlands. The thirteen categories are derived from the Anderson Land Use Classification system (Anderson 1976).

ARC GIS software area computation is used to determine the size of each specific land use category within the different data sets. Area changes within specific categories are compared in order to determine the percent composition of each land use within the watershed and trends such as agricultural or forest conversion.

4.2 Impervious Cover Analysis

The amount of impervious cover in the White Clay Creek watershed is determined by the application of coefficients to land use categories. The thirteen land use categories used in ARC GIS land use analysis are each assigned a specific impervious cover coefficient. The impervious cover coefficients are derived from Kauffman (2003). The specific coefficients are as follows in Table 4.1:

Table 4.1 Impervious Cover Coefficients of Land Use Categories

Land Use Category	Impervious Cover Coefficient
Single Family Residential	0.30
Multi Family Residential	0.65
Commercial	0.85
Industrial	0.72
Transportation/Utility	0.9
Mixed Urban/Other	0.5
Institutional/Governmental	0.55
Recreational	0
Agriculture	0
Rangeland	0
Forest	0
Water	0
Wetlands	0

For example, a single family residential community ten acres in size has three acres of impervious cover, or 30 percent impervious.

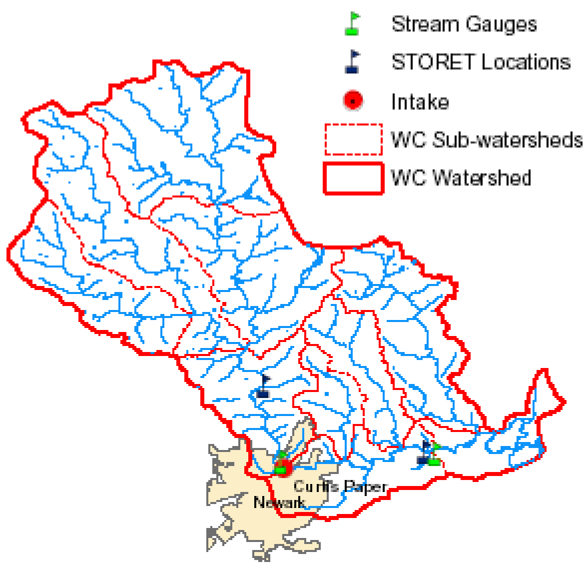
4.3 White Clay Creek Water Quality Analysis

4.3.1 Data Acquisition

Streamflow data was obtained from the USGS NWISWeb and can be found online at www.usgs.gov/water. USGS has streamflow gauges at Newark above the Curtis Mill intake and at the Delaware Park Race Track. Data used to analyze historical water quality of the White Clay Creek was obtained from STORET, the United States Environmental Protection Agency national water quality archive. Data from this archive was pulled specifically for monitoring stations 105151 and 105031. These two locations were chosen because of their locations along the White Clay Creek as depicted below on Map 4.1.

Station 105031 is located above the Newark source water intake on Chambers Rock Road and identifies the quality of the source water to the City of Newark's Curtis Mill Water Treatment Plant. Station 105151 at Delaware Park is located downstream from the Newark intake.

Map 4.1 Water Quality Monitoring Locations Along White Clay Creek



Turbidity data used in the streamflow regression analysis discussed in 5.3.4 was taken from sites 105031 and 105151.

4.3.2 Baseflow Separation

Baseflow separation, also known as hydrograph separation is a hydrograph analysis technique that subtracts the contribution of groundwater from the hydrograph (Viessman 2003). This technique was used to create a direct runoff hydrograph that reflects storm magnitude and intensity. Turbidity events within a stream occur at the onset of rain events, so it was important to remove the groundwater component of the hydrograph in order to determine the exact turbidity/streamflow relationship.

The baseflow separation method used in this research is the fixed interval method (Sloto 1996). The fixed interval method assigns a baseflow value to the lowest value in interval $2N^*$. The interval $2N^*$ is determined through the relationship $N=A^{0.2}$, where A is the area of the watershed. When multiplied by 2, the interval $2N^*$ days becomes the closest odd number to that product (Linsley 1975). For example, in the case of the White Clay Creek at Newark $A = 60.7, N = 2.27, 2N = 4.5, \text{and } 2N^* = 5 \text{ days}$. Table 4.2 shows the results of this equation for the White Clay at Newark and Delaware Park. All three locations observed along the White Clay Creek have the same baseflow interval of 5 days.

Table 4.2 Baseflow Separation Interval Calculation

White Clay Creek Location	**A**	**N**	**2N**	**2N* Days**
Newark	60.7	2.27	4.54	5
Delaware Park	146.4	2.71	5.42	5

4.3.3 Turbidity and Streamflow Relationship Determination

Adequate turbidity data could not be retrieved from the Curtis Mill water treatment plant, so the randomly sampled STORET data from station 105031 had to be used. Once the baseflow separation was performed on streamflow measurements from the Newark source watershed, a regression analysis was performed to determine if there was a relationship between the streamflow and turbidity. The results of this analysis are in section 5.1. The regression analysis showed a strong relationship, and the regression equation was used to extrapolate the missing turbidity data.

4.4 Newark Water Treatment Plant Economic Analysis

Resources used to analyze the economic efficiency of the Curtis Mill water treatment plant at current operating conditions were the 2001-2005 budget and chemical purchase requirements obtained from personal communication with Bill Zimmerman, Water Quality Engineer to the City of Newark. Historical demand data from the United Water Delaware Interconnection was retrieved from WRA records.

The above resources were used in conjunction with the turbidity analysis to determine the number of turbidity events above 20 NTU and the amount of additional water purchased from United Water Delaware during those events. Each turbidity event over 20 NTU resulted in an additional purchase of 0.8 million gallons from United Water Delaware. The 0.8 million gallons was then multiplied by the cost of purchasing water from United Water Delaware as determined from the budgets provided by Bill Zimmerman.

The assigned 0.8 million gallons per turbidity event was determined by averaging the increase in interconnection demand during turbidity events from 2000-2004. Average interconnection demand during normal turbidity levels, 1-10 NTU, is 0.5 million gallons per day, and peaks up to 2.2 million gallons per day during summer turbidity events. The seasonal effect on interconnection demand is an increase in demand during June, July, and August, and a lower demand during the remainder of the year. The demand records were incomplete, so an average 0.8 million gallons per turbidity event was used rather than the exact increase per dated turbidity event.

The current production cost of water during a high turbidity event is the amount of money spent buying a specific amount of water from United Water Delaware, and the production cost of treating water during a high turbidity event at Curtis Mill is the additional chemical cost per day. The additional chemical cost to treat a turbidity event is estimated to be double the cost of daily coagulant usage, shown in table 5.15. The results of this analysis are shown in Tables 5.12, 5.13, 5.14, and 5.16 for 20 NTU, 40 NTU, and the events between 20 NTU and 40 NTU.

A second analysis of the turbidity events surrounds revenue to the Newark Water Department for every 1000 gallons of water they need to purchase rather than produce. This analysis incorporates the price of water, additional cost of chemically treating the turbidity event, and cost of purchasing water from United Water Delaware. The revenue analysis was performed on the streamflow and turbidity relationships dictated by the results in sections 5.4.1 and 5.4.2 for both the White Clay Creek at Newark and the White Clay Creek at Delaware Park.

Chapter 5

RESULTS AND DISCUSSION

Chapter five presents the results of the turbidity, land use change, impervious cover, and economic analysis obtained from the methodology of the previous chapter. Listed below is a summary of results.

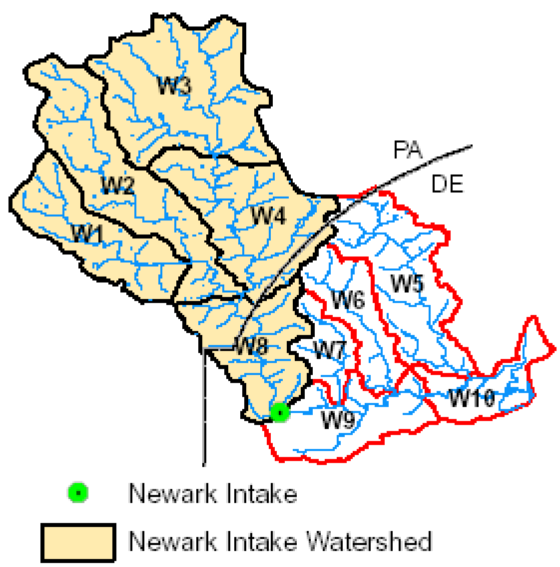
1. The most prevalent land use change is the transition of agricultural and forested land to single family residential areas.
2. Impervious cover of the Newark source water area is 11 percent and the rate of increase is one half percent per year.
3. The Curtis Mill Water Treatment Plant is sensitive to stream turbidity levels, which increase during precipitation events.
4. The cost of treating high turbidity water is cheaper than purchasing water from the United Water Delaware Interconnection during high turbidity events.

5.1 Newark Source Water Area

The municipal water supply for the city of Newark is withdrawn from the White Clay Creek at the Curtis Mill water treatment plant. The area of the Newark source water area is 69 square miles. The source water area for the Curtis Mill water treatment plant is shown on Map 5.1. The Newark source water portion of the White Clay Creek watershed is W1, W2, W3, W4, and W8.

Map 5.1 Newark Source Water Area

W1 West Branch
W2 Middle Branch
W3 E. Br. Above Avondale
W4 E. Br. Below Avondale
W5 Mill Creek
W6 Pike Creek
W7 Middle Run
W8 Main Stem Above Newark
W9 Main Stem Above Del. Park
W10 Main Stem at Churchman's Marsh



5.2 Newark Source Water Land Use Analysis

The analysis of land use change in the Delaware portion of the Newark source watershed focuses on 8.4 square miles, and the 60.7 square mile Pennsylvania section of the watershed, shown above on Map 5.1. Each GIS data set used provided a slightly different total area for the Delaware and Pennsylvania areas, 8.4 and 61 square miles are averages.

5.2.1 Delaware Land Use Change

Table 5.1 below shows the land use category break down of the Delaware portion of the Newark source water area. Land use in the Delaware section is predominantly forest; this is due to the 3373 acre White Clay Creek State Park (Kauffman 2003). The White Clay Creek State Park becomes the White Clay Creek Preserve at the Pennsylvania border, and the system is up to 5000 acres of protected forestland.

Table 5.1 Land Use Divisions within the Delaware Portion of the Newark Source Watershed

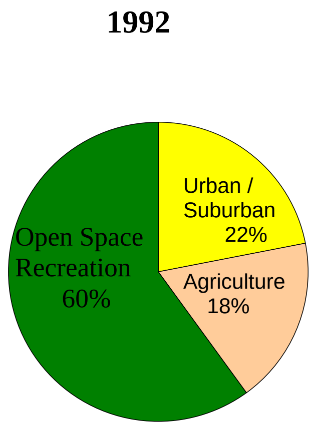
	DE 1992		**DE 1997**		**DE 2002**	
	Square Miles	**% Comp.**	**Square Miles**	**% Comp.**	**Square Miles**	**% Comp.**
Single Family Residential	1.31	15.46	1.57	21.88	1.78	20.77
Multi Family Residential	0.03	0.32	0.05	0.70	0.05	0.58
Commercial	0.20	2.33	0.20	2.79	0.18	2.10
Industrial	0.02	0.20	0.02	0.24	0.05	0.58
Utility/Transportation	0.00	0.00	0.00	0.04	0.00	0.05
Mixed Urban	0.16	1.89	0.19	2.67	0.13	1.47
Institutional/Governmental	0.08	0.97	0.08	1.18	0.10	1.17
Recreational	0.31	3.68	0.32	4.45	0.36	4.20
Agriculture	1.44	17.01	1.40	16.53	1.34	15.64
Rangeland	0.10	1.20	0.12	1.71	0.10	1.17
Forest	4.57	53.97	4.39	61.21	4.34	50.65
Water	0.10	1.16	0.07	0.95	0.08	0.98
Wetlands	0.04	0.52	0.04	0.62	0.05	0.63
Barren	0.11	1.30	0.01	0.10	0.00	0.00
Total Values	**8.47**	**100**	**7.18**	**100**	**8.57**	**100**

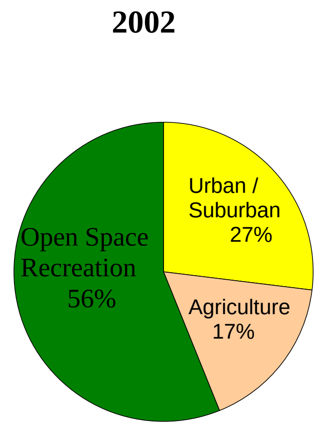
The second largest land use in the Delaware portion of the Newark source watershed is single family residential housing. Agricultural practice is the third largest land use. Table 5.3 shows the percentage change in composition of each land use between 1992 and 2002

Tables 5.1 and 5.3 show the trend of forest and agricultural conversion into residential property. The increase in single family residential housing was 5.3 percent over ten years, while agricultural and forestland decreased by 4.7 percent. This conversion is significant because the single family residential land has a higher impervious cover coefficient of 30 percent compared to agricultural and forestland with a 0 percent impervious cover coefficient.

To summarize, the percent composition of urban/suburban, agriculture, and wooded/open space land use changes from 1992 to 2002 within the 8.4 square miles of the Delaware portion is shown in Figure 5.1.

Figure 5.1 Delaware Land Use Change





5.2.2 Pennsylvania Land Use Change

Table 5.2 shows the area of specific land use designations within the Pennsylvania section of the White Clay Creek watershed. Land use in the Pennsylvania section of the White Clay Creek watershed above the Newark intake is predominantly agricultural, at nearly 50 percent of the area. The second highest land use is forest, and closely followed by single family residential.

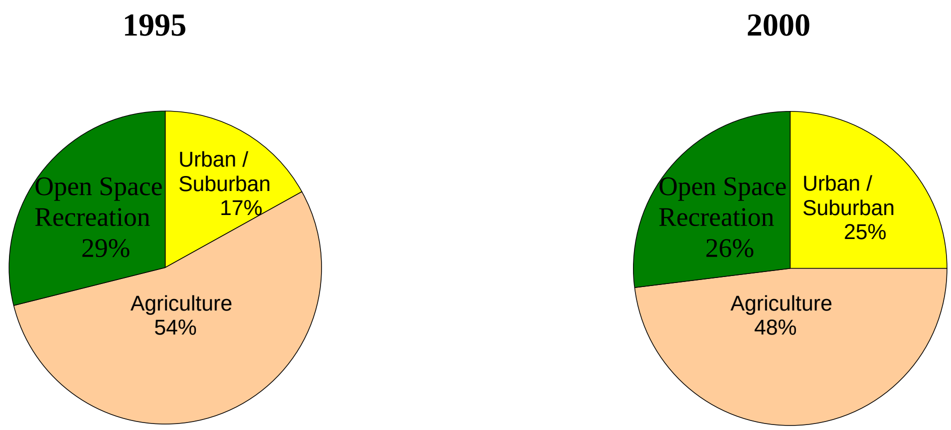
Table 5.2 Land Use Divisions within the Pennsylvania Portion of the Newark Source Watershed

	PA 1995		PA 2000	
Land Use Categories	**Square Miles**	**% Comp.**	**Square Miles**	**% Comp.**
Single Family Residential	8.44	13.73	12.37	20.05
Multi Family Residential	0.00	0.00	0.13	0.20
Commercial	0.46	0.75	0.85	1.38
Industrial	0.10	0.17	0.16	0.26
Utility/Transportation	0.68	1.11	0.59	0.96
Mixed Urban	0.00	0.00	0.00	0.00
Institutional/Governmental	0.16	0.26	0.28	0.45
Recreational	0.30	0.49	0.81	1.32
Agriculture	33.00	53.67	29.56	47.90
Rangeland	0.00	0.00	0.00	0.00
Forest	16.60	27.00	14.57	23.61
Water	0.35	0.57	0.39	0.63
Wetlands	0.70	1.14	1.00	1.62
Barren	0.70	1.14	1.00	1.62
Total Values	**61.49**	**100**	**61.71**	**100**

The main difference in land use between the Delaware and Pennsylvania sections is the predominance of agriculture. 48 percent of the Pennsylvania section is agriculture while Delaware is 17 percent. Agricultural land is often sold when the farms denigrate in value and loose productivity. The common trend shown through this land use analysis is the conversion of agricultural land to single family residential property.

The summary analysis of land use change in the Pennsylvania portion of the Newark source watershed within the White Clay Creek watershed is displayed below in Figure 5.2.

Figure 5.2 Pennsylvania Land Use Change



The percent changes in land use composition in the Pennsylvania and Delaware sections of the Newark source watershed with the White Clay Creek watershed are displayed in Table 5.3. Agricultural land in Pennsylvania has fallen 5.8 percent in just five years. That is the conversion of four square miles over 5 years, or 0.8 miles per year. Considering the impervious coefficient of single family residential property is 0.3 and that of agriculture is zero, agricultural preservation efforts need to be taken by Pennsylvania authorities to prevent water quality degradation. At the current pace of conversion by 2020 an additional 16 square miles of farmland will be replaced, or half of the current agricultural area.

Forest preservation must also become a priority within Pennsylvania sections of the White Clay Creek watershed. Since 1995 forest has decreased by 3.4 percent, or 2 square miles. At this pace by 2020 an additional 8 square miles could be converted, which is half of the current forest area.

Table 5.3 Land Use Change in the Delaware and Pennsylvania Portions of the Newark Source Watershed.

Land Use Category	**2002 DE Square Miles**	**Delaware % Change 1992-2002**	**2000 PA Square Miles**	**Pennsylvania % Change 1995-2000**
Single Family Residential	1.78	5.32	12.37	6.32
Multi Family Residential	0.05	0.26	0.13	0.20
Commercial	0.18	-0.23	0.85	0.63
Industrial	0.05	0.38	0.16	0.10
Utility/Transportation	0.004	0.05	0.59	-0.15
Mixed Urban	0.13	-0.42	0.00	0.00
Institutional/Governmental	0.1	0.20	0.28	0.19
Recreational	0.36	0.52	0.81	0.83
Agriculture	1.34	-1.37	29.56	-5.77
Rangeland	0.1	-0.04	0.00	0.00
Forest	4.34	-3.31	14.57	-3.39
Water	0.08	-0.18	0.39	0.06
Wetlands	0.05	0.11	1.00	0.48
Barren	0	-1.30	1.00	0.48

5.3 Newark Source Water Impervious Cover Analysis

In order to measure impervious cover change, the area values from Tables 5.1 and 5.2 were multiplied by the impervious cover coefficients given in Chapter 4, Section 4.2, Table 4.1. The results from these calculations are in Table 5.4 and Table 5.5 which show the square miles of impervious cover per land use designation and the percent contribution to the watershed in Pennsylvania and Delaware. A summary graph is presented in Figure 5.3 that shows the calculated impervious cover percentages, and estimated current and past values based on the rates of change in the combined Delaware and Pennsylvania portions of the Newark source watershed.

5.3.1 Delaware Impervious Cover Change

Table 5.4 Impervious Cover of the Delaware Portion of the Newark Source Water Area

	DE 1992		DE 1997		DE 2002	
Land Use Category	**Square Miles**	**% IC**	**Square Miles**	**% IC**	**Square Miles**	**% IC**
Single Family Residential	0.4	4.7%	0.4	4.7%	0.5	6.3%
Multi Family Residential	0.02	0.2%	0.02	0.2%	0.03	0.4%
Commercial	0.2	2%	0.2	2%	0.2	2%
Industrial	0.01	0.2%	0.01	0.2%	0.04	0.4%
Utility/Transportation	0.0	0.0%	0.0	0.02%	0.004	0.04%
Mixed Urban	0.1	1%	0.1	1%	0.06	0.7%
Institutional/Governmental	0.05	0.5%	0.05	0.5%	0.06	0.7%
Recreational	0.0	0.0%	0.0	0.0%	0.0	0.0%
Agriculture	0.0	0.0%	0.0	0.0%	0.0	0.0%
Rangeland	0.0	0.0%	0.0	0.0%	0.0	0.0%
Forest	0.0	0.0%	0.0	0.0%	0.0	0.0%
Water	0.0	0.0%	0.0	0.0%	0.0	0.0%
Wetlands	0.0	0.0%	0.0	0.0%	0.0	0.0%
Barren	0.01	0.1%	0.01	0.1%	0.0	0.0%
Total Values	**0.7**	**8.7%**	**0.7**	**8.7%**	**0.9**	**10.5%**

The total impervious value of the Delaware portion of the Newark source water area is 10.5 percent. Imperviousness has increased from 8.7 percent in 1992 to the current 10.5 percent in 2002. This increase is 0.2 percent per year. The majority of the impervious contribution is in the single family residential land use designation.

5.3.2 Pennsylvania Impervious Cover Change

The Pennsylvania portion of the Newark source water area has seen the most significant conversions in land use designation. Table 5.5 shows the amount of impervious cover associated with those changes. The current Pennsylvania portion of the Newark source water area is 8.6 percent impervious. Impervious cover has increased from 6.1 percent to 8.6 percent in five years at an increase of 0.5 percent per year

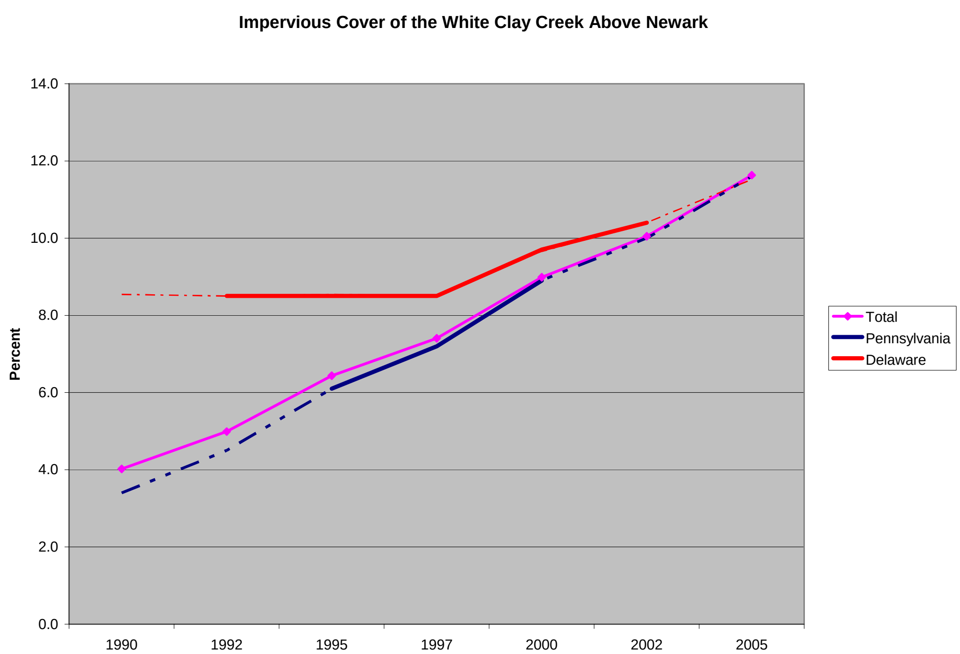
Table 5.5 Impervious Cover of the Pennsylvania Portion of the Newark Source Water Area

	PA 1995		**PA 2000**	
Land Use Category	**Square Miles**	**% IC**	**Square Miles**	**% IC**
Single Family Residential	2.5	4.2%	3.7	6.1%
Multi Family Residential	0.0	0.0%	0.1	0.1%
Commercial	0.4	0.6%	0.7	1.2%
Industrial	0.1	0.1%	0.1	0.2%
Utility/Transportation	0.6	1%	0.5	0.9%
Mixed Urban	0.0	0.0%	0.0	0.0%
Institutional/Governmental	0.1	0.1%	0.2	0.25%
Recreational	0.0	0.0%	0.0	0.0%
Agriculture	0.0	0.0%	0.0	0.0%
Rangeland	0.0	0.0%	0.0	0.0%
Forest	0.0	0.0%	0.0	0.0%
Water	0.0	0.0%	0.0	0.0%
Wetlands	0.0	0.0%	0.0	0.0%
Barren	0.04	0.06%	0.05	0.08%
Total Values	**3.7**	**6.1%**	**5.4**	**8.6%**

Combining the results of the impervious cover analysis, the total impervious cover in the Newark source water area is 9 percent using 2000 Pennsylvania data and 2002 Delaware data. The fastest increases are in Pennsylvania and occur during the conversion of agricultural and forested areas to single family residential housing. A conversion rate of 0.5 percent per year has been occurring in Pennsylvania for the last five years, and will likely continue given the abundance of agricultural land available for conversion.

The impervious cover growth rates can be used to extrapolate what the current impervious cover values in 2005 are. Figure 5.3 shows that estimated total 2005 impervious cover is 11 percent. Nearly ninety (88) percent of the Newark source area watershed is in Pennsylvania where the majority of impervious cover increases and the fastest conversion rate is found. Impervious cover increase in the Delaware portion of the Newark source water area has been slow because Delaware has fewer agricultural areas and the forestland it does have within the source water area is protected.

Figure 5.3 Impervious Cover Calculated and Estimated Values



Above: Solid lines represent calculated values, dashed lines represent estimated values

The total combined impervious area of the Newark source water area using a combination of the most recent 2002 Delaware data and the 2000 Pennsylvania data is 9 percent. The estimated 2005 impervious cover value is 11 percent.

Table 5.6 Impervious Cover Summary

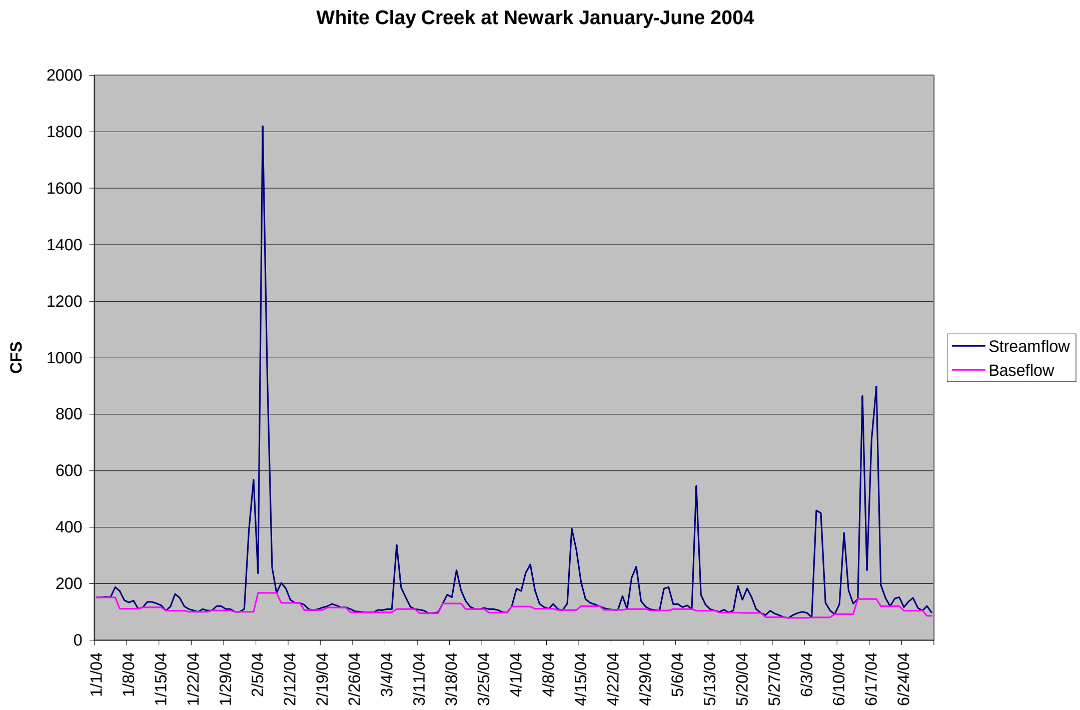
State	**Year**	**Impervious Cover**
Delaware	1992	8.7%
	1997	8.7%
	2002	10.5%
Pennsylvania	1995	6.1%
	2000	8.6%
Total 2005 estimated watershed impervious cover 11 percent		

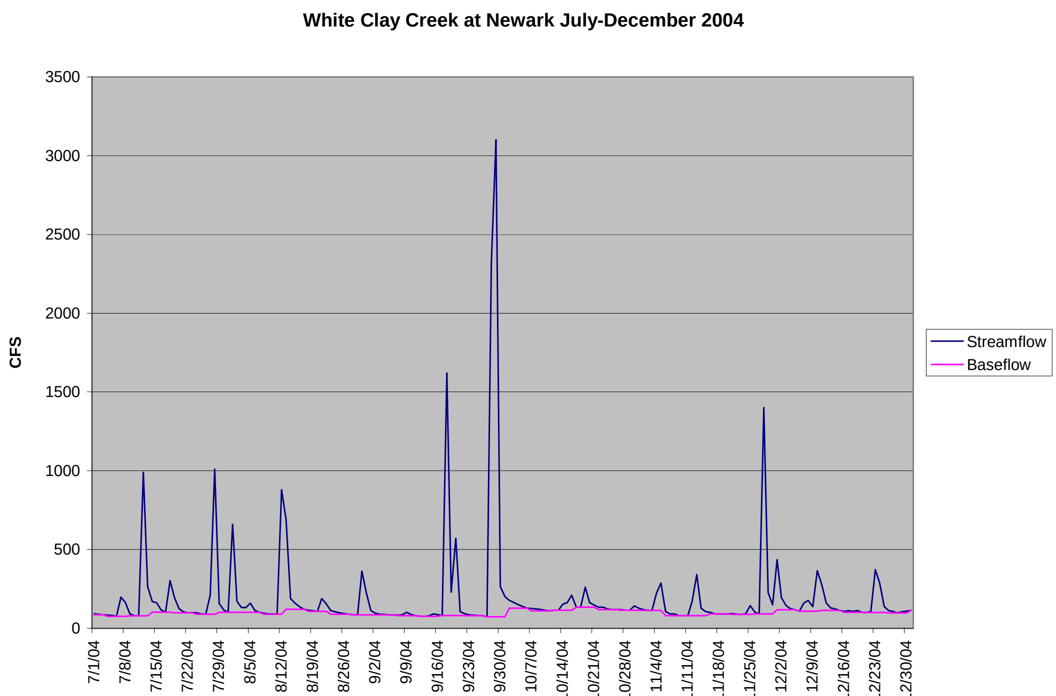
5.4 Turbidity and Streamflow Results

This section contains the graphed results of the baseflow adjustment, regression analysis, and turbidity calculations. Baseflow adjustment was performed in order to remove the contribution of groundwater from the hydrograph. The removal of baseflow makes it possible to establish the amount of streamflow contributed by surface water runoff. It is runoff that is responsible for causing turbidity variations during precipitation events, and it is this relationship that will be investigated through a regression analysis. Results from the regression analysis are used to calculated turbidity measurements at the White Clay Creek above Newark and at Delaware Park Race Track.

Figure 5.4 shows the most recent baseflow adjustment at the White Clay Creek above Newark, the remaining years at Newark and Delaware Park are graphed and included in Appendices A and B. Appendices A and B also contain the tabled data of the adjustment for Newark and Delaware Park.

Figure 5.4 Baseflow Adjustment White Clay Creek at Newark 2004





5.4.1 White Clay Creek at Newark Regression Analysis

Figure 5.5 is a graph of the baseflow adjusted streamflow, or runoff, versus STORET turbidity measurements. Regression analysis was performed to determine if a relationship existed between the turbidity measurements and the runoff. A regression analysis represents the amount of variance in one variable due to another that can be accounted for , where in a perfect regression $R^2 = 1$ and in a poor regression $R^2 = 0$.

The R^2 value = 0.8251, signifying a strong linear relationship. The equation $y = 6.1896x - 19.806$ was used to extrapolate missing turbidity data from 2000-2004. Appendix A contains all of the extrapolated turbidity measurements from 2000-2004. The data contained in Appendix A was used to determine how many days the turbidity of the White Clay Creek surpassed 20 NTU and 40 NTU and is graphed in the following pages. 20 NTU was noted because it is the current operating capacity of the Curtis Mill water treatment plant, and 40 NTU was chosen as a possible future operating capacity for the Curtis Mill plant.

Figure 5.5 White Clay Creek at Newark Regression Analysis

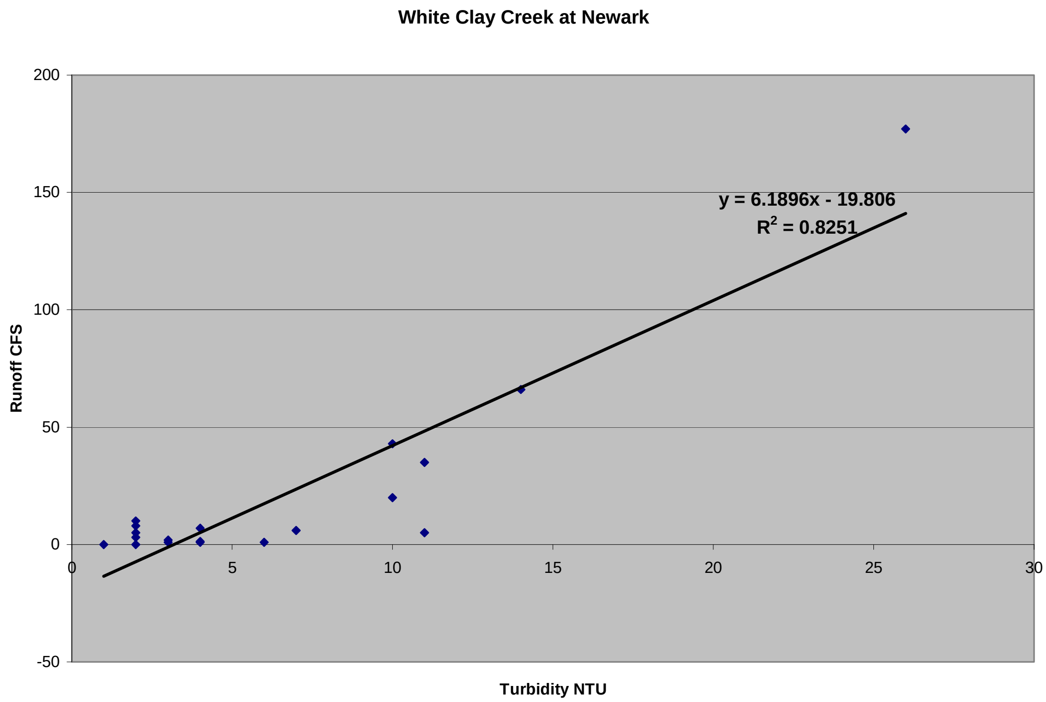
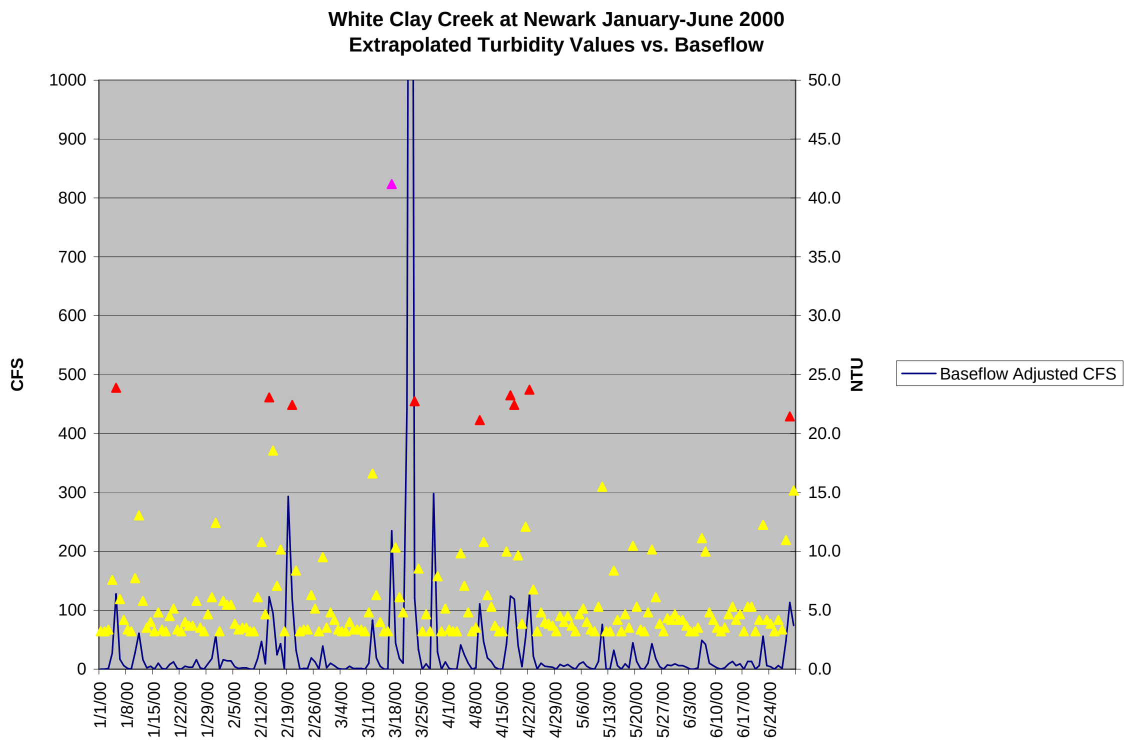


Figure 5.6 White Clay Creek at Newark 2000 Turbidity Values



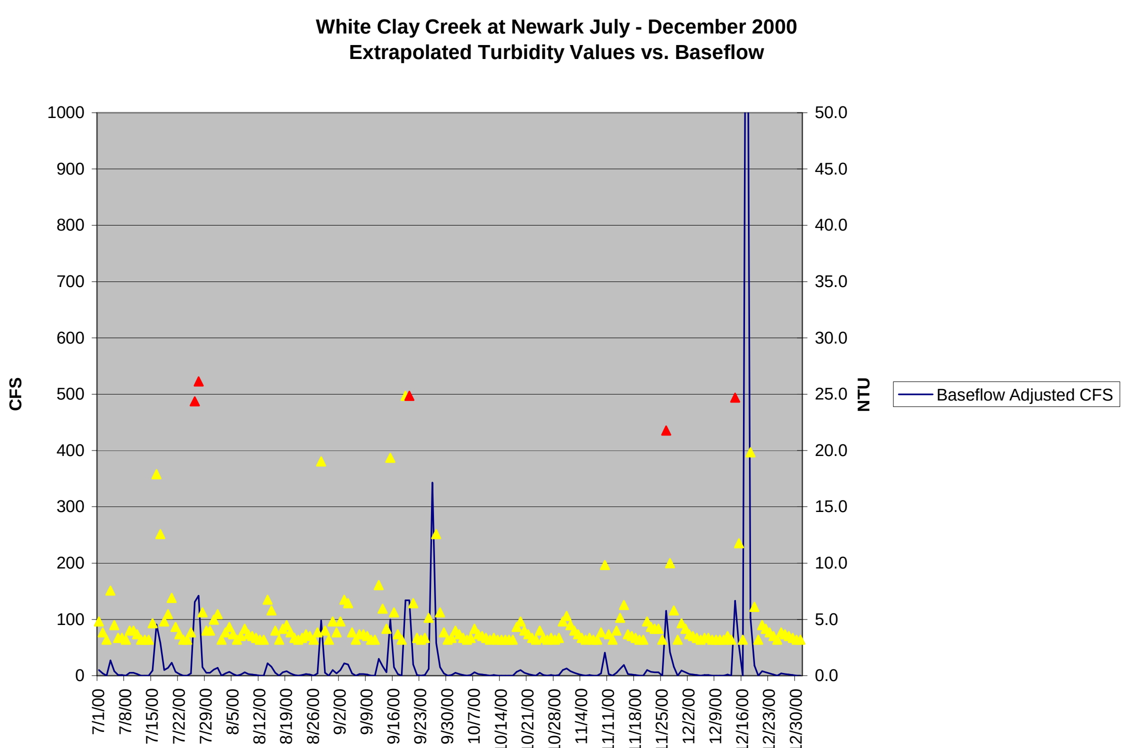
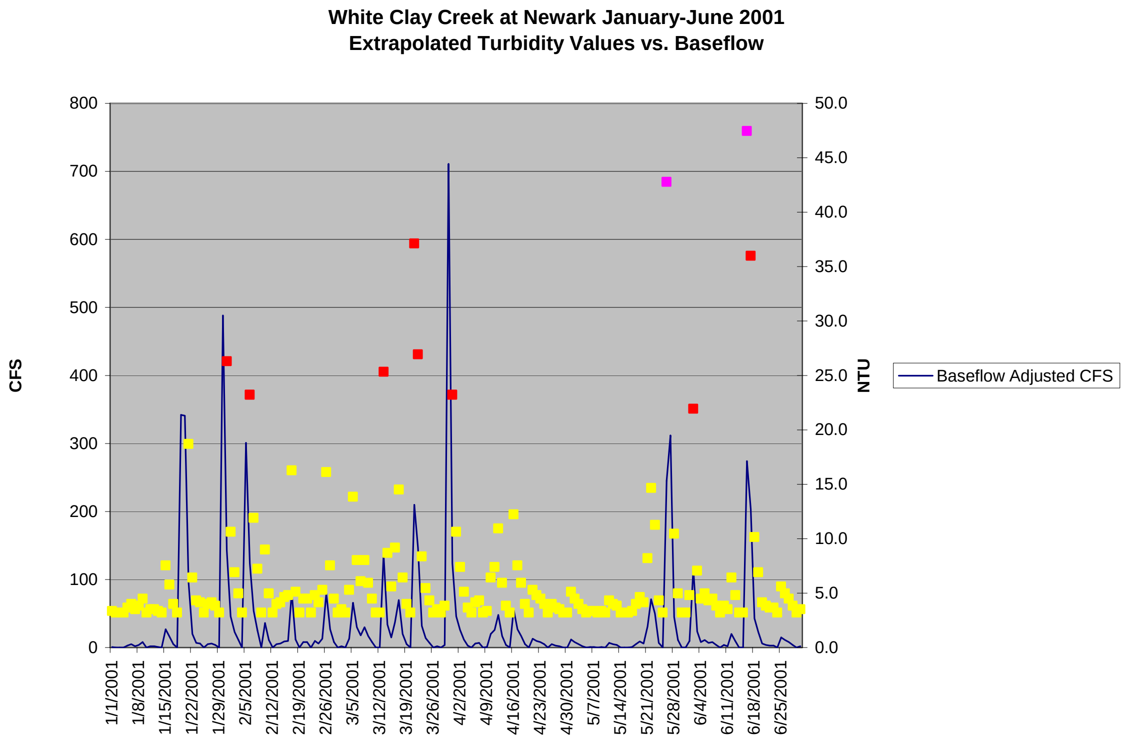


Figure 5.7 White Clay Creek at Newark 2001 Turbidity Values



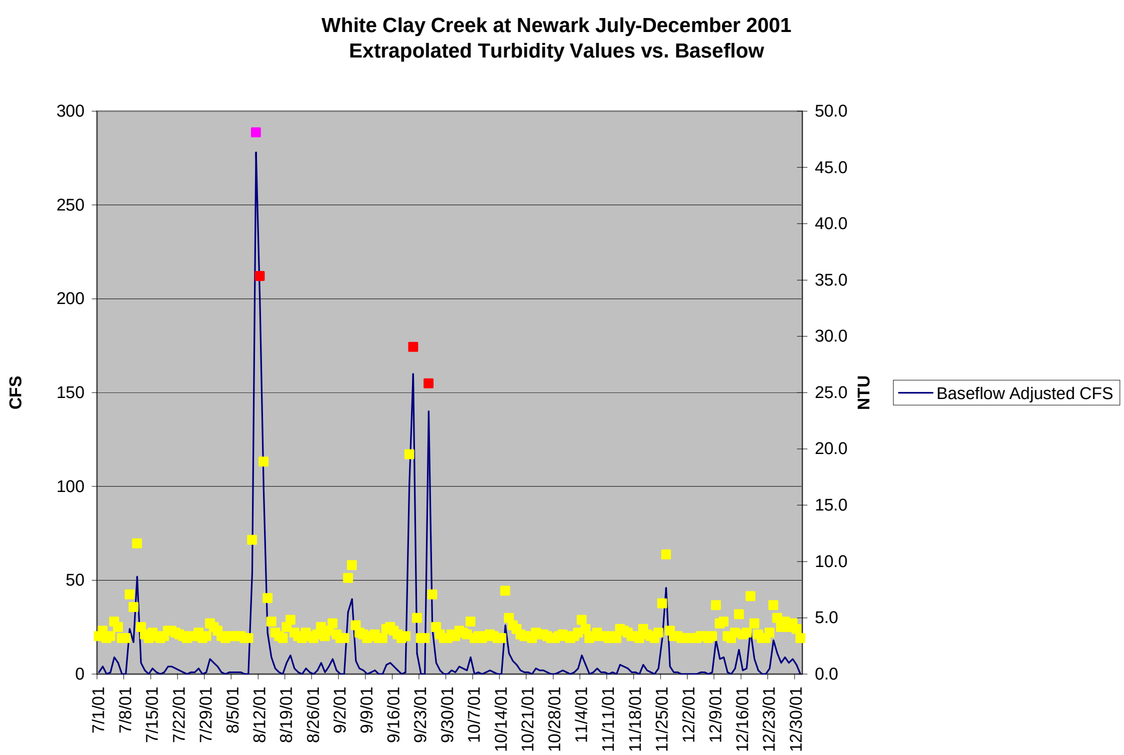
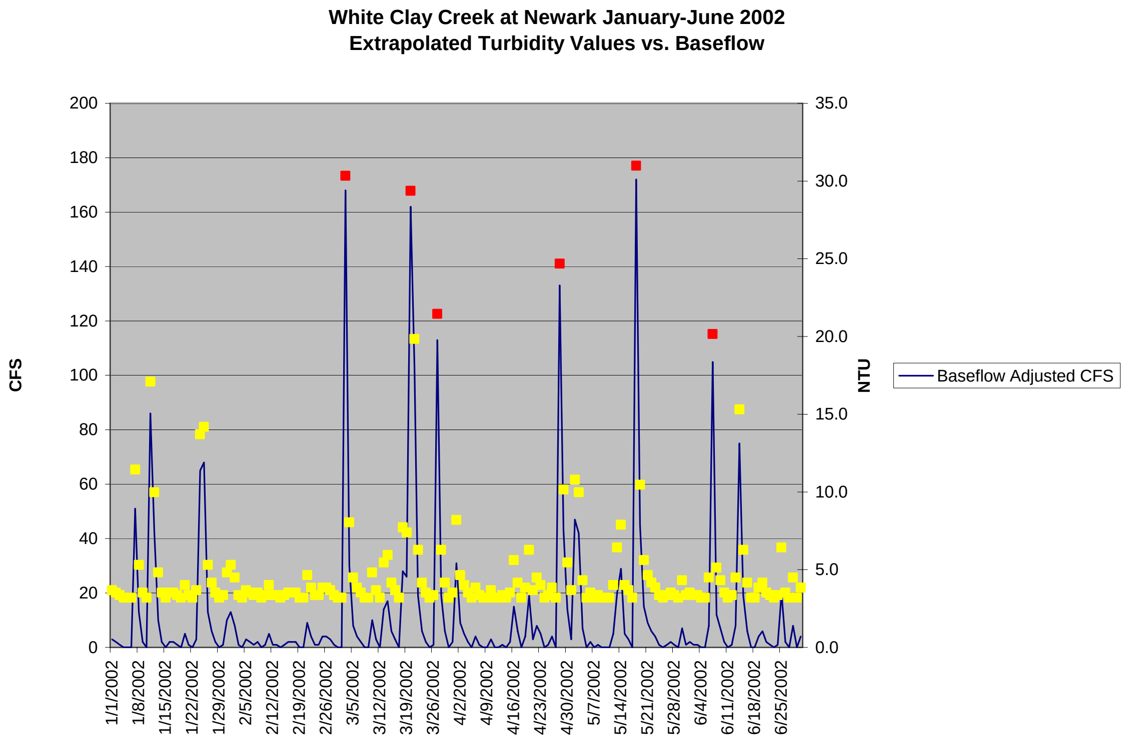


Figure 5.8 White Clay Creek at Newark 2002 Turbidity Values



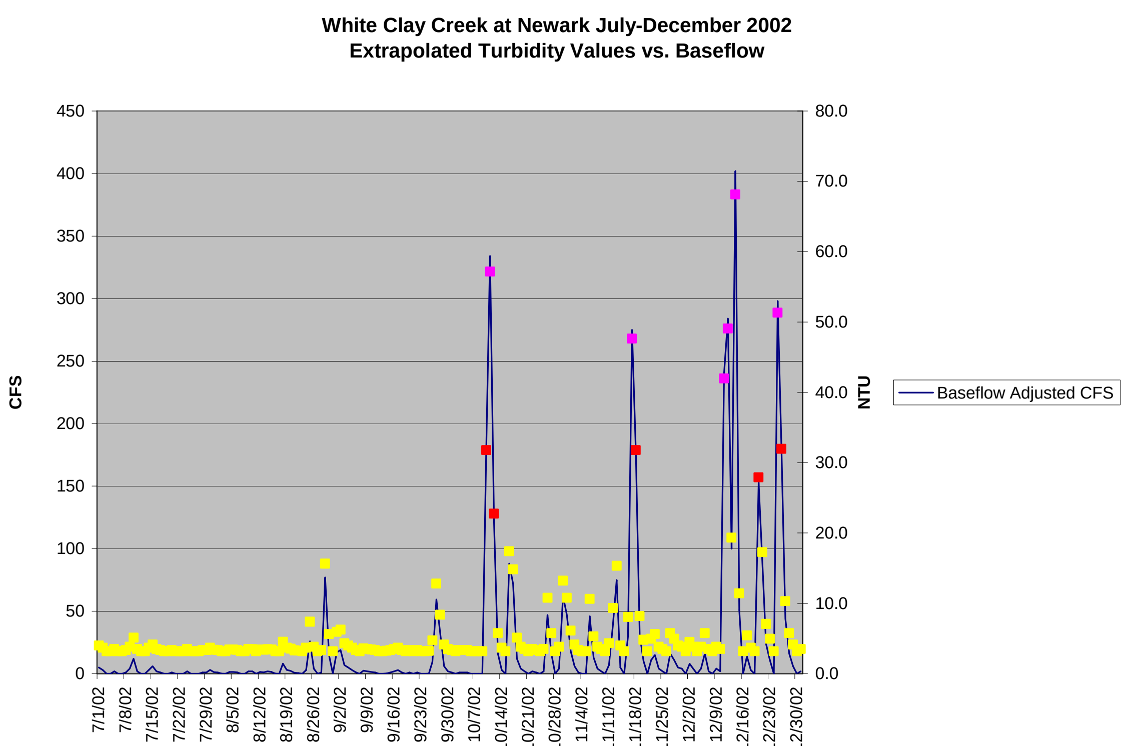
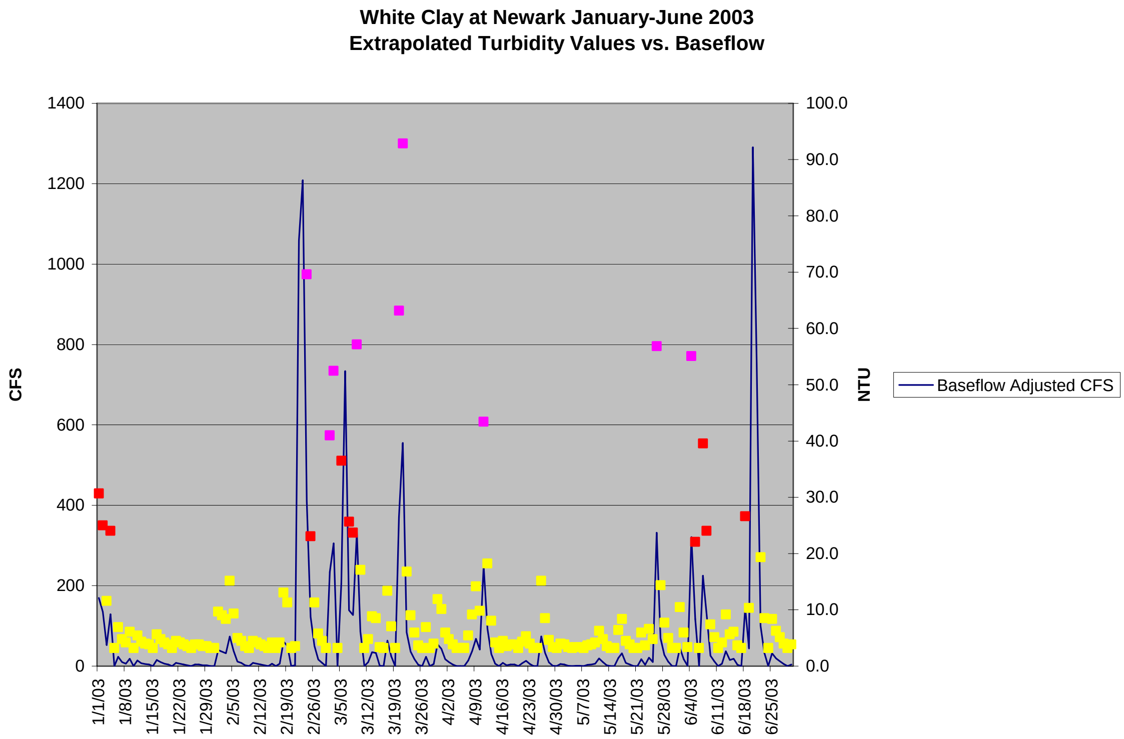


Figure 5.9 White Clay Creek at Newark 2003 Turbidity Values



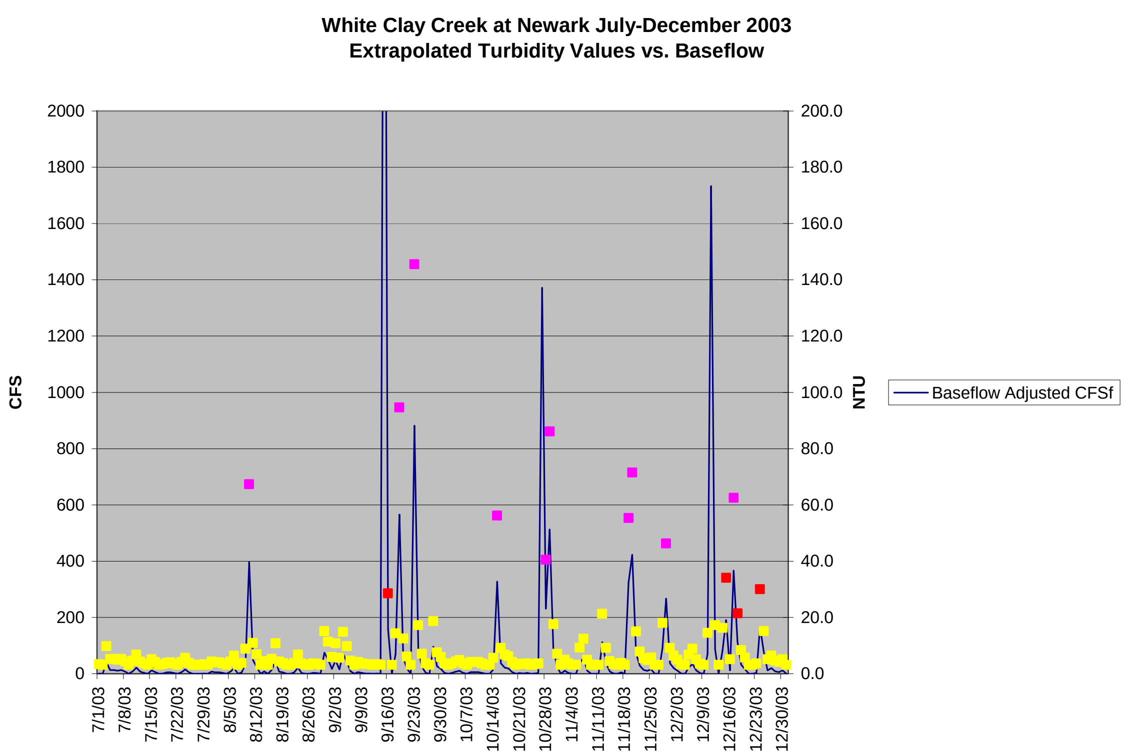
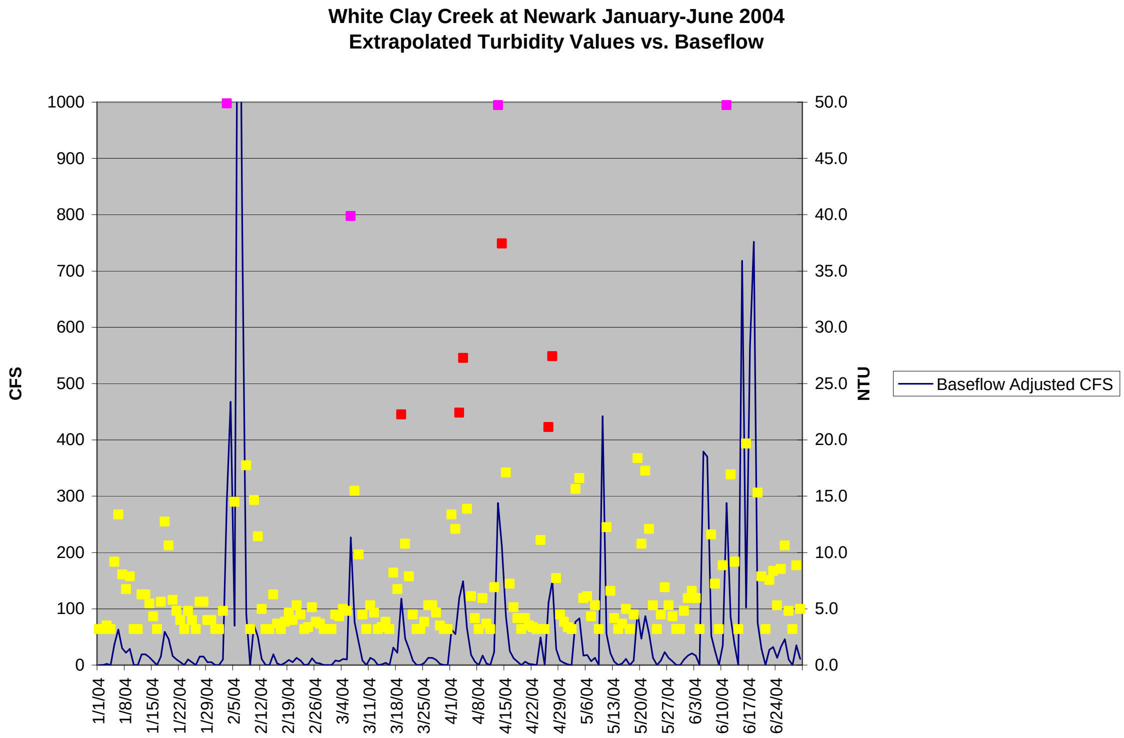
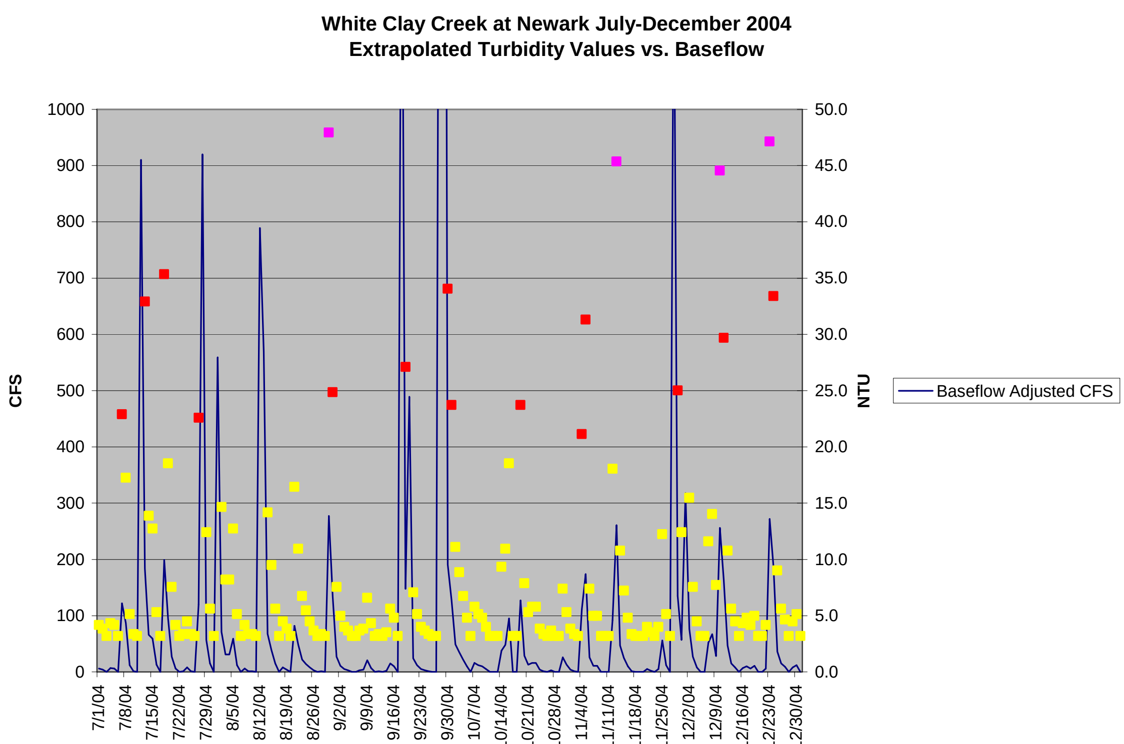


Figure 5.10 White Clay Creek at Newark 2004 Turbidity Values



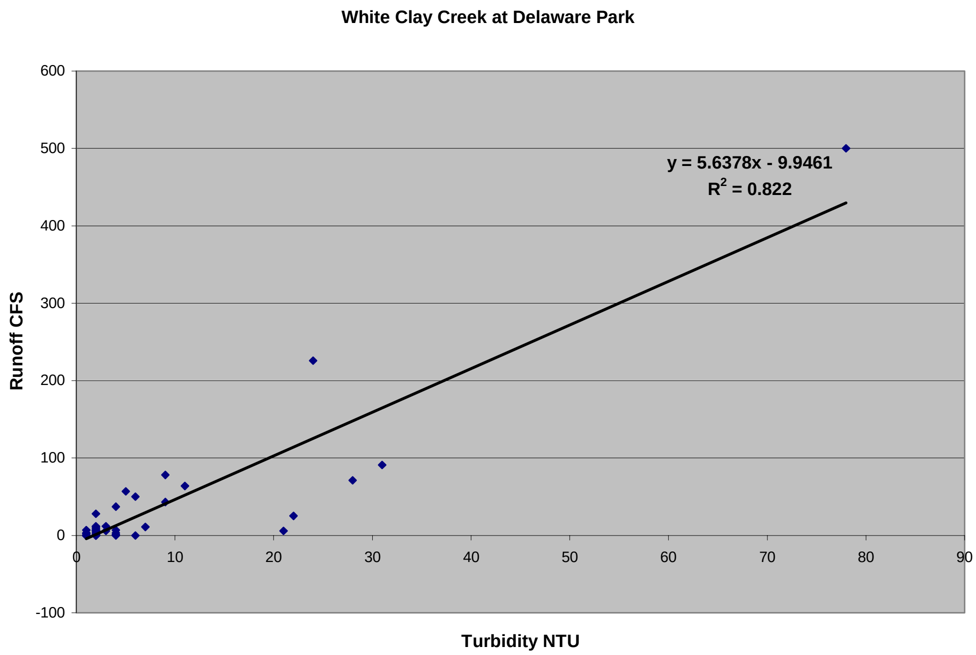


5.4.2 White Clay Creek at Delaware Park Regression Analysis

The regression analysis of turbidity and runoff for the White Clay Creek at Delaware Park is shown in Figure 5.11. This analysis is similar to the analysis performed on the White Clay Creek above Newark location. The results of these analyses will calculate the turbidity measurements of the White Clay Creek in two areas distinctive from one another by impervious cover and over all watershed health. The White Clay Creek watershed above Newark is 11 percent impervious cover and in good health, while the White Clay Creek watershed at Delaware Park is of average health, and impervious cover was 13 percent in 2002 and higher in 2005 (Kauffman 2003).

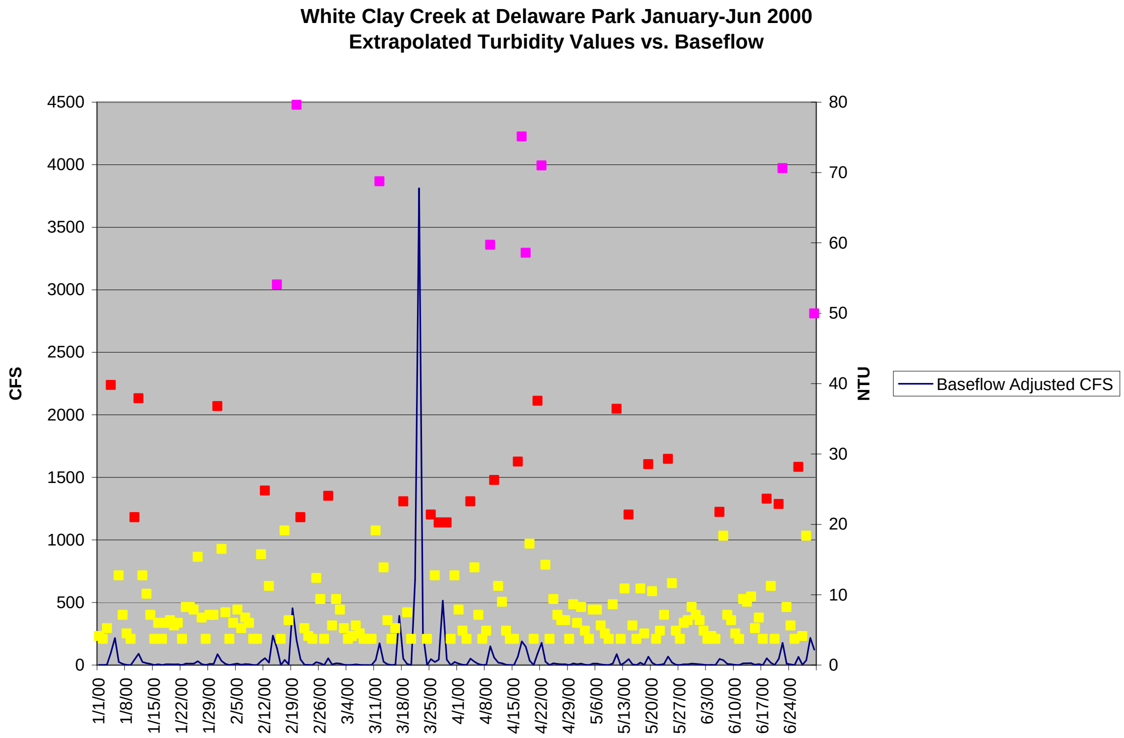
Following the graphed results of the regression analysis of the White Clay Creek at Delaware Park is a summary of turbidity calculations from the White Clay Creek above Newark and at Delaware Park. These numbers will be applied to the methodology discussed in Chapter 4, Section 4.4 to determine the cost of purchasing water during high turbidity events over the five years studied.

Figure 5.11 White Clay Creek at Delaware Park Regression Analysis



Data used in Figure 5.11 was taken from the STORET water quality archive and USGS streamflow data after baseflow adjustment. $R^2 = 0.822$ and shows a strong linear relationship between turbidity and runoff. The equation $y = 5.6378x - 9.9461$ was used to extrapolate turbidity levels for 2000-2004. The results of this analysis were used to determine the number of times that turbidity surpassed both 20 NTU and 40 NTU. The values of turbidity and runoff at this site can be found in Appendix B. The following pages show the graphical representation of these results.

Figure 5.12 White Clay Creek at Delaware Park 2000 Turbidity Values



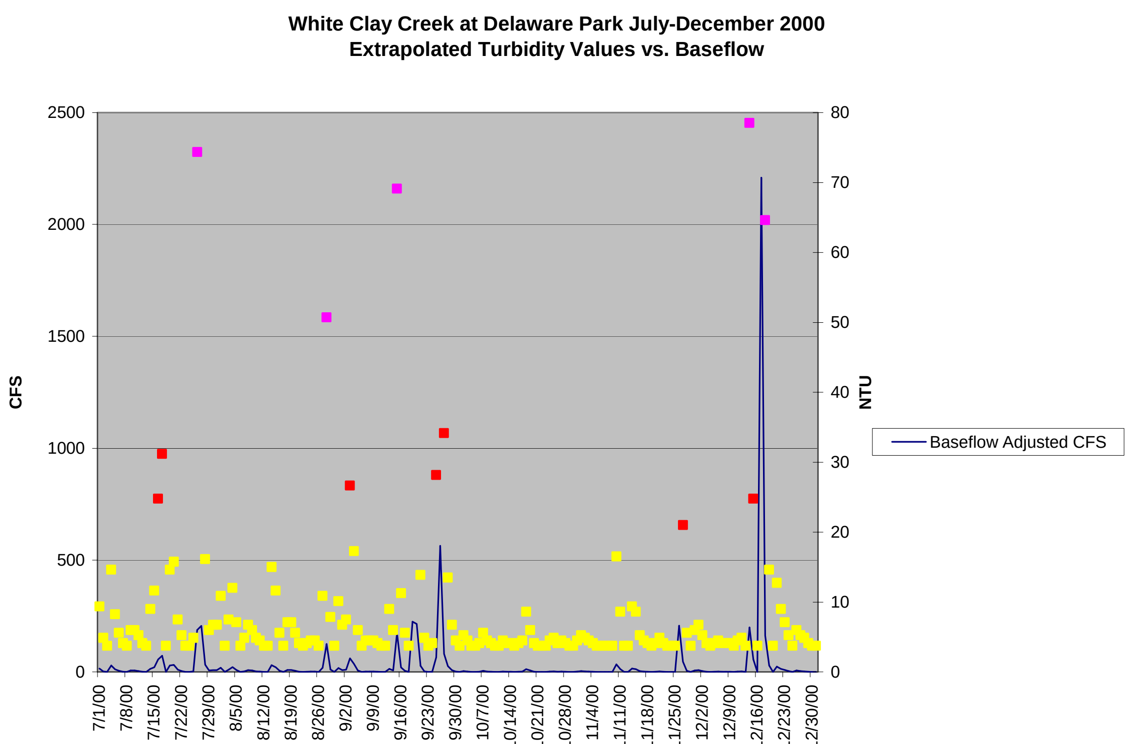
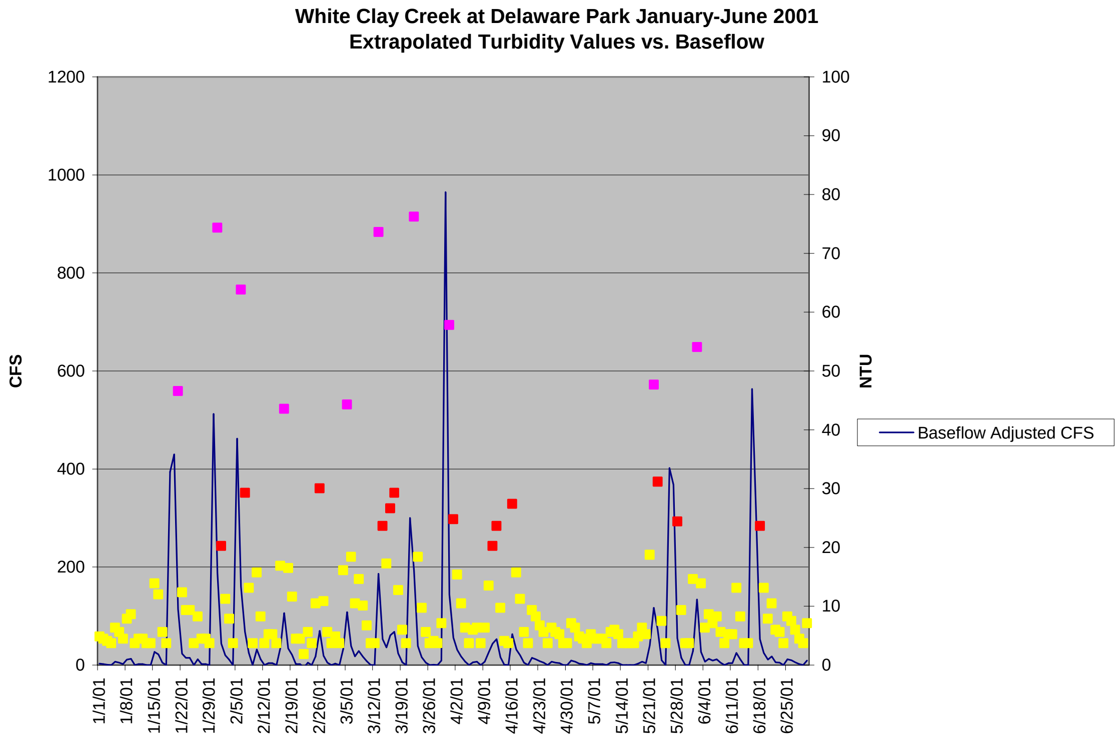


Figure 5.13 White Clay Creek at Delaware Park 2001 Turbidity Values



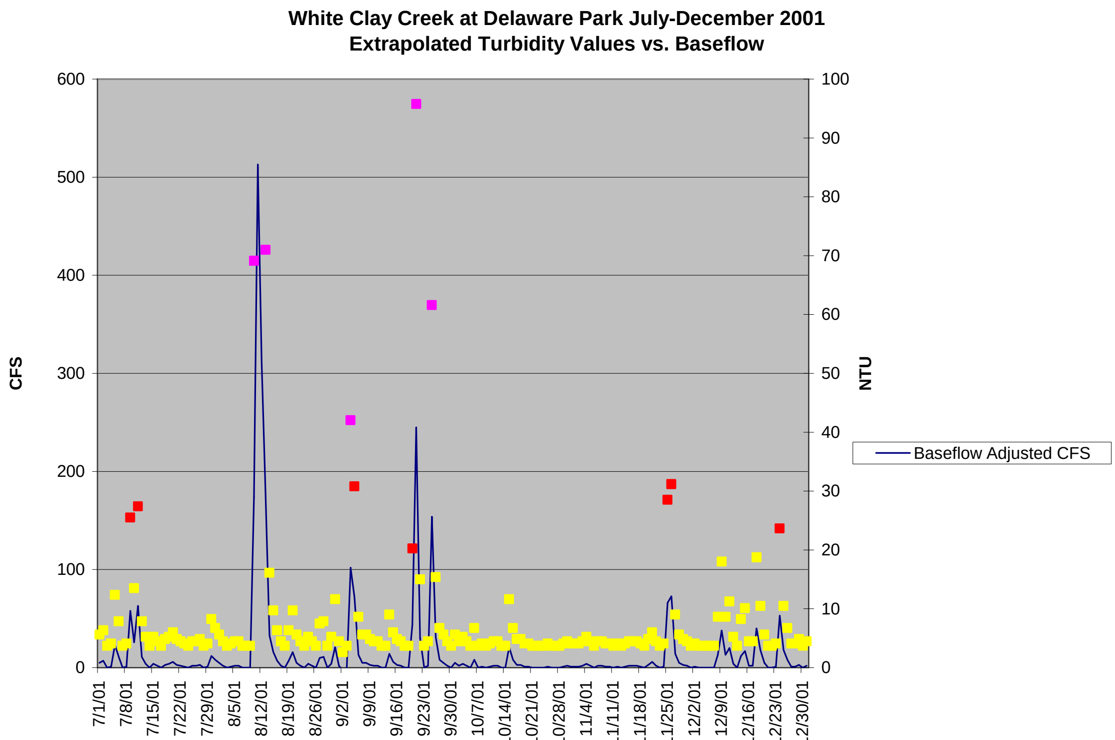
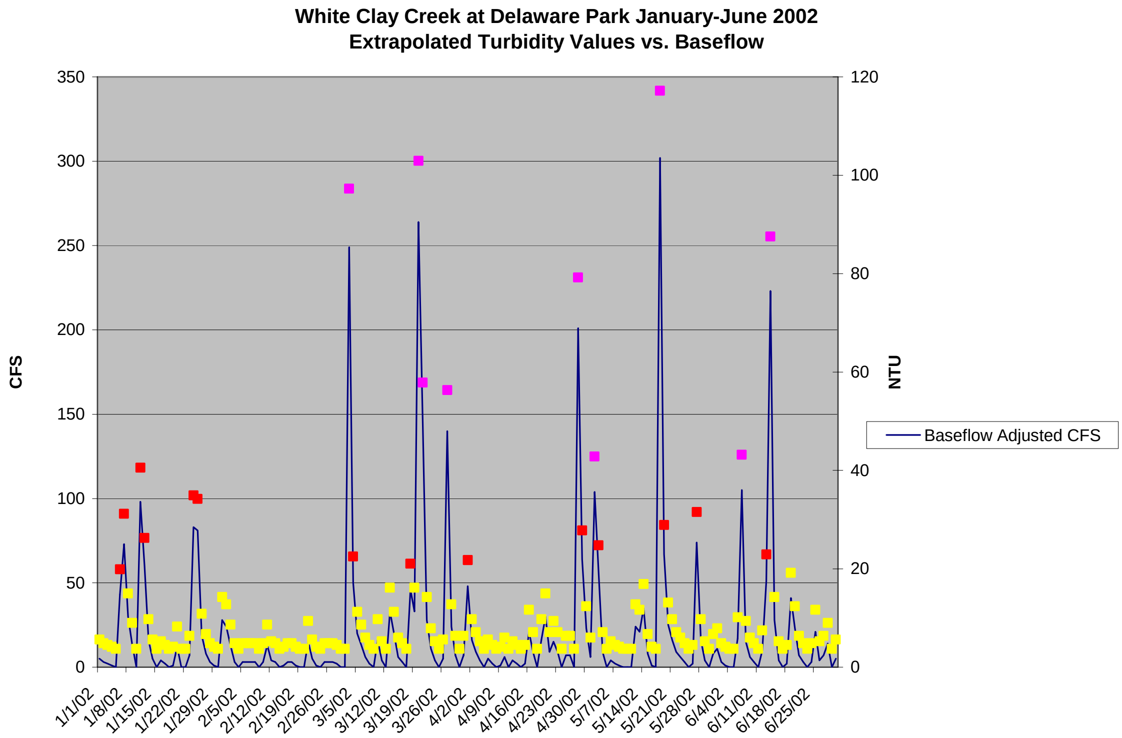


Figure 5.14 White Clay Creek at Delaware Park 2002 Turbidity Values



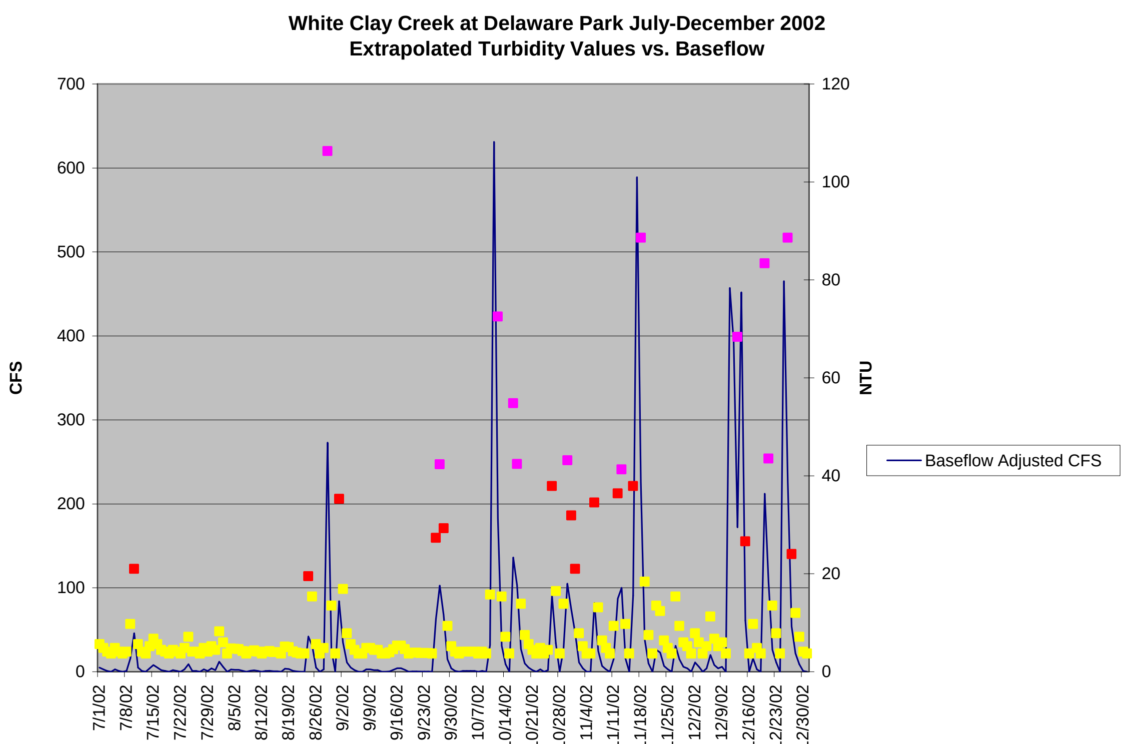
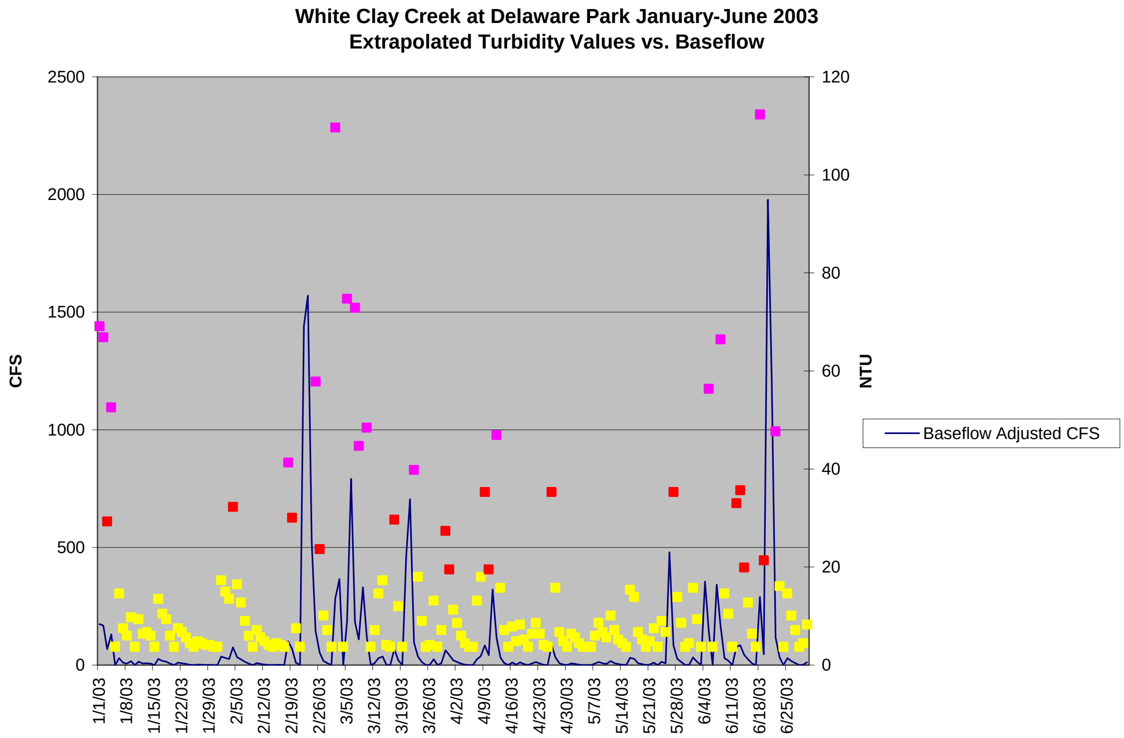


Figure 5.15 White Clay Creek at Delaware Park 2003 Turbidity Values



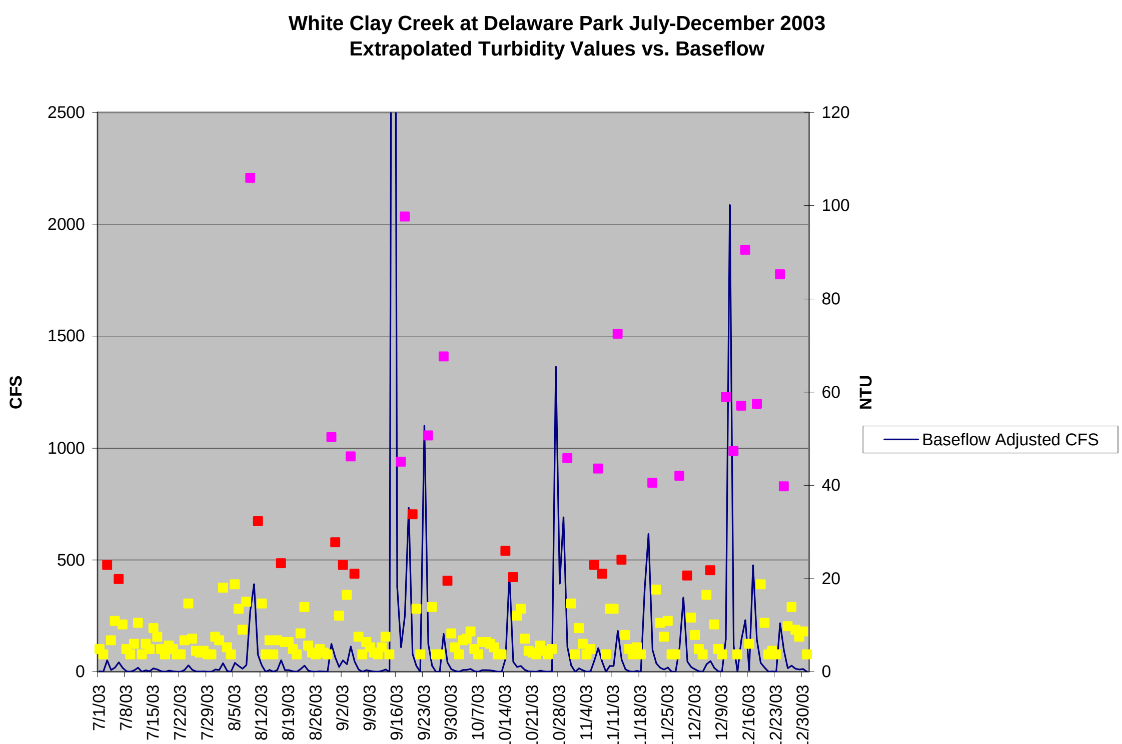
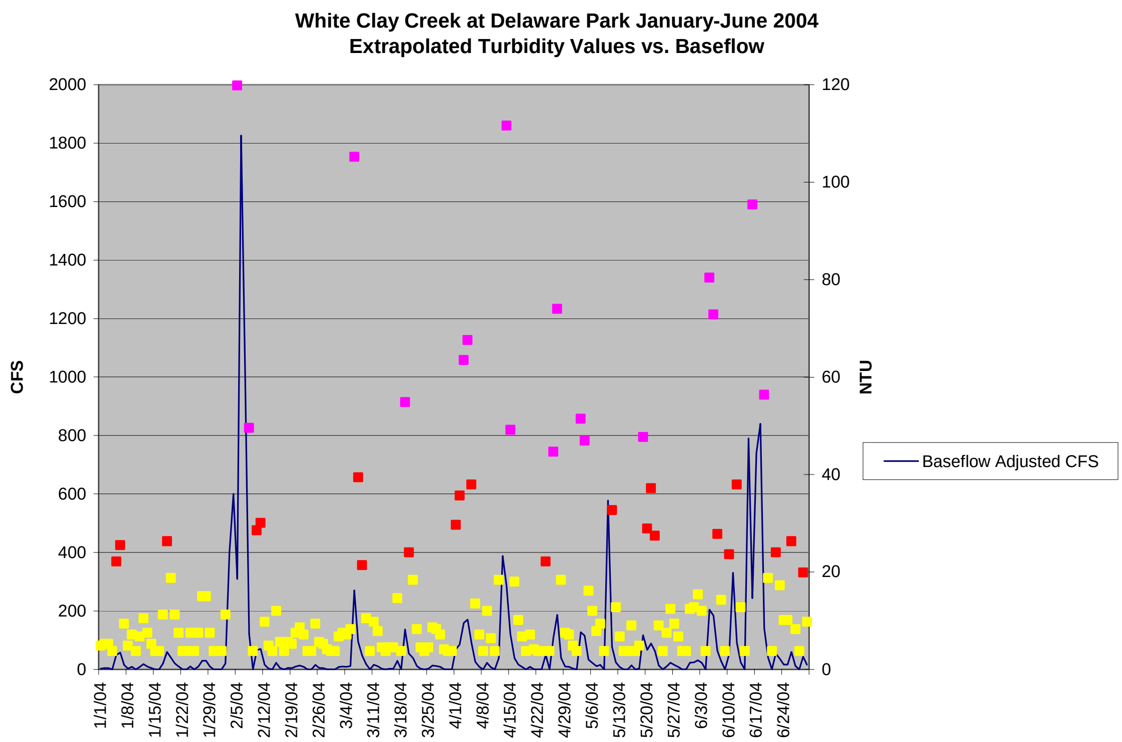
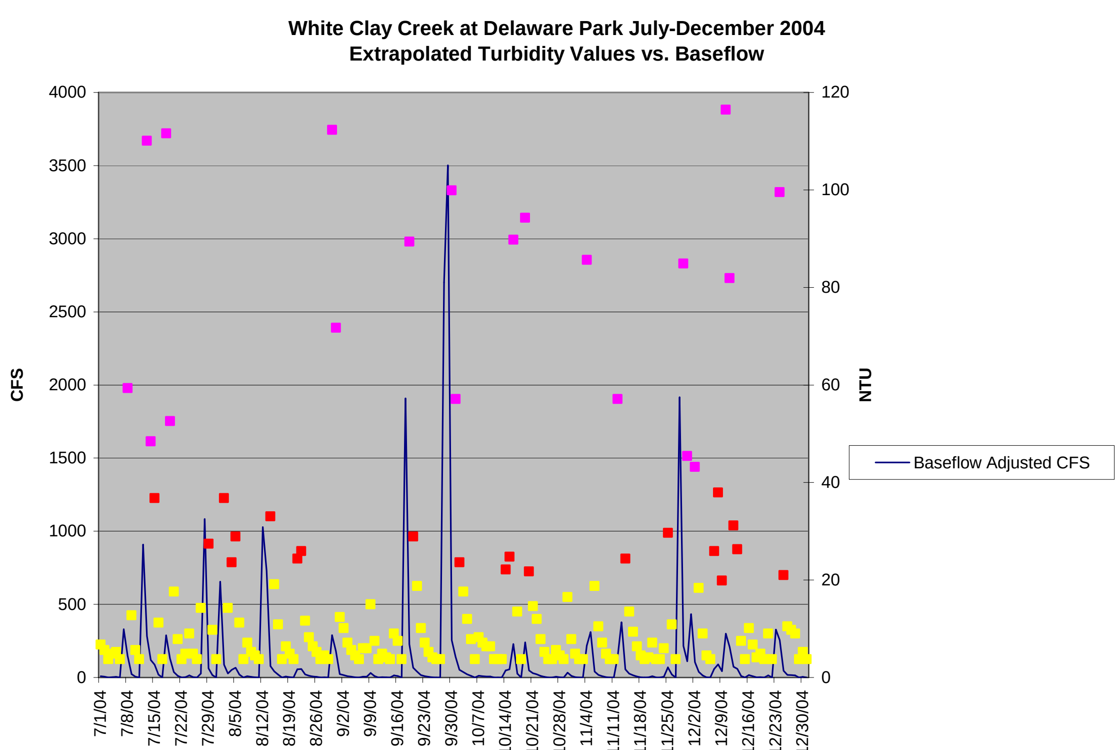


Figure 5.16 White Clay Creek at Delaware Park 2004 Turbidity Values





The regression analysis calculated the number of days that turbidity levels in the White Clay Creek above Newark and at Delaware Park exceeded 20 NTU and 40 NTU. The results are summarized below in Table 5.7 and Table 5.8

Table 5.7 White Clay Creek above Newark Turbidity Results

Date	Days Above 20 NTU	Days >20 NTU and <40 NTU	Days Above 40 NTU
2000	23	16	7
2001	21	12	9
2002	18	12	6
2003	43	15	28
2004	49	21	28
Five Year Average	**31**	**15**	**16**

Table 5.8 White Clay Creek at Delaware Park Turbidity Results

Date	Days Above 20 NTU	Days > 20 NTU and < 40 NTU	Days Above 40 NTU
2000	59	29	30
2001	47	20	27
2002	54	26	28
2003	94	31	63
2004	104	46	58
Five Year Average	**72**	**30**	**41**

5.5 Curtis Mill Water Treatment Plant Analysis and Discussion

The efficiency of the Curtis Mill Water Treatment Plant is linked to future water quality conditions due to land use changes. The discussion will focus on the relationship between White Clay Creek water quality as measured by turbidity and plant efficiency, revealing the technical and economic sensitivity of the Curtis Mill Water Treatment Plant to White Clay Creek water quality. Data used in this analysis is the turbidity calculations from the previous section, and budget and operations information about the Curtis Mill Water Treatment Plant acquired from Bill Zimmerman the Water Quality Engineer for Newark, Delaware. The information obtained from Bill Zimmerman is presented in the following three pages.

5.5.1 Overview

Table 5.9 Curtis Mill Water Treatment Plant Overview

Purveyor	City of Newark			
Town Served	Newark, Delaware			
Population Served	33,000			
Surface Intake Water Body	White Clay Creek			
Surface Plant Capacity	3 mgd, 2 mgd in line			
Total Newark Water Supply	Surface water 3 mgd Ground water 3.5 mgd Interconnection 3 mgd			
Storage Capacity				
Raw	317 million gallon reservoir in construction			
Finished	2 mgd in line			
Annual Demand 2003	341,414,456 gallons per year			
Annual Demand 2004	493,218,691 gallons per year			
Curtis Mill Daily Demand	**2003** 1.7 mgd	**2004** 1.7 mgd		
Curtis Mill Peak Demand	**2003** 2.5 mgd	**2004** 2.8 mgd		
Water Rates* **	Inside City	First 9500 gal. at $4.01/1000 gal. > 9500 gal. at $5.18/1000 gal.		
	Outside City	First 9500 gal. at $5.37/1000 gal. > 9500 gal. at $6.99/1000 gal.		
Fees* **	$2.85 quarterly Fire Hydrant service charge			
Watershed Report Card Grade	B			
Water Quality Grade	B-			
Source Watershed Impervious Cover*	11%			
Watershed Land Use*	Urban/Suburban 18% Agriculture 50% Wooded/Open Space 32%			
Water Quality****				
		Maximum	Minimum	Average
Turbidity NTU**		20 shut down level	2.9	3.5
pH		8.9	5.9	8.1
Nitrates				3.9
Enterococcus		2000		199
Chlorides		54		24

*****Data retrieved from Newark Source Water Assessment 2002
****** Data unpublished; acquired from Zimmerman personal communication 2005
******* Data from Kauffman 2004
********Data retrieved from Kauffman 2003

Table 5.10 Newark Water Department Budget Report

Newark Water Department Budget Report*

	Actual			Budget	Budget
	2001	**2002**	**2003**	**2004**	**2005**
Revenue					
Sale of Water	$3,898,364	$4,780,165	$4,595,877	$4,937,000	$4,937,000
# 1000 Gallons	1,264,606	1,226,975	1,173,178	1,285,000	1,235,000
Penalties and Service Charges	$59,043	$64,591	$19,347	$50,000	$50,000
Total	**$3,957,389**	**$4,844,756**	**$4,645,224**	**$4,987,000**	**$4,987,000**
Water Purchased	$697,480	$902,032	$1,002,771	$438,000	$600,000
# 1000 Gallons	375,452	467,052	562,072	250,000	336,310
Gross Operating Revenue	**$3,259,909**	**$3,942,724**	**$3,642,453**	**$4,549,000**	**$4,387,000**

	Actual			Budget	Budget
	2001	**2002**	**2003**	**2004**	**2005**
Operating Expenses					
Personnel Services	$1,136,918	$1,175,705	$1,350,767	$1,378,190	$1,471,380
Materials and Supplies	$212,144	$269,614	$271,610	$304,850	$300,800
Contractual Services	$168,547	$165,125	$166,453	$170,100	$174,510
Other Charges	$41,233	$106,630	$1,472,397	$1,416,520	$1,423,070
Inter-Department Charges	$256,728	$285,046	$260,128	$256,490	$281,740
Total Operating Expenses	**$1,815,570**	**$2,001,119**	**$3,521,335**	**$3,626,150**	**$3,651,500**
Gross Operating Revenue - Total Operating Expenses = Net Operating Margin					
Net Operating Margin	**$1,444,339**	**$1,941,604**	**$121,098**	**$922,850**	**$735,500**

***** Data unpublished; acquired from Zimmerman personal communication 2005

Table 5.11 Newark Water Department Production Volumes

Newark Water Department Volumes					
	2001	**2002**	**2003**	**2004**	
Curtis Plant Production Gallons / Year	638,054,000	338,643,000	341,414,456	493,218,691	
Groundwater Withdrawals Gallons / Year	251,100,000	421,280,000	269,692,000	319,235,000	
Interconnection Contract	5 year contract for $1.75 / 1000 gallons Minimum purchase of 21,000,000 gallons/month Began in the early 1960s				
Purchases	**2001**	**2002**	**2003**	**2004**	**2005**
1000 Gallons/Year	375,452	467,052	562,072	337,864	336,310
Total Cost	$697,480	$902,032	$1,002,771	$602,771	$600,000
Extra Capacity	Two 1mgd capacity Trident systems $150,000 for materials and activation of both				
Cost / 1000 Gallons =					
(United Purchase Costs + Operating Expenses) / Total Volume Produced					
	Actual			Projected	Budget
	2001	**2002**	**2003**	**2004**	**2005**
United Purchase	$697,480	$902,032	$1,002,771	$602,771	$600,000
Operating Expenses	$1,815,570	$2,001,119	$3,521,335	$3,520,098	$3,651,500
Total Volume 1000 Gallons	1,264,606	1,226,975	1,173,178	1,150,017	1,235,000
Cost/1000 Gallons	$1.99	$2.37	$3.86	$3.58	$4.04

Note:
2002 drought carried water restrictions
2003 Curtis Plant was closed for 166 days

***** Data unpublished; acquired from Zimmerman personal communication 2005

5.5.2 Curtis Mill Operations

In the past fifteen years the City of Newark has taken three major steps towards having a self sufficient water supply: in 1992 the Curtis Mill Water Treatment Plant was built to provide surface water, in 2003 the South Well Field iron and manganese reduction plant was built to provide ground water, and a 317 million gallon reservoir is in construction to serve as drought relief for the city. These actions show the city wants to be self sufficient when it comes to providing water to its citizens and has made significant investments. However, the Curtis Mill Water Treatment Plant is sensitive to turbidity fluctuations of the White Clay Creek. The Newark Water Department physically relies on a United Water Delaware interconnection to provide water when stream turbidity reaches 20 NTU. The lost revenue of this practice is discussed in section 5.5.3.

Interconnection reliance during turbidity events has become a common practice because of the nature of the Newark water supply that receives thirty percent of its water from the United Water Delaware interconnection in place. The problem is that declining water quality due to land change is a likely future scenario given the agricultural conversion rates seen in section 5.2 and the gradual increase of impervious cover discussed in section 5.3. The declining quality would slowly increase the number of times that Curtis Mill buys water from the interconnection, losing revenue year after year because the plant did not operate at technologically efficient levels, discussed in section 5.5.4.

In order to determine the technical and economic efficiency of the Curtis Mill Water Treatment Plant, the cost of producing water and purchasing water during high turbidity events, the lost revenue associated with this practice, and the number of turbidity events over 20 NTU, over 40 NTU, and in between the two values that occurred in the past five years is evaluated from 2000 to 2004. The turbidity events above 20 NTU include all instances where water turbidity surpassed 20 NTU, including the times that turbidity was also higher than 40 NTU. In this calculation of the production cost of purchasing water, the 40 NTU events are included in the 20 NTU event total because the water company was buying water for all turbidity values above 20 NTU. It is important to note that later in the manuscript the 40 NTU events will not be included in the production cost of treating water because turbidity events above 40 NTU border the technical limitations of the technology used by the Curtis Mill Water Treatment Plant. The Water Quality Engineer, Bill Zimmerman, said the technology could treat between 40 and 50 NTU, so if the Curtis Mill Water Treatment Plant were to increase capacity to 40 NTU, the interconnection purchases will begin when water turbidity reaches 40 NTU.

Table 5.12 calculates the production cost to the City of Newark of purchasing water during turbidity events by multiplying the number of turbidity events exceeding 20 NTU, the average 800,000 gallon increase in interconnection demand, and the cost per thousand gallons of water purchased from United Water Delaware. A similar calculation is performed using the number of times water turbidity surpassed 40 NTU in order to calculate the cost of purchasing water from the United Water Delaware interconnection if the Curtis Mill Water Treatment Plant was operating at higher capacity (Table 5.14). In order to determine if it is cost effective to increase capacity to 40 NTU, the production cost of purchasing water when turbidity was between 20 NTU and 40 NTU is also calculated (Table 5.13). The cost of water from the year 2001 was used for 2000 due to lack of data.

Table 5.12 Production Cost of Purchasing Water during >20 NTU Turbidity Events

Date	**Days > 20 NTU x 800 thousand gallons x Cost per thousand gallons**			**= Total Cost**
2000	23	x 800	$1.86	$34,224
2001	21	x 800	$1.86	$31,248
2002	18	x 800	$1.93	$27,792
2003	43	x 800	$1.78	$61,232
2004	49	x 800	$1.78	$69,776

Table 5.13 Production Cost of Purchasing Water ≥ 20 NTU and < 40 NTU Turbidity Events

Date	**Days ≥20 NTU and < 40 NTU x 800 Thousand Gallons x Cost per Thousand Gallons**			**= Total Cost**
2000	16	x 800	$1.86	$23,808
2001	12	x 800	$1.86	$17,856
2002	12	x 800	$1.93	$18,528
2003	15	x 800	$1.78	$21,360
2004	21	x 800	$1.78	$29,904

Table 5.14 Production Cost of Purchasing Water during >40 NTU Turbidity Events

Date	Days > 40 NTU x 800 Thousand Gallons x Cost per Thousand Gallons			= Total Cost
2000	7	x 800	$1.86	$10,416
2001	9	x 800	$1.86	$13,392
2002	6	x 800	$1.93	$9,264
2003	28	x 800	$1.78	$39,872
2004	28	x 800	$1.78	$39,872

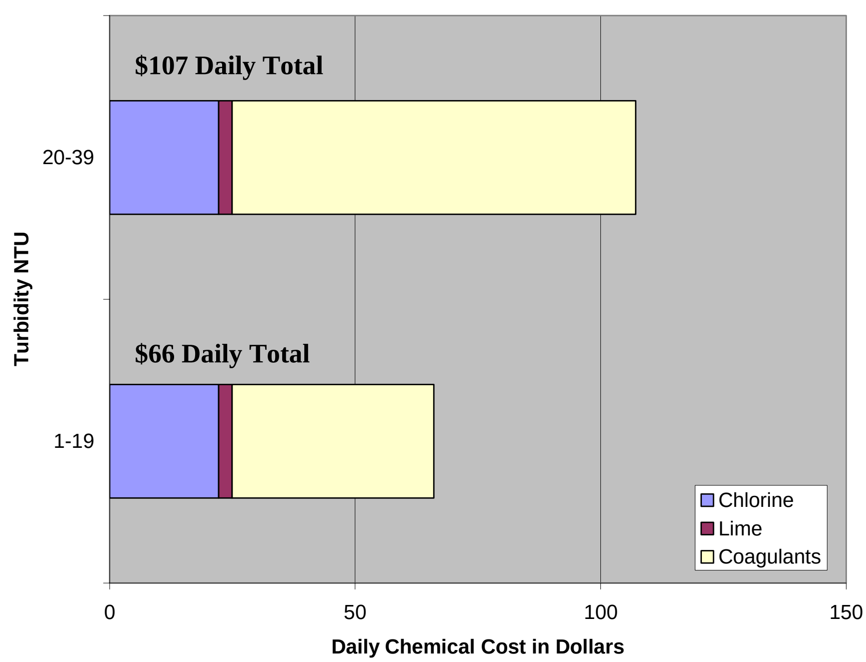
The five years analyzed contain dry and wet precipitation patterns, so the turbidity differences between the years is great. 2002 has the lowest incidence of turbidity events due to the record drought that occurred that year. The wide range of turbidity events greater than 20 NTU from 18 per year to 49 per year has incidentally a large cost range from $34,224 to $69,776, a 200 percent increase representative of the influence weather patterns can have on production costs.

In order to estimate the amount of revenue lost by purchasing from United Water Delaware rather than treating water at Curtis Mill, the cost of treating during turbidity events was estimated. The water engineer, water operators, and technology manuals all could not provide the exact dosing schedule for such events. Without the exact dosing schedule, the estimated cost of chemically treating a turbidity event above 20 NTU and below 40 NTU is based on doubling the use of coagulants and their purchase costs. Table 5.15 shows the chemical needs and associated costs of treating water at the Curtis Mill Water Treatment Plant. Chemical amounts and costs were provided by Bill Zimmerman, Water Quality Engineer of the Curtis Mill Water Treatment Plant.

Table 5.15 Chemical Costs of Treatment

Chemical	**Usage**	**Cost Per Unit**	**Total Cost**
Alum	60-80 tons / year	$180 / ton	$10,800-$14,400
Polymer	600 pounds / year	$4 / pound	$2,400
Chlorine	8-10 tons / year	$900 / ton	$7,200-$9,000
Lime	10 tons / year	$100 / ton	$1,000
		Yearly Cost	**$21,400-$26,800**
		Average Cost Per Year	**$24,100**

Figure 5.17 Daily Chemical Costs of Water Treatment



Shown above in Figure 5.17, the average cost per year of the chemical supply for the plant is $24,100 divided by 365 days is $66 worth of chemicals used per day by the treatment plant. A daily turbidity above 20 NTU but below 40 NTU is estimated to require double the amount of coagulants, including alum and polymer, and cost $107 to treat. The values were estimated in this way to reflect the increasing use of coagulants to treat higher water turbidity. Chlorine use may increase in order to disinfect the larger concentration of suspended particulates associated with higher turbidity, but this increase is not assumed in this analysis.

Table 5.16 presents the production cost of treating water at the Curtis Mill Water Treatment Plant, rather than purchasing it, during turbidity events above 20 NTU and below 40 NTU. The calculations use the chemical costs of treatment described in the preceding paragraph and the number of turbidity events calculated in section 5.4.

Table 5.16 Production Cost of Treating Water ≥20 and <40 NTU Turbidity Events

Date	Days ≥ 20 <40 NTU	Chemical Cost per Event	Cost of Treating per Year
2000	16	$107	$1,712
2001	12	$107	$1,284
2002	12	$107	$1,284
2003	15	$107	$1,605
2004	21	$107	$2,247

5.5.3 Comparative Revenue Analysis and Discussion

To incorporate and analyze the results of the production costs of purchasing and treating water, the highest gains in revenue between the two practices of buying water over 20

NTU and, treating water up to 40 NTU then buying over 40 NTU will show which practice is economically efficient.

The current practice at the Curtis Mill Water Treatment Plant for dealing with high turbidity is to purchase water from the United Water Delaware interconnection when turbidity levels of the White Clay Creek at Newark surpass 20 NTU. The amount of money the Newark Water Department spends during the turbidity events above 20 NTU to purchase water is shown in Table 5.12 and Table 5.17 column two.

The production cost of a new practice for dealing with high turbidity that includes treating water up to turbidity levels of 40 NTU and then buying water from the interconnection when turbidity surpasses 40 NTU is the addition of the results in Table 5.14 and Table 5.16. The results of this calculation are below in Table 5.17 column three, followed by a graphic in Figure 5.18 that shows how the calculation was made.

Table 5.17 Comparison of Production Costs during High Turbidity Events

Date	**Production Cost Current Practice**	**Production Cost New Practice**
2000	$34,224	$12,128
2001	$31,248	$14,676
2002	$27,792	$10,548
2003	$61,232	$41,477
2004	$69,776	$42,119

Figure 5.18 Calculations of Production Costs Due to High Turbidity Under Current and New Practices

Current Practice	New Practice
Cost of Purchasing Water At 20 NTU Operating Limit	**Cost of Treating and Purchasing Water at 40 NTU Operating Limit**
=	=
High Turbidity Days N where: N>20 NTU	High Turbidity Days N where: 20NTU < N < 40 NTU
X	**X**
Volume Purchased	Chemical Cost of $107
X	+
Interconnection Price	Cost of Purchasing Water Days N where: 40 NTU < N
Current Practice	**New Practice**

Table 5.17 shows that in all five years examined, it would cost less to produce water at a higher plant capacity where water is treated up to 40 NTU and then purchased, rather than the current production practice that treats water up to 20 NTU and then purchases water from the interconnection.

The production costs have a direct reflection on how much revenue the Newark Water Department earns when it sells water. The Newark Water Department Budget Report, Table 5.10, lists the volume of water sold, penalties and charges, minus the water purchased from the interconnection as the inputs to calculating the gross operating revenue. In this calculation of revenue the penalties and charges will be omitted due to lack of data.

Table 5.18 compares the revenue earned from the current practice at which 20 NTU is a buying level, and the new practice similar to Table 5.17 where 40 NTU is the buying level. Table 5.18 column two was calculated by multiplying the number of days of turbidity above 20 NTU by volume and sale price of water at $4.01 per thousand gallons and then subtracting the production cost of purchasing the water (Table 5.17). In summary, the second column represents the revenue earned by reselling water purchased from the United Water Delaware interconnection.

The third column in Table 5.18 calculates revenue earned by the Newark Water Department where water is treated up to turbidity levels of 40 NTU and purchased from the interconnection whenever water turbidity passes the 40 NTU limit. The revenue of the 40 NTU limited practice is calculated in two parts; calculating revenue from sales of water treated up to 40 NTU, and adding that number to revenue earned from reselling water purchased from the interconnection when White Clay Creek turbidity levels surpass 40 NTU.

Table 5.18 Revenue of 20 NTU Limit and 40 NTU Limit Practices at Newark

Date	**Revenue Current Practice 20 NTU Limit**	**Revenue New Practice 40 NTU Limit**	**New - Current Practice Revenue Difference**
2000	$39,560	$61,656	$22,096
2001	$36,120	$52,692	$16,572
2002	$29,952	$47,196	$17,244
2003	$76,712	$96,467	$19,755
2004	$87,416	$115,073	$27,657
		Five Year Total	**$103,324**

As recently as last year the City of Newark lost $27,657 in revenue by buying water when it could have been treating it. The Newark Water Department will earn more revenue by treating raw water with turbidity levels up to 40 NTU, rather than 20 NTU. Increasing the plant capacity so that the Curtis Mill Water Treatment Plant can treat higher turbidity levels would have generated the Newark Water Department a total of $103,324 in additional revenue between 2000 and 2004. The practice of treating water up to 40 NTU and then purchasing from the interconnection is a more efficient operating procedure because it is technologically feasible and brings in more revenue to the Newark Water Department.

5.5.4 Future Water Quality Analysis and Discussion

Within ten years in 2015, the land use changes and impervious cover growth rate within the Newark source water area is projected to increase the impervious cover composition of the watershed to 16 percent. The water quality implications of this percentage are noted in the literature review. The majority of research found that between 10-20 percent impervious cover was a threshold that once surpassed rapidly increased the decline of both biotic and abiotic water quality parameters. An impervious cover of 16 percent would also place the White Clay Creek watershed above Newark in the medium pollution potential category as defined by the Watershed Restoration Action Strategy.

Specifically, the turbidity levels of a 16 percent impervious cover watershed surrounding the White Clay Creek at Newark can be inferred from the behavior of the White Clay Creek at the Delaware Park Race Track. The impervious cover composition of the watershed above the Delaware Park Race Track is 13.2 percent impervious cover based on 2002 Delaware data and 2000 Pennsylvania data, so the actual 2005 percentage is likely higher.

A map and land use breakdown of the Delaware Park source water area is located in Appendix C. The USGS has a streamflow gauge at Delaware Park, and STORET includes Delaware Park as a sampling location. The available data enables the regression analysis and revenue analysis performed on the White Clay Creek at Newark to be done on the Delaware Park site. The results simulate the number of high turbidity days the Newark Water Department would have to purchase water from the interconnection and the associated costs under poor water quality conditions.

Table 5.19 compares the high turbidity events on the White Clay Creek at Newark and Delaware Park. In all cases, the Delaware Park location further downstream from Newark has a higher frequency of turbidity events above 20 NTU, between 20NTU and 40 NTU, and above 40 NTU.

Table 5.19 Comparison of Turbidity Events at Newark and Delaware Park

	Days >20 NTU		**Days ≥ 20 and < 40 NTU**		**Days > 40 NTU**	
Date	**Newark**	**Delaware Park**	**Newark**	**Delaware Park**	**Newark**	**Delaware Park**
2000	23	59	16	29	7	30
2001	21	47	12	20	9	27
2002	18	54	12	26	6	28
2003	43	94	15	31	28	63
2004	49	104	21	46	28	58

The difference in high turbidity event occurrence between Delaware Park and Newark is an average 2.4 fold above Newark values. The increase in turbidity events indicates the Curtis Mill Water Treatment Plant will become increasingly reliant on an outside supply of water as White Clay Creek water quality declines. The water quality conditions at Delaware Park will amplify the current sensitivity that the operation process has to turbidity.

The Newark Water Department will also loose larger amounts of revenue due to more frequent turbidity events as water quality declines to Delaware Park levels. Table 5.20 calculates the revenue generated by the resale of water purchased from the interconnection above 20 NTU in column two, and the revenue generated by increasing the capacity of Curtis Mill Water Treatment Plant to a 40 NTU limit in column three.

Table 5.20 Revenue of 20 NTU Limit and 40 NTU Limit Practices at Delaware Park

Date	**Revenue Current Practice 20 NTU Limit**	**Revenue New Practice 40 NTU Limit**	**New – Current Practice Revenue Difference**
2000	$101,480	$141,529	$40,049
2001	$80,840	$108,460	$27,620
2002	$89,856	$127,218	$37,362
2003	$167,696	$208,523	$40,827
2004	$185,536	$246,118	$60,582
		Five Year Total	**$206,440**

The average revenue loss from 2000 to 2004, or gains from upgrading capacity, at Delaware Park is $41,288, which means ten years of current operations practices under poor water quality conditions will become nearly one half of a million dollars in lost revenue to the Newark Water Department without a capacity upgrade. The increased frequency of turbidity events at Delaware Park will force the Curtis Mill Water Treatment Plant to treat high turbidity between 20 and 40 NTU more often, and purchase more water from the interconnection due to the increase in turbidity events above 40 NTU.

There is a clear financial impact of water quality on the Newark Water Department. The five year total of revenue gains from upgrading capacity under poor water quality conditions is double those earned under good water quality (Table 5.18). This means that as the water quality declines, the differences in gains to the Newark Water Department will continue to diverge when comparing the current practice and new practice. The sooner the Newark Water Department increases the operating capacity of the Curtis Mill Water Treatment Plant the higher the savings.

The current practice of purchasing water from the United Water Delaware interconnection is proven to be economically inefficient compared to increasing Curtis Mill treatment capacity. Operating at a turbidity level of 20 NTU will cost the Newark Water Department more money at current water quality conditions and future conditions than the cost of increasing capacity to operate at 40 NTU.

The Newark Water Department will still loose money by having to purchase from the United Water Interconnection if the plant increases its capacity to 40NTU under future degraded water quality conditions simulated by Delaware Park levels. The ideal situation for the water department would be static water quality and an increase of operating capacity to 40NTU. This way the Water Department can earn higher revenue during turbidity events that are infrequent.

The ability of the Curtis Mill Water Treatment Plant to increase its operating capacity gives it an expanded, but limited range of water quality that it can treat. The operations of the plant indicate that watershed management and water quality best management practices should focus on reducing future water turbidity and maintaining the current high quality.

Chapter 6

CONCLUSION

6.1 Conclusion

The Curtis Mill Water Treatment Plant is sensitive to turbidity levels of the White Clay Creek water supply. Values above 20 NTU are limiting to current operation practices. The plant can affordably increase its operating efficiency in which case turbidity levels above 40 NTU will be limiting to the treatment technology. The most desirable turbidity levels of the water supply from the White Clay Creek are below 40 NTU. For the uses and purposes of the City of Newark, the water quality must be protected because the Curtis Mill Water Treatment Plant has technological limitations based on water turbidity levels that will be present after available adjustments to the water treatment process are made.

The Curtis Mill Water Treatment Plant is estimated to gain $103,000 in additional revenue over five years under current water quality conditions if it increases the 20 NTU operating limit to 40 NTU. Under poor water quality conditions the Curtis Mill Water Treatment Plant will earn an additional $200,000 over five years in revenue by upgrading to the 40 NTU operating limit.

The plant was constructed in 1992 and was engineered to function for fifty years (Zimmerman personal communication 2005). If the water quality is not protected, the number of days the plant can treat water will decline through the remaining thirty seven years of designed operation. These findings support the recommendations of the Watershed Restoration Action Strategy that designate the watershed of the White Clay Creek above Newark as an area where water quality must be protected.

The watershed of the White Clay Creek above Newark is currently eleven percent impervious cover. Watershed impervious area has increased at a rate of 0.5 percent per year. The largest trend in land use change the increase of impervious surfaces is the conversion of agricultural land to residential areas.

Streamflow and water quality analysis has revealed that on the White Clay Creek at Newark in the past five years the lowest frequency of turbidity events above 20 NTU was 18 days in 2002 and the highest frequency was 49 days in 2004. The range of turbidity events above 40 NTU is 28 days in 2004 and 6 days in 2002, a drought year. On the White Clay Creek at Delaware Park the highest frequency of turbidity events over 40 NTU was 63 days in 2003 and the lowest frequency was 27 days in 2001. Turbidity events above 20 NTU at Delaware Park ranged from 47 days in 2001 and 104 days in 2004; a frequency double that of the turbidity events on the White Clay Creek at Newark.

Increased impervious surfaces in the White Clay Creek over a ten year time period will increase the frequency of turbidity events above 40 NTU to 27-63 times per year, up to two months as derived from the analysis of the White Clay Creek at Delaware Park. Even if the water treatment plant upgrades, that implies that in ten years the plant will be operating at 84 percent annual capacity because it physically can not operate when the turbidity is greater than 40 NTU. The annual capacity will continue to decline because the frequency of turbidity events above 40 NTU will increase if land use change continues to convert 0.5 percent of the watershed area into impervious surfaces per year.

6.2 Recommendations

1. *Newark Water Department Maintain Role in Watershed Management*

The Newark Water Department should maintain its participation in watershed conservation programs. The savings from treating higher turbidity water rather than purchasing it can be used to fund watershed management measures that will protect the water quality of the White Clay Creek. The Newark Water Department has budgeted for interconnection purchases, so it would be progressive to use that money for watershed protection. The money would be useful for watershed projects carried out through three major watershed management associations the Newark Water Department is active in.

Currently the Newark Water Department participates in three watershed management programs: the White Clay Creek Management Committee, Delaware Source Water Protection Program, and Christina Basin Clean Water Partnership. The Newark Water Department is represented by Bill Zimmerman in the White Clay Creek Watershed Management Committee. The White Clay Creek Watershed Management Committee is interested in the long-term protection of the White Clay Creek watershed and employs educational, outreach, and conservation mechanisms. Members of the White Clay Creek

Watershed Management Committee are representatives from Pennsylvania and Delaware municipalities, local governments, non-profit organizations, and educational institutions.

The Delaware Source Water Protection Program is funded by the Environmental Protection Agency through individual states to assess the pollution potential and susceptibility of public drinking water supplies to contamination. The Newark Water Department is represented in this program by the University of Delaware Water Resources Agency.

The Newark Water Department is also represented by the Water Resources Agency in the Christina Basin Clean Water Partnership. The mission of the Christina Basin Clean Water Partnership is to restore all streams and tributaries within the Christina River Basin to fish-able, swim-able, and potable status by 2015. Through the Christina Basin Clean Water Partnership the Newark Water Department should advocate the use of a watershed restoration action strategy to slow the rate of land use change in Pennsylvania and Delaware by limiting impervious cover and preserving forest and agricultural land.

The Pennsylvania portion of the White Clay Creek watershed is responsible for the majority of land use change through the highest land area, impervious cover contribution, fastest rate of land use change, and largest potential for further agricultural conversion to impervious surfaces. The Newark Water Department must remain an active figure in promoting agricultural preservation, impervious cover regulation, and potentially funding permanent best management practices that will reduce stream sediment loads, stormwater erosion, and other turbidity controlling measures.

2. *Operation of Real Time Turbidity Meter on the White Clay Creek at Newark*

The Newark Water Department should fund and operate a real time online turbidity meter at the USGS streamflow gauge on the White Clay Creek at Newark. This turbidity meter will enable the Newark Water Department to study the actual turbidity behavior of the White Clay Creek and measure the effectiveness of watershed management practices. The USGS currently operates a real time online turbidity meter on the Delaware River above Trenton, and this site could pose as a model of operation.

There are two options for the installation of a real time turbidity meter on the White Clay Creek. For $7,000-$10,000 an YSI 6920 meter can be purchased and installed at the stream gauge above Newark. The meter will record turbidity, pH, and specific conductance in any interval between five and sixty minutes and download the data, which must be manually retrieved every few weeks. The meter will also need calibration, cleaning, and other maintenance every one to two weeks. For $40,000 per year the City of Newark can rent from the USGS the same turbidity meter that includes, installation, satellite communication to live internet feeds, and routine maintenance and calibration every two weeks. This information was obtained from Jacob Gibbs, Water Quality Specialist to the USGS New Jersey Division.

For the uses and purposes of studying the turbidity behavior of the White Clay Creek above Newark, the option to rent the turbidity meter from the USGS is recommended. Although the expense is greater to rent the unit rather than purchase, the calibration and servicing expertise of the USGS, and most importantly the data communication with the internet are likely expenditures already included in the rent cost.

3. *Increase the Operating Limit of Curtis Mill Water Treatment Plant to 40 NTU*

The Newark Water Department should increase the operating limit of the Curtis Mill Water Treatment Plant to 40 NTU from 20 NTU. If the Curtis Mill Water Treatment Plant increases its operating limit to 40 NTU, the amount of water purchased from United Water Delaware will be reduced. Decreasing the amount of water purchased from the interconnection will add to the self sufficiency of the Newark water supply.

Increasing the operating limit will entail keeping aggregated turbidity data and analyzing the exact turbidity response of the White Clay Creek to precipitation events. These actions are necessary to develop a dosing schedule of coagulants necessary to treat quickly rising turbidity levels due to precipitation. The increase in operating limit is not only affordable, it will increase the amount of revenue earned by the Newark Water Department because it is cheaper to treat the water than purchase it from United Water Delaware.

6.3 Summary of Findings

Chapter 1 hypothesizes the municipal use of water resources is economically dependent upon the health of the watershed, based on technological limitations of the water treatment facility. Watershed management was introduced as the vehicle to protect, conserve, or remediate water quality. If water quality changes would force major adjustments in the technical operations of the water treatment plant, the watershed management strategy should aim to conserve and remediate water quality. If water quality changes would force minor adjustments in treatment technique, watershed management should follow a path of water quality protection to keep the quality of supply static. The hypothesis will be tested through examination of the Curtis Mill Water Treatment Plant and water supply from the White Clay Creek.

Chapter 2 is a characterization of the White Clay Creek watershed located in northern Delaware and southeastern Pennsylvania. The chapter also describes the Newark, Delaware source water area portion of the White Clay Creek watershed.

Chapter 3 is a literature review that covers land use and water quality relationships and the technical capacity of water treatment technology employed by the City of Newark. The land use and water quality relationships found in the literature are shown below on Table 6.1.

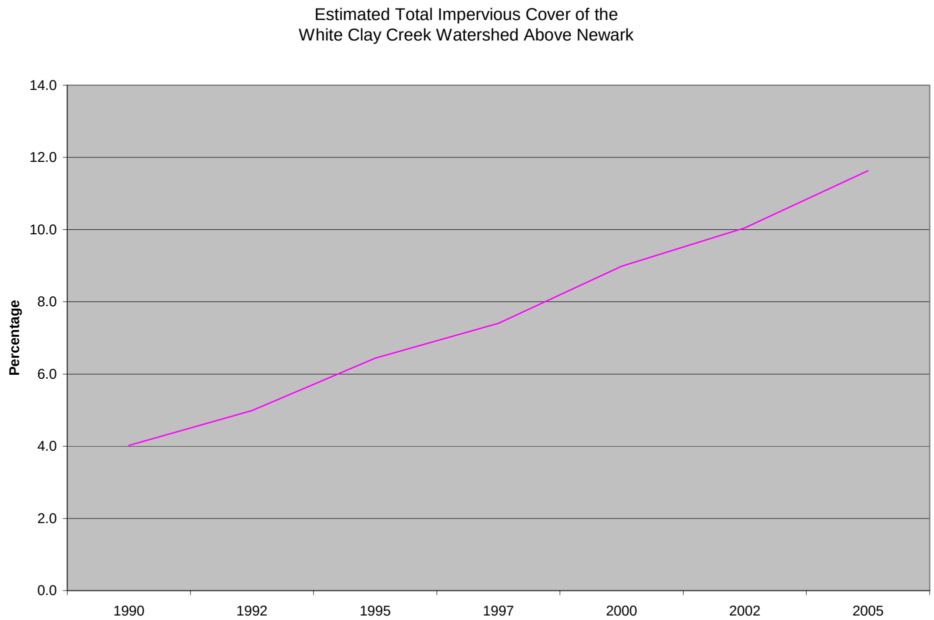
Chapter 3 also describes the package plant treatment technology history and findings mainly by the EPA and the American Water Works Association. The Trident technology used by the Curtis Mill Water Treatment Plant is capable of treating between 40-50 NTU.

Table 6.1 Land Use and Water Quality Relationships

Abiotic	**Impervious Cover**	**Parameter Effect**
	10-20%	Altered hydrography, salinity variance, increased chemical contaminants, increased fecal coliform
	Range of values	Increased: Baseflow, DOC, FRP, and TP, ammonium, conductivity
	>10%	Unstable channels
	8-12%	Decreased baseflow, increased bank erosion
	10.4%	Increased peak flow, decreased instantaneous time to peak
	35% Connected IC: 13%	Connected IC is a stronger indicator of urban runoff behavior than IC
Biotic	8-12%	Macroinvertebrate community sharp decline
	13.8%	IBI measurement showed significant decline
	4.%	IBI began to decline
	<8%	High IBI and fish species diversity
	>12%	IBI decline, fish species diversity decline
	20-30%	Reduced stress-sensitive taxa, loss of commercial shrimp, altered food webs
	Range	Reduced fish and crustacean abundance
Agricultural Land		Increased transport of nutrients, pesticides, herbicides, metals, turbidity, and bacteria
Urban Land		Degradation of macroinvertebrate communities, increased transport of sediment, nutrients, metals, chemicals, increased water temperature and pH
Forested Land		Soil stabilization, temperature regulation, allochthonous carbon contribution, food web stimulation

Chapter 4 outlines the methodology used to test the hypothesis. A GIS land use analysis was performed on the White Clay Creek upstream and downstream from Newark in order to measure land use change and impervious cover composition and growth, summarized on Figure 6.1.

Figure 6.1 Estimated Total Impervious Cover



A downstream location at Delaware Park was chosen to simulate future water quality conditions based on the measured growth rate of impervious cover above Newark and the current impervious cover composition of the watershed above Delaware Park.

Analysis was performed on the turbidity and streamflow relationship of the White Clay Creek above Newark and below at Delaware Park because the technology is turbidity dependent. The results of that relationship were used to compute the amount of revenue to the Newark Water Department that is dependent on turbidity.

Chapter 5 discusses the results obtained from Chapter 4. The land use analysis revealed a significant rate of land use change occurring in the Pennsylvania portion of the White Clay Creek watershed. This land use change would give the White Clay Creek above Newark impervious cover values that in ten years would be similar to the watershed above Delaware Park. Anticipated water quality changes would include increased frequency of turbidity events >20 NTU and >40 NTU that will force the Curtis Mill Water Treatment Plant to increase the amount of water purchased from the United Water Delaware Interconnection.

Curtis Mill can increase its operating capacity to 40 NTU to deal with water quality changes, but land use change will render that capacity economically inefficient because water will still have to be purchased as the number of high turbidity events increases over time. Operating at 40 NTU will bring more revenue in to the Newark Water Department than operating at 20 NTU, but this increase in capacity is not 100 percent efficient. The minor changes capable of increasing capacity as water quality declines are limited by a 40 NTU turbidity ceiling. The water quality of the White Clay Creek above Newark must be protected so that turbidity levels stay below the 40 NTU ceiling.

Chapter 6 concludes the research indicates that the Curtis Mill Water Treatment Plant has a turbidity limit of 40 NTU that when surpassed decreases the operating capacity of the plant. This limit implies that the watershed management strategy of the White Clay Creek watershed should protect the water quality of the White Clay Creek in order to keep turbidity levels below 40 NTU. This conclusion supports the recommendation of the Christina Basin Watershed Restoration Action Strategy that designates the White Clay Creek watershed above Newark as an area where best management practices should focus on water quality protection through prevention, preservation, and protection implementation strategies.

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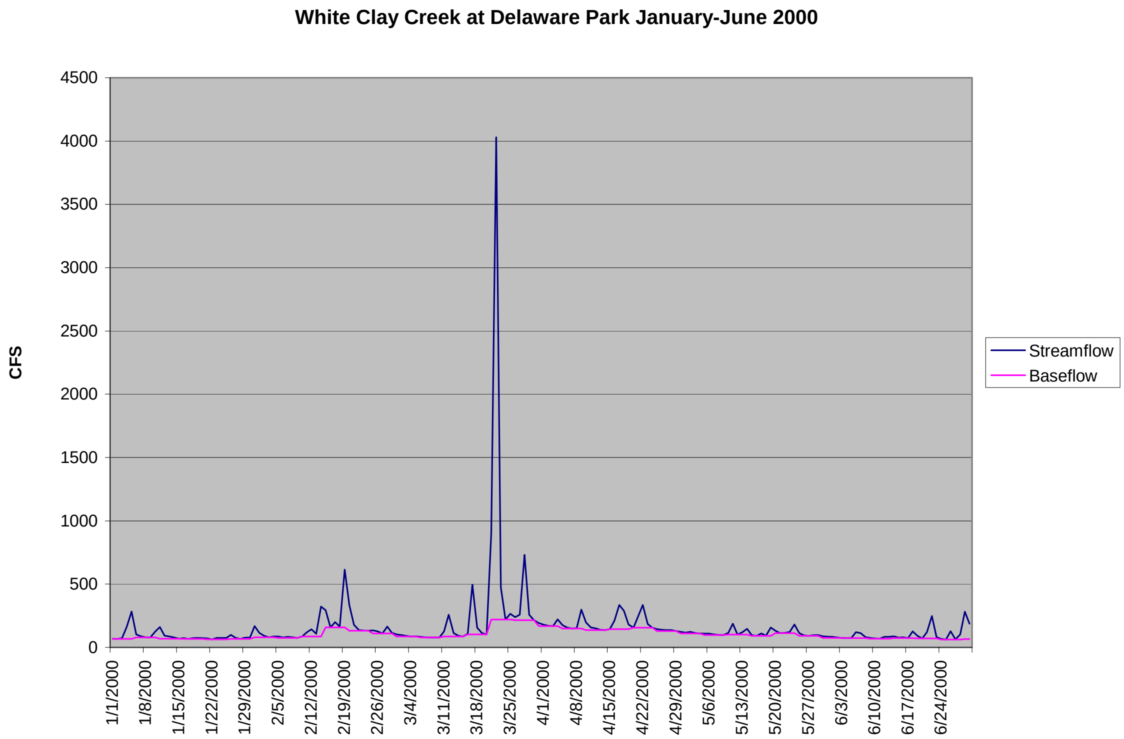
APPENDIX A

Baseflow Adjustment Graphs
Data of the White Clay Creek at Newark 2000-2004:
Streamflow
Baseflow Adjustment
STORET data
Turbidity Extrapolation

Figure A-1 Baseflow Adjustment White Clay Creek at Newark 2000



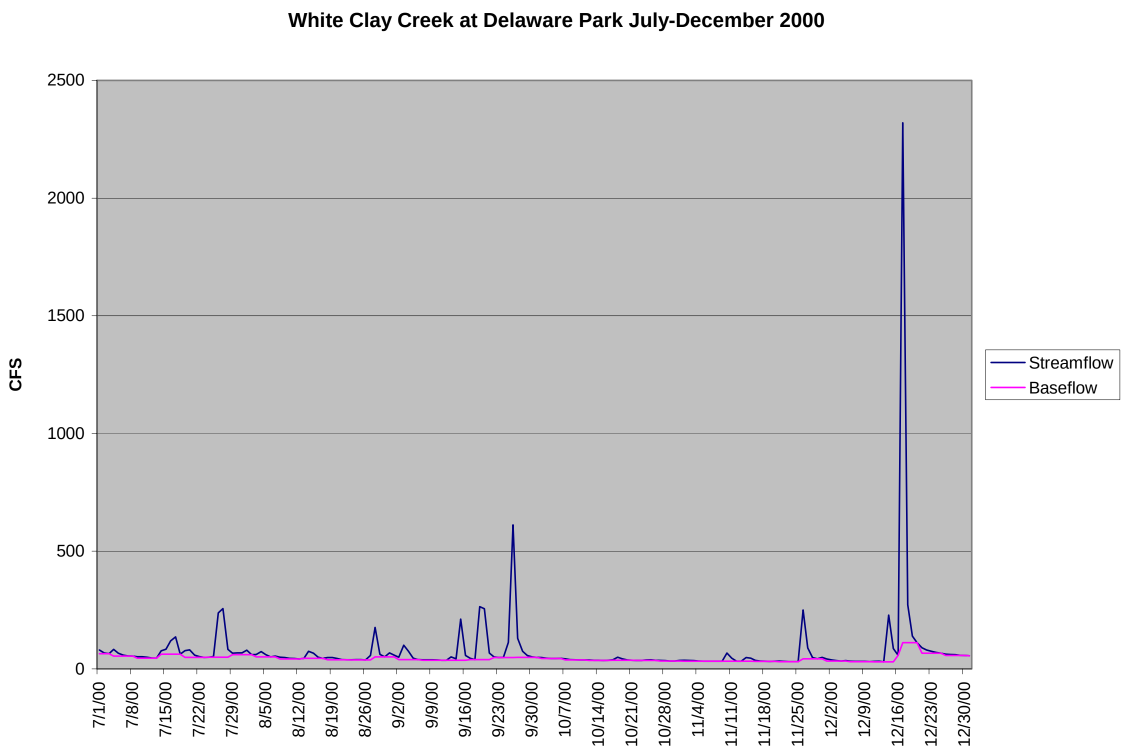
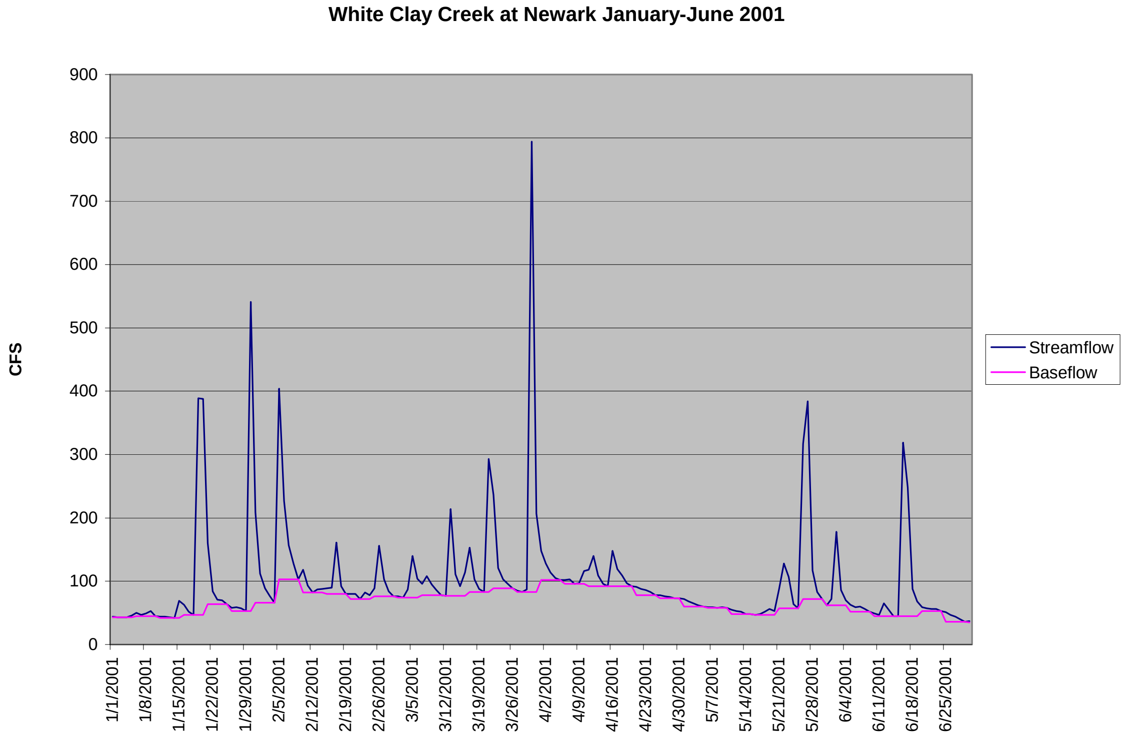


Figure A-2 Baseflow Adjustment White Clay Creek at Newark 2001



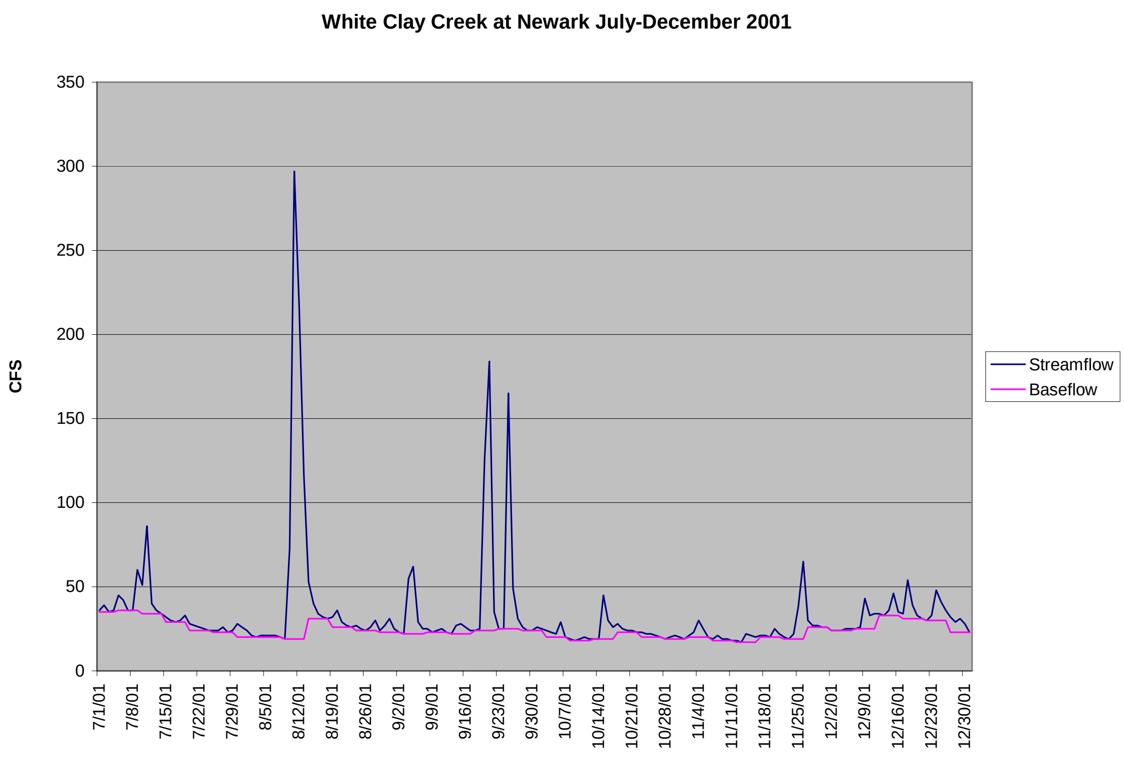
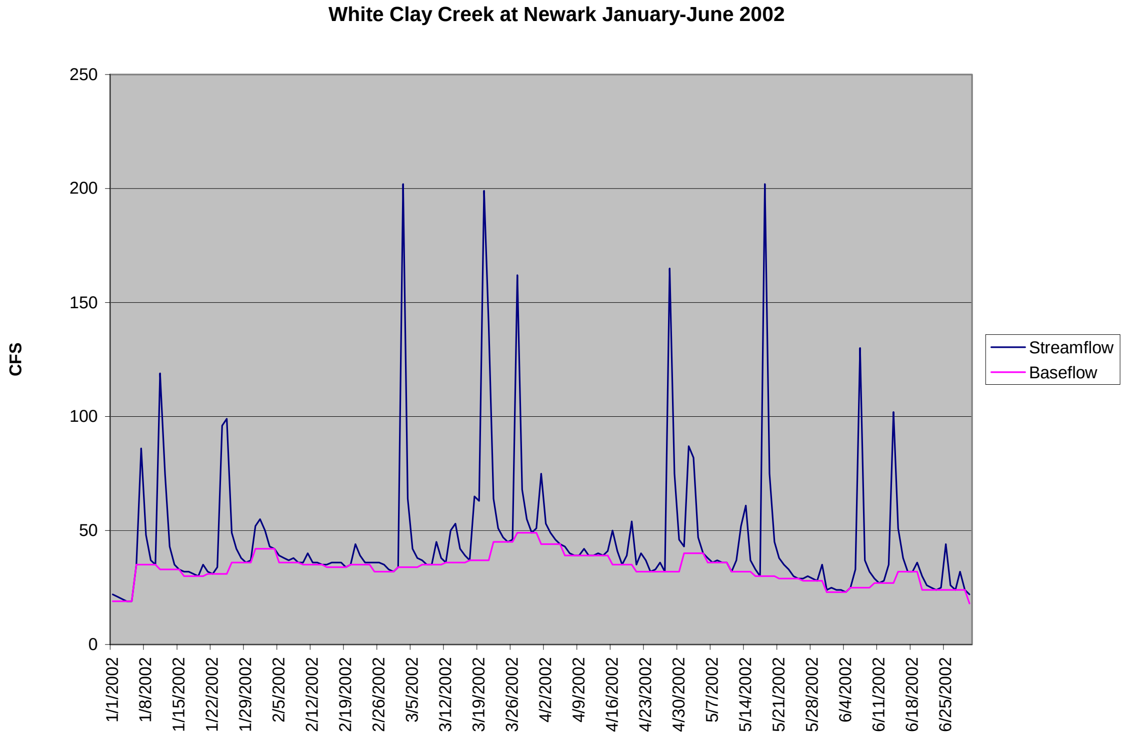


Figure A-3 Baseflow Adjustment White Clay Creek at Newark 2002



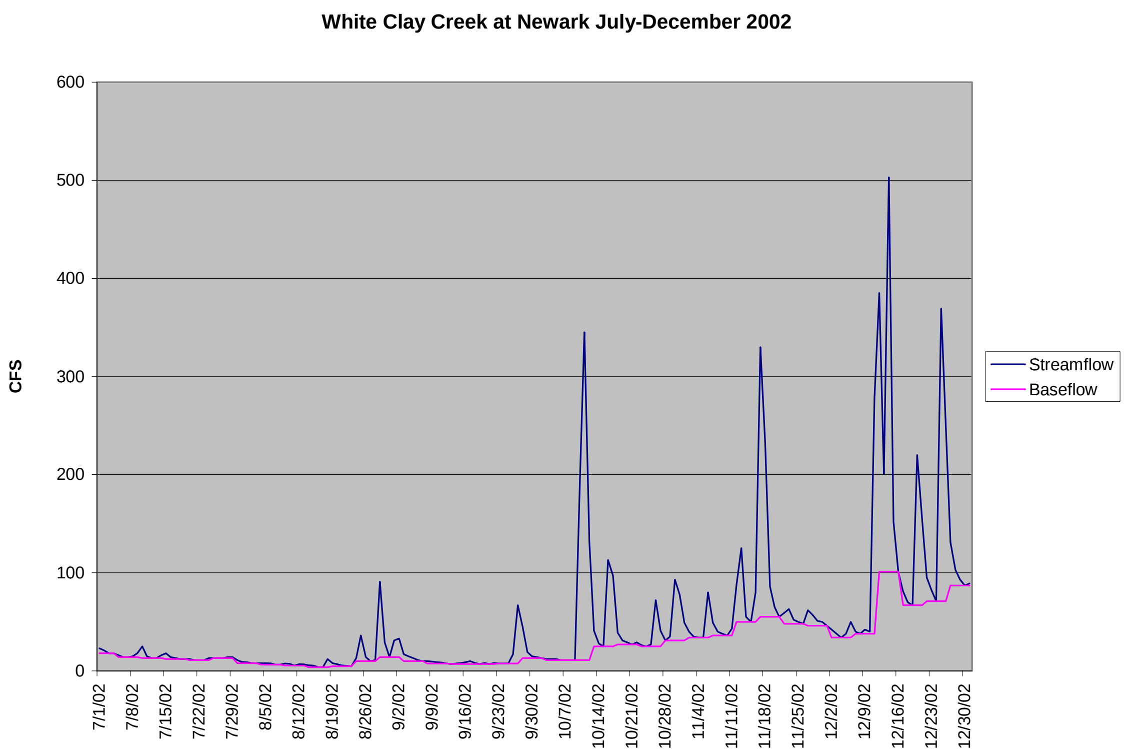
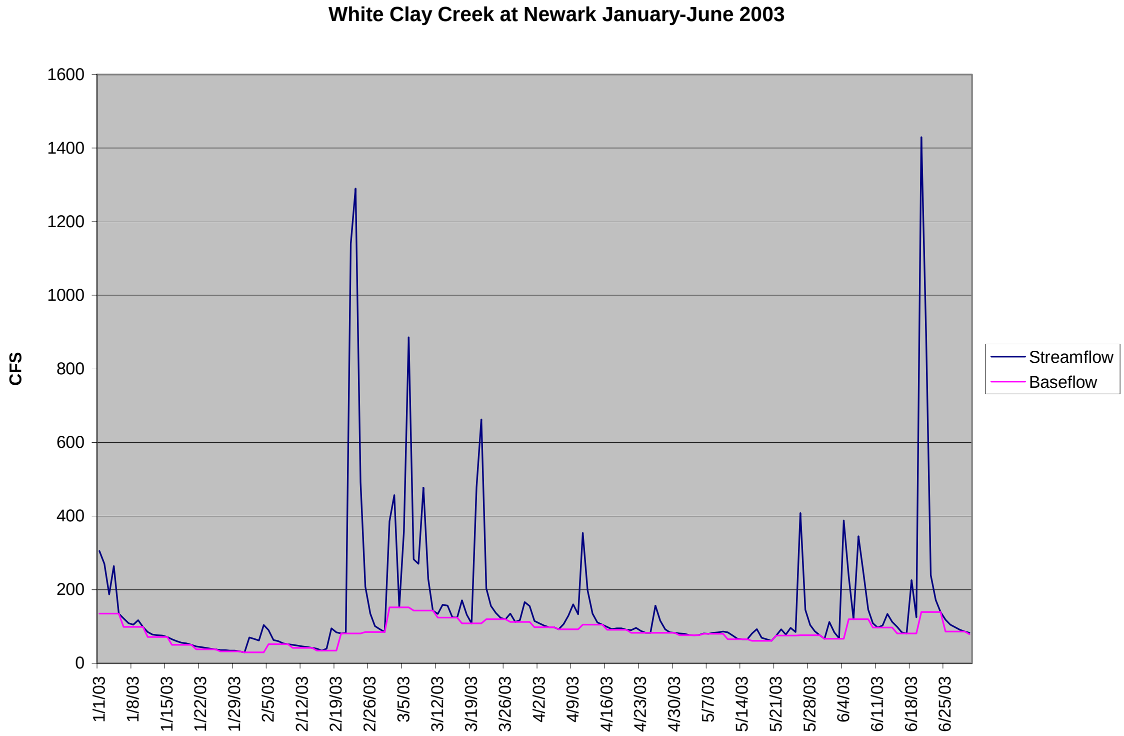
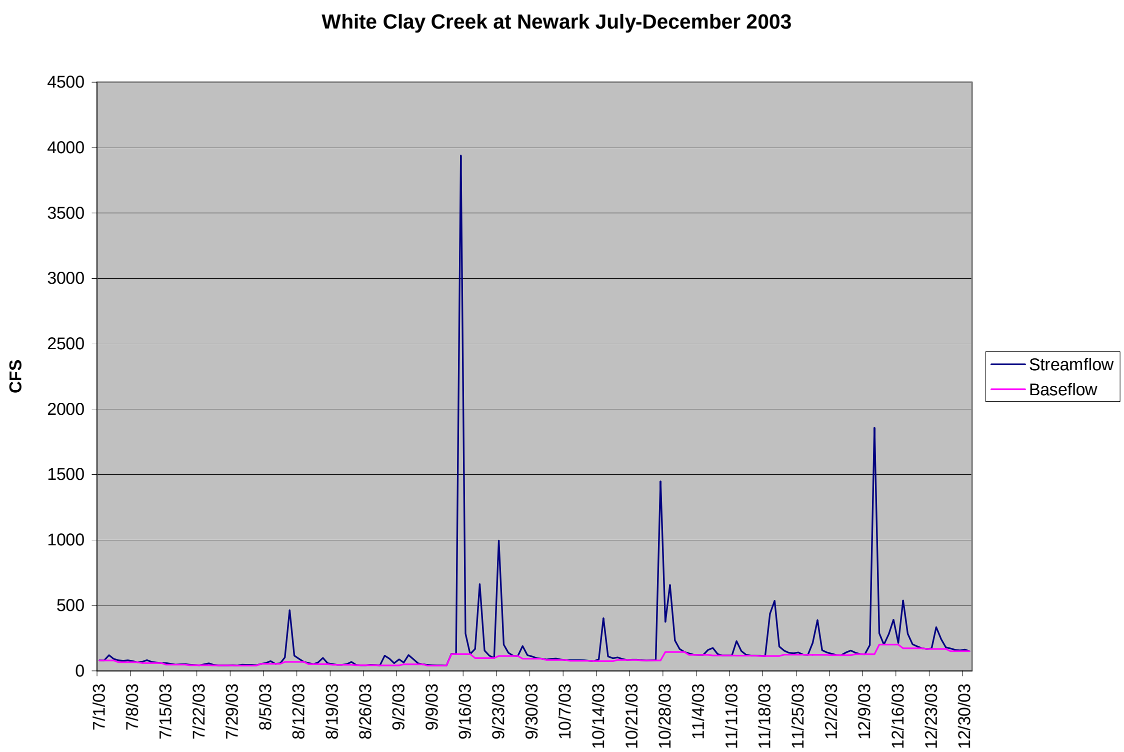


Figure A-4 Baseflow Adjustment White Clay Creek at Newark 2003





2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
1/1/00	57		57	0	3.2
1/2/00	57		57	0	3.2
1/3/00	58		57	1	3.4
1/4/00	84		57	27	7.6
1/5/00	185		57	128	23.9
1/6/00	80		63	17	5.9
1/7/00	69		63	6	4.2
1/8/00	64		63	1	3.4
1/9/00	63		63	0	3.2
1/10/00	91		63	28	7.7
1/11/00	118		57	61	13.1
1/12/00	73		57	16	5.8
1/13/00	59		57	2	3.5
1/14/00	62		57	5	4.0
1/15/00	57		57	0	3.2
1/16/00	61		51	10	4.8
1/17/00	52		51	1	3.4
1/18/00	51		51	0	3.2
1/19/00	59		51	8	4.5
1/20/00	63		51	12	5.1
1/21/00	61		60	1	3.4
1/22/00	60		60	0	3.2
1/23/00	65		60	5	4.0
1/24/00	63		60	3	3.7
1/25/00	63		60	3	3.7
1/26/00	74		58	16	5.8
1/27/00	60		58	2	3.5
1/28/00	58		58	0	3.2
1/29/00	67		58	9	4.7
1/30/00	76		58	18	6.1
1/31/00	106		49	57	12.4
2/1/00	49		49	0	3.2
2/2/00	65		49	16	5.8
2/3/00	63		49	14	5.5
2/4/00	63		49	14	5.5
2/5/00	63		59	4	3.8
2/6/00	60		59	1	3.4
2/7/00	61		59	2	3.5
2/8/00	61		59	2	3.5
2/9/00	59		59	0	3.2
2/10/00	63		63	0	3.2
2/11/00	81		63	18	6.1
2/12/00	110		63	47	10.8
2/13/00	72		63	9	4.7
2/14/00	186		63	123	23.1

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
2/15/00	208		113	95	18.5
2/16/00	137		113	24	7.1
2/17/00	156		113	43	10.1
2/18/00	113		113	0	3.2
2/19/00	406		113	293	50.5
2/20/00	230		111	119	22.4
2/21/00	143		111	32	8.4
2/22/00	111		111	0	3.2
2/23/00	112		111	1	3.4
2/24/00	112		111	1	3.4
2/25/00	112		93	19	6.3
2/26/00	105		93	12	5.1
2/27/00	93		93	0	3.2
2/28/00	132		93	39	9.5
2/29/00	95		93	2	3.5
3/1/00	85		75	10	4.8
3/2/00	81		75	6	4.2
3/3/00	76		75	1	3.4
3/4/00	75		75	0	3.2
3/5/00	75		75	0	3.2
3/6/00	70		65	5	4.0
3/7/00	66		65	1	3.4
3/8/00	66		65	1	3.4
3/9/00	66		65	1	3.4
3/10/00	65		65	0	3.2
3/11/00	81		71	10	4.8
3/12/00	154		71	83	16.6
3/13/00	90		71	19	6.3
3/14/00	76	2	71	5	4.0
3/15/00	71		71	0	3.2
3/16/00	75		75	0	3.2
3/17/00	310		75	235	41.2
3/18/00	119		75	44	10.3
3/19/00	93		75	18	6.1
3/20/00	85		75	10	4.8
3/21/00	615		174	441	74.4
3/22/00	2740		174	2566	417.8
3/23/00	295		174	121	22.7
3/24/00	207		174	33	8.5
3/25/00	174		174	0	3.2
3/26/00	155		146	9	4.7
3/27/00	146		146	0	3.2
3/28/00	444		146	298	51.3
3/29/00	175		146	29	7.9
3/30/00	146		146	0	3.2
3/31/00	133		121	12	5.1

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
4/1/00	122		121	1	3.4
4/2/00	121		121	0	3.2
4/3/00	121		121	0	3.2
4/4/00	162		121	41	9.8
4/5/00	128		104	24	7.1
4/6/00	114		104	10	4.8
4/7/00	104		104	0	3.2
4/8/00	106		104	2	3.5
4/9/00	215		104	111	21.1
4/10/00	146		99	47	10.8
4/11/00	118		99	19	6.3
4/12/00	112		99	13	5.3
4/13/00	102		99	3	3.7
4/14/00	99		99	0	3.2
4/15/00	103		103	0	3.2
4/16/00	145		103	42	10.0
4/17/00	227		103	124	23.2
4/18/00	222		103	119	22.4
4/19/00	143		103	40	9.7
4/20/00	124		120	4	3.8
4/21/00	175		120	55	12.1
4/22/00	247		120	127	23.7
4/23/00	142		120	22	6.8
4/24/00	120		120	0	3.2
4/25/00	109		99	10	4.8
4/26/00	104		99	5	4.0
4/27/00	103		99	4	3.8
4/28/00	102		99	3	3.7
4/29/00	99		99	0	3.2
4/30/00	93		85	8	4.5
5/1/00	90		85	5	4.0
5/2/00	93	2	85	8	4.5
5/3/00	88		85	3	3.7
5/4/00	85		85	0	3.2
5/5/00	84		75	9	4.7
5/6/00	87		75	12	5.1
5/7/00	80		75	5	4.0
5/8/00	76		75	1	3.4
5/9/00	75		75	0	3.2
5/10/00	93		80	13	5.3
5/11/00	156		80	76	15.5
5/12/00	80		80	0	3.2
5/13/00	80		80	0	3.2
5/14/00	112		80	32	8.4
5/15/00	74		68	6	4.2
5/16/00	68		68	0	3.2

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
5/17/00	77		68	9	4.7
5/18/00	70		68	2	3.5
5/19/00	113		68	45	10.5
5/20/00	104		91	13	5.3
5/21/00	92		91	1	3.4
5/22/00	91		91	0	3.2
5/23/00	101		91	10	4.8
5/24/00	134		91	43	10.1
5/25/00	87		69	18	6.1
5/26/00	73		69	4	3.8
5/27/00	69		69	0	3.2
5/28/00	76		69	7	4.3
5/29/00	75		69	6	4.2
5/30/00	66		57	9	4.7
5/31/00	63		57	6	4.2
6/1/00	63		57	6	4.2
6/2/00	60		57	3	3.7
6/3/00	57		57	0	3.2
6/4/00	55		55	0	3.2
6/5/00	57		55	2	3.5
6/6/00	104		55	49	11.1
6/7/00	97		55	42	10.0
6/8/00	65		55	10	4.8
6/9/00	60		54	6	4.2
6/10/00	56		54	2	3.5
6/11/00	54		54	0	3.2
6/12/00	56		54	2	3.5
6/13/00	63		54	9	4.7
6/14/00	70		57	13	5.3
6/15/00	63		57	6	4.2
6/16/00	66		57	9	4.7
6/17/00	57		57	0	3.2
6/18/00	70		57	13	5.3
6/19/00	64		51	13	5.3
6/20/00	51		51	0	3.2
6/21/00	57		51	6	4.2
6/22/00	107		51	56	12.2
6/23/00	57		51	6	4.2
6/24/00	50		46	4	3.8
6/25/00	46		46	0	3.2
6/26/00	52		46	6	4.2
6/27/00	47		46	1	3.4
6/28/00	94		46	48	11.0
6/29/00	160		47	113	21.5
6/30/00	121		47	74	15.2
7/1/00	57		47	10	4.8

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
7/2/00	51		47	4	3.8
7/3/00	47		47	0	3.2
7/4/00	70		43	27	7.6
7/5/00	51		43	8	4.5
7/6/00	44		43	1	3.4
7/7/00	44		43	1	3.4
7/8/00	43		43	0	3.2
7/9/00	40		35	5	4.0
7/10/00	40		35	5	4.0
7/11/00	38		35	3	3.7
7/12/00	35		35	0	3.2
7/13/00	35		35	0	3.2
7/14/00	40		40	0	3.2
7/15/00	49		40	9	4.7
7/16/00	131		40	91	17.9
7/17/00	98		40	58	12.6
7/18/00	50		40	10	4.8
7/19/00	52		38	14	5.5
7/20/00	61		38	23	6.9
7/21/00	45		38	7	4.3
7/22/00	41		38	3	3.7
7/23/00	38		38	0	3.2
7/24/00	38		38	0	3.2
7/25/00	42		38	4	3.8
7/26/00	169		38	131	24.4
7/27/00	180		38	142	26.1
7/28/00	53		38	15	5.6
7/29/00	53		48	5	4.0
7/30/00	53		48	5	4.0
7/31/00	59		48	11	5.0
8/1/00	62		48	14	5.5
8/2/00	48		48	0	3.2
8/3/00	45		41	4	3.8
8/4/00	48		41	7	4.3
8/5/00	44		41	3	3.7
8/6/00	41		41	0	3.2
8/7/00	43	3	41	2	3.5
8/8/00	39		33	6	4.2
8/9/00	36		33	3	3.7
8/10/00	35		33	2	3.5
8/11/00	34		33	1	3.4
8/12/00	33		33	0	3.2
8/13/00	35		35	0	3.2
8/14/00	57		35	22	6.8
8/15/00	51		35	16	5.8
8/16/00	40		35	5	4.0

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
8/17/00	35		35	0	3.2
8/18/00	37		31	6	4.2
8/19/00	39		31	8	4.5
8/20/00	35		31	4	3.8
8/21/00	32		31	1	3.4
8/22/00	31		31	0	3.2
8/23/00	31		30	1	3.4
8/24/00	33		30	3	3.7
8/25/00	32		30	2	3.5
8/26/00	30		30	0	3.2
8/27/00	34		30	4	3.8
8/28/00	142		44	98	19.0
8/29/00	49		44	5	4.0
8/30/00	44		44	0	3.2
8/31/00	54		44	10	4.8
9/1/00	48		44	4	3.8
9/2/00	43		33	10	4.8
9/3/00	55		33	22	6.8
9/4/00	53		33	20	6.4
9/5/00	37		33	4	3.8
9/6/00	33		33	0	3.2
9/7/00	33		30	3	3.7
9/8/00	33		30	3	3.7
9/9/00	32		30	2	3.5
9/10/00	30		30	0	3.2
9/11/00	30		30	0	3.2
9/12/00	30		30	30	8.0
9/13/00	47		30	17	5.9
9/14/00	36		30	6	4.2
9/15/00	130		30	100	19.4
9/16/00	45		30	15	5.6
9/17/00	37		34	3	3.7
9/18/00	34		34	0	3.2
9/19/00	168		34	134	24.8
9/20/00	168		34	134	24.8
9/21/00	54		34	20	6.4
9/22/00	43		42	1	3.4
9/23/00	42		42	0	3.2
9/24/00	43		42	1	3.4
9/25/00	54		42	12	5.1
9/26/00	385		42	343	58.6
9/27/00	106		48	58	12.6
9/28/00	63		48	15	5.6
9/29/00	52		48	4	3.8
9/30/00	48		48	0	3.2
10/1/00	49		48	1	3.4

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
10/2/00	46		41	5	4.0
10/3/00	44		41	3	3.7
10/4/00	42		41	1	3.4
10/5/00	41		41	0	3.2
10/6/00	42		41	1	3.4
10/7/00	40		34	6	4.2
10/8/00	37		34	3	3.7
10/9/00	36		34	2	3.5
10/10/00	35		34	1	3.4
10/11/00	34		34	0	3.2
10/12/00	33		32	1	3.4
10/13/00	32		32	0	3.2
10/14/00	32		32	0	3.2
10/15/00	32		32	0	3.2
10/16/00	32		32	0	3.2
10/17/00	34		34	0	3.2
10/18/00	41		34	7	4.3
10/19/00	44		34	10	4.8
10/20/00	39		34	5	4.0
10/21/00	37		34	3	3.7
10/22/00	34		33	1	3.4
10/23/00	33		33	0	3.2
10/24/00	38	11	33	5	4.0
10/25/00	34		33	1	3.4
10/26/00	33		33	0	3.2
10/27/00	32		31	1	3.4
10/28/00	31		31	0	3.2
10/29/00	32		31	1	3.4
10/30/00	41		31	10	4.8
10/31/00	44		31	13	5.3
11/1/00	40		32	8	4.5
11/2/00	37		32	5	4.0
11/3/00	35		32	3	3.7
11/4/00	33		32	1	3.4
11/5/00	32		32	0	3.2
11/6/00	31		30	1	3.4
11/7/00	30		30	0	3.2
11/8/00	30		30	0	3.2
11/9/00	34		30	4	3.8
11/10/00	71		30	41	9.8
11/11/00	35		32	3	3.7
11/12/00	32		32	0	3.2
11/13/00	37		32	5	4.0
11/14/00	44		32	12	5.1
11/15/00	51		32	19	6.3
11/16/00	33		30	3	3.7

2000	CFS	STORET NTU	Baseflow	Runoff	Extrapolated NTU
11/17/00	32		30	2	3.5
11/18/00	31		30	1	3.4
11/19/00	30		30	0	3.2
11/20/00	30		30	0	3.2
11/21/00	34		24	10	4.8
11/22/00	31		24	7	4.3
11/23/00	30		24	6	4.2
11/24/00	30		24	6	4.2
11/25/00	24		24	0	3.2
11/26/00	152		37	115	21.8
11/27/00	79		37	42	10.0
11/28/00	53		37	16	5.8
11/29/00	37		37	0	3.2
11/30/00	46		37	9	4.7
12/1/00	37		31	6	4.2
12/2/00	34		31	3	3.7
12/3/00	33		31	2	3.5
12/4/00	32		31	1	3.4
12/5/00	31		31	0	3.2
12/6/00	30		29	1	3.4
12/7/00	30		29	1	3.4
12/8/00	29		29	0	3.2
12/9/00	29		29	0	3.2
12/10/00	29		29	0	3.2
12/11/00	28		28	0	3.2
12/12/00	30		28	2	3.5
12/13/00	28		28	0	3.2
12/14/00	161		28	133	24.7
12/15/00	81		28	53	11.8
12/16/00	60		60	0	3.2
12/17/00	1760		60	1700	277.9
12/18/00	163		60	103	19.8
12/19/00	78		60	18	6.1
12/20/00	60		60	0	3.2
12/21/00	58		50	8	4.5
12/22/00	56		50	6	4.2
12/23/00	54		50	4	3.8
12/24/00	52		50	2	3.5
12/25/00	50		50	0	3.2
12/26/00	49		45	4	3.8
12/27/00	48		45	3	3.7
12/28/00	47		45	2	3.5
12/29/00	46		45	1	3.4
12/30/00	45		45	0	3.2
12/31/00	45		45	0	3.2

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/01	44		43	1	3.4
1/2/01	43		43	0	3.2
1/3/01	43		43	0	3.2
1/4/01	43		43	0	3.2
1/5/01	46		43	3	3.7
1/6/01	50		45	5	4.0
1/7/01	47		45	2	3.5
1/8/01	49		45	4	3.8
1/9/01	53		45	8	4.5
1/10/01	45		45	0	3.2
1/11/01	44		42	2	3.5
1/12/01	44		42	2	3.5
1/13/01	43		42	1	3.4
1/14/01	42		42	0	3.2
1/15/01	69		42	27	7.6
1/16/01	63		47	16	5.8
1/17/01	52		47	5	4.0
1/18/01	47		47	0	3.2
1/19/01	389		47	342	58.5
1/20/01	388		47	341	58.3
1/21/01	160		64	96	18.7
1/22/01	84		64	20	6.4
1/23/01	71		64	7	4.3
1/24/01	70		64	6	4.2
1/25/01	64		64	0	3.2
1/26/01	58		53	5	4.0
1/27/01	59		53	6	4.2
1/28/01	57		53	4	3.8
1/29/01	53		53	0	3.2
1/30/01	541		53	488	82.0
1/31/01	209		66	143	26.3
2/1/01	112		66	46	10.6
2/2/01	89		66	23	6.9
2/3/01	77		66	11	5.0
2/4/01	66		66	0	3.2
2/5/01	404		103	301	51.8
2/6/01	227		103	124	23.2
2/7/01	157		103	54	11.9
2/8/01	128		103	25	7.2
2/9/01	103		103	0	3.2
2/10/01	118		82	36	9.0
2/11/01	93		82	11	5.0
2/12/01	82		82	0	3.2
2/13/01	87		82	5	4.0
2/14/01	88		82	6	4.2
2/15/01	89		80	9	4.7

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/16/01	90		80	10	4.8
2/17/01	161		80	81	16.3
2/18/01	92		80	12	5.1
2/19/01	80		80	0	3.2
2/20/01	80		72	8	4.5
2/21/01	80		72	8	4.5
2/22/01	72		72	0	3.2
2/23/01	82		72	10	4.8
2/24/01	78		72	6	4.2
2/25/01	89		76	13	5.3
2/26/01	156		76	80	16.1
2/27/01	103		76	27	7.6
2/28/01	84		76	8	4.5
3/1/01	76		76	0	3.2
3/2/01	76		74	2	3.5
3/3/01	74		74	0	3.2
3/4/01	87		74	13	5.3
3/5/01	140		74	66	13.9
3/6/01	104		74	30	8.0
3/7/01	96		78	18	6.1
3/8/01	108		78	30	8.0
3/9/01	95		78	17	5.9
3/10/01	86		78	8	4.5
3/11/01	78		78	0	3.2
3/12/01	77		77	0	3.2
3/13/01	214		77	137	25.3
3/14/01	111		77	34	8.7
3/15/01	92		77	15	5.6
3/16/01	114		77	37	9.2
3/17/01	153		83	70	14.5
3/18/01	103		83	20	6.4
3/19/01	88		83	5	4.0
3/20/01	83		83	0	3.2
3/21/01	293		83	210	37.1
3/22/01	236		89	147	26.9
3/23/01	121		89	32	8.4
3/24/01	103		89	14	5.5
3/25/01	96		89	7	4.3
3/26/01	89	2	89	0	3.2
3/27/01	85		83	2	3.5
3/28/01	83		83	0	3.2
3/29/01	87		83	4	3.8
3/30/01	794		83	711	118.1
3/31/01	207		83	124	23.2
4/1/01	148		102	46	10.6
4/2/01	128		102	26	7.4
4/3/01	114		102	12	5.1

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/4/01	105		102	3	3.7
4/5/01	102		102	0	3.2
4/6/01	102		96	6	4.2
4/7/01	103		96	7	4.3
4/8/01	96		96	0	3.2
4/9/01	97		96	1	3.4
4/10/01	116		96	20	6.4
4/11/01	118		92	26	7.4
4/12/01	140		92	48	11.0
4/13/01	109		92	17	5.9
4/14/01	96		92	4	3.8
4/15/01	92		92	0	3.2
4/16/01	148		92	56	12.2
4/17/01	119		92	27	7.6
4/18/01	109		92	17	5.9
4/19/01	97		92	5	4.0
4/20/01	92		92	0	3.2
4/21/01	91		78	13	5.3
4/22/01	88		78	10	4.8
4/23/01	86		78	8	4.5
4/24/01	83		78	5	4.0
4/25/01	78		78	0	3.2
4/26/01	78		73	5	4.0
4/27/01	76		73	3	3.7
4/28/01	75		73	2	3.5
4/29/01	73		73	0	3.2
4/30/01	73		73	0	3.2
5/1/01	72		60	12	5.1
5/2/01	68		60	8	4.5
5/3/01	65		60	5	4.0
5/4/01	62		60	2	3.5
5/5/01	60		60	0	3.2
5/6/01	59		58	1	3.4
5/7/01	59		58	1	3.4
5/8/01	58		58	0	3.2
5/9/01	59		58	1	3.4
5/10/01	58		58	0	3.2
5/11/01	55		48	7	4.3
5/12/01	53		48	5	4.0
5/13/01	52		48	4	3.8
5/14/01	48		48	0	3.2
5/15/01	48		48	0	3.2
5/16/01	47		47	0	3.2
5/17/01	48		47	1	3.4
5/18/01	52		47	5	4.0
5/19/01	56		47	9	4.7
5/20/01	53		47	6	4.2

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/21/01	88		57	31	8.2
5/22/01	128		57	71	14.7
5/23/01	107		57	50	11.3
5/24/01	64		57	7	4.3
5/25/01	57		57	0	3.2
5/26/01	317		72	245	42.8
5/27/01	384		72	312	53.6
5/28/01	117		72	45	10.5
5/29/01	83		72	11	5.0
5/30/01	72		72	0	3.2
5/31/01	62		62	0	3.2
6/1/01	72		62	10	4.8
6/2/01	178		62	116	21.9
6/3/01	86		62	24	7.1
6/4/01	70		62	8	4.5
6/5/01	63		52	11	5.0
6/6/01	59		52	7	4.3
6/7/01	60		52	8	4.5
6/8/01	56		52	4	3.8
6/9/01	52		52	0	3.2
6/10/01	49		45	4	3.8
6/11/01	47		45	2	3.5
6/12/01	65	10	45	20	6.4
6/13/01	55		45	10	4.8
6/14/01	45		45	0	3.2
6/15/01	45		45	0	3.2
6/16/01	319		45	274	47.5
6/17/01	248		45	203	36.0
6/18/01	88		45	43	10.1
6/19/01	68		45	23	6.9
6/20/01	59		53	6	4.2
6/21/01	57		53	4	3.8
6/22/01	56		53	3	3.7
6/23/01	56		53	3	3.7
6/24/01	53		53	0	3.2
6/25/01	51		36	15	5.6
6/26/01	47		36	11	5.0
6/27/01	44		36	8	4.5
6/28/01	40		36	4	3.8
6/29/01	36		36	0	3.2
6/30/01	37		35	2	3.5
7/1/01	36		35	1	3.4
7/2/01	39		35	4	3.8
7/3/01	35		35	0	3.2
7/4/01	36		35	1	3.4
7/5/01	45		36	9	4.7
7/6/01	42		36	6	4.2

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/7/01	36		36	0	3.2
7/8/01	36		36	0	3.2
7/9/01	60		36	24	7.1
7/10/01	51		34	17	5.9
7/11/01	86		34	52	11.6
7/12/01	40		34	6	4.2
7/13/01	36		34	2	3.5
7/14/01	34		34	0	3.2
7/15/01	32		29	3	3.7
7/16/01	30		29	1	3.4
7/17/01	29		29	0	3.2
7/18/01	30		29	1	3.4
7/19/01	33		29	4	3.8
7/20/01	28		24	4	3.8
7/21/01	27		24	3	3.7
7/22/01	26		24	2	3.5
7/23/01	25		24	1	3.4
7/24/01	24		24	0	3.2
7/25/01	24		23	1	3.4
7/26/01	24		23	1	3.4
7/27/01	26		23	3	3.7
7/28/01	23		23	0	3.2
7/29/01	24		23	1	3.4
7/30/01	28		20	8	4.5
7/31/01	26		20	6	4.2
8/1/01	24		20	4	3.8
8/2/01	21		20	1	3.4
8/3/01	20		20	0	3.2
8/4/01	21		20	1	3.4
8/5/01	21		20	1	3.4
8/6/01	21		20	1	3.4
8/7/01	21		20	1	3.4
8/8/01	20		20	0	3.2
8/9/01	19		19	0	3.2
8/10/01	73		19	54	11.9
8/11/01	297		19	278	48.1
8/12/01	218		19	199	35.4
8/13/01	116		19	97	18.9
8/14/01	53		31	22	6.8
8/15/01	40		31	9	4.7
8/16/01	34		31	3	3.7
8/17/01	32		31	1	3.4
8/18/01	31		31	0	3.2
8/19/01	32		26	6	4.2
8/20/01	36		26	10	4.8
8/21/01	29		26	3	3.7
8/22/01	27		26	1	3.4

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/23/01	26		26	0	3.2
8/24/01	27		24	3	3.7
8/25/01	25		24	1	3.4
8/26/01	24		24	0	3.2
8/27/01	26		24	2	3.5
8/28/01	30	7	24	6	4.2
8/29/01	24		23	1	3.4
8/30/01	27		23	4	3.8
8/31/01	31		23	8	4.5
9/1/01	25		23	2	3.5
9/2/01	23		23	0	3.2
9/3/01	22		22	0	3.2
9/4/01	55		22	33	8.5
9/5/01	62		22	40	9.7
9/6/01	29		22	7	4.3
9/7/01	25		22	3	3.7
9/8/01	25		23	2	3.5
9/9/01	23		23	0	3.2
9/10/01	24		23	1	3.4
9/11/01	25		23	2	3.5
9/12/01	23		23	0	3.2
9/13/01	22		22	0	3.2
9/14/01	27		22	5	4.0
9/15/01	28		22	6	4.2
9/16/01	26		22	4	3.8
9/17/01	24		22	2	3.5
9/18/01	24		24	0	3.2
9/19/01	25		24	1	3.4
9/20/01	125		24	101	19.5
9/21/01	184		24	160	29.0
9/22/01	35		24	11	5.0
9/23/01	25		25	0	3.2
9/24/01	25		25	0	3.2
9/25/01	165		25	140	25.8
9/26/01	49		25	24	7.1
9/27/01	31		25	6	4.2
9/28/01	26		24	2	3.5
9/29/01	24		24	0	3.2
9/30/01	24		24	0	3.2
10/1/01	26		24	2	3.5
10/2/01	25		24	1	3.4
10/3/01	24		20	4	3.8
10/4/01	23		20	3	3.7
10/5/01	22		20	2	3.5
10/6/01	29		20	9	4.7
10/7/01	20		20	0	3.2
10/8/01	19		18	1	3.4

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/9/01	18	1	18	0	3.2
10/10/01	19		18	1	3.4
10/11/01	20		18	2	3.5
10/12/01	19		18	1	3.4
10/13/01	19		19	0	3.2
10/14/01	19		19	0	3.2
10/15/01	45		19	26	7.4
10/16/01	30		19	11	5.0
10/17/01	26		19	7	4.3
10/18/01	28		23	5	4.0
10/19/01	25		23	2	3.5
10/20/01	24		23	1	3.4
10/21/01	24		23	1	3.4
10/22/01	23		23	0	3.2
10/23/01	23		20	3	3.7
10/24/01	22		20	2	3.5
10/25/01	22		20	2	3.5
10/26/01	21		20	1	3.4
10/27/01	20		20	0	3.2
10/28/01	19		19	0	3.2
10/29/01	20		19	1	3.4
10/30/01	21		19	2	3.5
10/31/01	20		19	1	3.4
11/1/01	19		19	0	3.2
11/2/01	21		20	1	3.4
11/3/01	23		20	3	3.7
11/4/01	30		20	10	4.8
11/5/01	25		20	5	4.0
11/6/01	20		20	0	3.2
11/7/01	19		18	1	3.4
11/8/01	21		18	3	3.7
11/9/01	19		18	1	3.4
11/10/01	19		18	1	3.4
11/11/01	18		18	0	3.2
11/12/01	18		17	1	3.4
11/13/01	17		17	0	3.2
11/14/01	22		17	5	4.0
11/15/01	21		17	4	3.8
11/16/01	20		17	3	3.7
11/17/01	21		20	1	3.4
11/18/01	21		20	1	3.4
11/19/01	20		20	0	3.2
11/20/01	25		20	5	4.0
11/21/01	22		20	2	3.5
11/22/01	20		19	1	3.4
11/23/01	19		19	0	3.2
11/24/01	22		19	3	3.7

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/25/01	38		19	19	6.3
11/26/01	65		19	46	10.6
11/27/01	30		26	4	3.8
11/28/01	27		26	1	3.4
11/29/01	27		26	1	3.4
11/30/01	26		26	0	3.2
12/1/01	26		26	0	3.2
12/2/01	24		24	0	3.2
12/3/01	24		24	0	3.2
12/4/01	24		24	0	3.2
12/5/01	25		24	1	3.4
12/6/01	25		24	1	3.4
12/7/01	25		25	0	3.2
12/8/01	26		25	1	3.4
12/9/01	43		25	18	6.1
12/10/01	33		25	8	4.5
12/11/01	34		25	9	4.7
12/12/01	34		33	1	3.4
12/13/01	33		33	0	3.2
12/14/01	36		33	3	3.7
12/15/01	46		33	13	5.3
12/16/01	35		33	2	3.5
12/17/01	34		31	3	3.7
12/18/01	54		31	23	6.9
12/19/01	39		31	8	4.5
12/20/01	33		31	2	3.5
12/21/01	31		31	0	3.2
12/22/01	30		30	0	3.2
12/23/01	33		30	3	3.7
12/24/01	48		30	18	6.1
12/25/01	41		30	11	5.0
12/26/01	36		30	6	4.2
12/27/01	32		23	9	4.7
12/28/01	29		23	6	4.2
12/29/01	31		23	8	4.5
12/30/01	28		23	5	4.0
12/31/01	23		23	0	3.2

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/02	22		19	3	3.7
1/2/02	21		19	2	3.5
1/3/02	20		19	1	3.4
1/4/02	19		19	0	3.2
1/5/02	19		19	0	3.2
1/6/02	35		35	0	3.2
1/7/02	86		35	51	11.4
1/8/02	48		35	13	5.3
1/9/02	37		35	2	3.5
1/10/02	35		35	0	3.2
1/11/02	119		33	86	17.1
1/12/02	75		33	42	10.0
1/13/02	43		33	10	4.8
1/14/02	35		33	2	3.5
1/15/02	33		33	0	3.2
1/16/02	32		30	2	3.5
1/17/02	32		30	2	3.5
1/18/02	31		30	1	3.4
1/19/02	30		30	0	3.2
1/20/02	35		30	5	4.0
1/21/02	32		31	1	3.4
1/22/02	31		31	0	3.2
1/23/02	34		31	3	3.7
1/24/02	96		31	65	13.7
1/25/02	99		31	68	14.2
1/26/02	49		36	13	5.3
1/27/02	42		36	6	4.2
1/28/02	38		36	2	3.5
1/29/02	36		36	0	3.2
1/30/02	37		36	1	3.4
1/31/02	52		42	10	4.8
2/1/02	55		42	13	5.3
2/2/02	50		42	8	4.5
2/3/02	43		42	1	3.4
2/4/02	42		42	0	3.2
2/5/02	39		36	3	3.7
2/6/02	38		36	2	3.5
2/7/02	37		36	1	3.4
2/8/02	38		36	2	3.5
2/9/02	36		36	0	3.2
2/10/02	36		35	1	3.4
2/11/02	40		35	5	4.0
2/12/02	36		35	1	3.4
2/13/02	36		35	1	3.4
2/14/02	35		35	0	3.2
2/15/02	35		34	1	3.4
2/16/02	36		34	2	3.5

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/02	36		34	2	3.5
2/18/02	36		34	2	3.5
2/19/02	34		34	0	3.2
2/20/02	35		35	0	3.2
2/21/02	44		35	9	4.7
2/22/02	39		35	4	3.8
2/23/02	36		35	1	3.4
2/24/02	36		35	1	3.4
2/25/02	36		32	4	3.8
2/26/02	36		32	4	3.8
2/27/02	35		32	3	3.7
2/28/02	33		32	1	3.4
3/1/02	32		32	0	3.2
3/2/02	34		34	0	3.2
3/3/02	202		34	168	30.3
3/4/02	64		34	30	8.0
3/5/02	42		34	8	4.5
3/6/02	38		34	4	3.8
3/7/02	37		35	2	3.5
3/8/02	35		35	0	3.2
3/9/02	35		35	0	3.2
3/10/02	45		35	10	4.8
3/11/02	38		35	3	3.7
3/12/02	36		36	0	3.2
3/13/02	50		36	14	5.5
3/14/02	53		36	17	5.9
3/15/02	42		36	6	4.2
3/16/02	39		36	3	3.7
3/17/02	37		37	0	3.2
3/18/02	65		37	28	7.7
3/19/02	63		37	26	7.4
3/20/02	199		37	162	29.4
3/21/02	140		37	103	19.8
3/22/02	64		45	19	6.3
3/23/02	51		45	6	4.2
3/24/02	47		45	2	3.5
3/25/02	45		45	0	3.2
3/26/02	46		45	1	3.4
3/27/02	162		49	113	21.5
3/28/02	68		49	19	6.3
3/29/02	55		49	6	4.2
3/30/02	49		49	0	3.2
3/31/02	51		49	2	3.5
4/1/02	75		44	31	8.2
4/2/02	53		44	9	4.7
4/3/02	49		44	5	4.0
4/4/02	46		44	2	3.5

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/5/02	44		44	0	3.2
4/6/02	43		39	4	3.8
4/7/02	40		39	1	3.4
4/8/02	39		39	0	3.2
4/9/02	39		39	0	3.2
4/10/02	42		39	3	3.7
4/11/02	39		39	0	3.2
4/12/02	39		39	0	3.2
4/13/02	40		39	1	3.4
4/14/02	39		39	0	3.2
4/15/02	41		39	2	3.5
4/16/02	50		35	15	5.6
4/17/02	41		35	6	4.2
4/18/02	35		35	0	3.2
4/19/02	39		35	4	3.8
4/20/02	54		35	19	6.3
4/21/02	35		32	3	3.7
4/22/02	40		32	8	4.5
4/23/02	37		32	5	4.0
4/24/02	32		32	0	3.2
4/25/02	33		32	1	3.4
4/26/02	36		32	4	3.8
4/27/02	32		32	0	3.2
4/28/02	165		32	133	24.7
4/29/02	75	10	32	43	10.1
4/30/02	46		32	14	5.5
5/1/02	43		40	3	3.7
5/2/02	87		40	47	10.8
5/3/02	82		40	42	10.0
5/4/02	47		40	7	4.3
5/5/02	40		40	0	3.2
5/6/02	38		36	2	3.5
5/7/02	36		36	0	3.2
5/8/02	37		36	1	3.4
5/9/02	36		36	0	3.2
5/10/02	36		36	0	3.2
5/11/02	32		32	0	3.2
5/12/02	37		32	5	4.0
5/13/02	52		32	20	6.4
5/14/02	61		32	29	7.9
5/15/02	37		32	5	4.0
5/16/02	33		30	3	3.7
5/17/02	30		30	0	3.2
5/18/02	202		30	172	31.0
5/19/02	75		30	45	10.5
5/20/02	45		30	15	5.6
5/21/02	38		29	9	4.7

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/22/02	35		29	6	4.2
5/23/02	33		29	4	3.8
5/24/02	30		29	1	3.4
5/25/02	29		29	0	3.2
5/26/02	29		28	1	3.4
5/27/02	30		28	2	3.5
5/28/02	29		28	1	3.4
5/29/02	28		28	0	3.2
5/30/02	35		28	7	4.3
5/31/02	24		23	1	3.4
6/1/02	25		23	2	3.5
6/2/02	24		23	1	3.4
6/3/02	24	3	23	1	3.4
6/4/02	23		23	0	3.2
6/5/02	25		25	0	3.2
6/6/02	33		25	8	4.5
6/7/02	130		25	105	20.2
6/8/02	37		25	12	5.1
6/9/02	32		25	7	4.3
6/10/02	29		27	2	3.5
6/11/02	27		27	0	3.2
6/12/02	28		27	1	3.4
6/13/02	35		27	8	4.5
6/14/02	102		27	75	15.3
6/15/02	51		32	19	6.3
6/16/02	38		32	6	4.2
6/17/02	32		32	0	3.2
6/18/02	32		32	0	3.2
6/19/02	36		32	4	3.8
6/20/02	30		24	6	4.2
6/21/02	26		24	2	3.5
6/22/02	25		24	1	3.4
6/23/02	24		24	0	3.2
6/24/02	25		24	1	3.4
6/25/02	44		24	20	6.4
6/26/02	26		24	2	3.5
6/27/02	24		24	0	3.2
6/28/02	32		24	8	4.5
6/29/02	24		24	0	3.2
6/30/02	22		18	4	3.8
7/1/02	23		18	5	4.0
7/2/02	21		18	3	3.7
7/3/02	18		18	0	3.2
7/4/02	18		18	0	3.2
7/5/02	16		14	2	3.5
7/6/02	14		14	0	3.2
7/7/02	14		14	0	3.2

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/8/02	15		14	1	3.4
7/9/02	18		14	4	3.8
7/10/02	25		13	12	5.1
7/11/02	15		13	2	3.5
7/12/02	13		13	0	3.2
7/13/02	13		13	0	3.2
7/14/02	16		13	3	3.7
7/15/02	18		12	6	4.2
7/16/02	14		12	2	3.5
7/17/02	13		12	1	3.4
7/18/02	12		12	0	3.2
7/19/02	12		12	0	3.2
7/20/02	12		11	1	3.4
7/21/02	11		11	0	3.2
7/22/02	11		11	0	3.2
7/23/02	11		11	0	3.2
7/24/02	13		11	2	3.5
7/25/02	13		13	0	3.2
7/26/02	13		13	0	3.2
7/27/02	13		13	0	3.2
7/28/02	14		13	1	3.4
7/29/02	14		13	1	3.4
7/30/02	11		7.9	3.1	3.7
7/31/02	9.2		7.9	1.3	3.4
8/1/02	8.9		7.9	1	3.4
8/2/02	8		7.9	0.1	3.2
8/3/02	7.9		7.9	0	3.2
8/4/02	7.9		6.5	1.4	3.4
8/5/02	7.9		6.5	1.4	3.4
8/6/02	7.6		6.5	1.1	3.4
8/7/02	6.5		6.5	0	3.2
8/8/02	6.5		6.5	0	3.2
8/9/02	7.4		5.4	2	3.5
8/10/02	7.3		5.4	1.9	3.5
8/11/02	5.4		5.4	0	3.2
8/12/02	6.9		5.4	1.5	3.4
8/13/02	6.6	4	5.4	1.2	3.4
8/14/02	5.7		3.8	1.9	3.5
8/15/02	5.3		3.8	1.5	3.4
8/16/02	3.9		3.8	0.1	3.2
8/17/02	3.8		3.8	0	3.2
8/18/02	12		3.8	8.2	4.5
8/19/02	7.8		4.7	3.1	3.7
8/20/02	6.9		4.7	2.2	3.6
8/21/02	5.5		4.7	0.8	3.3
8/22/02	5.2		4.7	0.5	3.3
8/23/02	4.7		4.7	0	3.2

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/24/02	13		10	3	3.7
8/25/02	36		10	26	7.4
8/26/02	14		10	4	3.8
8/27/02	10		10	0	3.2
8/28/02	11		10	1	3.4
8/29/02	91		14	77	15.6
8/30/02	29		14	15	5.6
8/31/02	14		14	0	3.2
9/1/02	31		14	17	5.9
9/2/02	33		14	19	6.3
9/3/02	17		10	7	4.3
9/4/02	15		10	5	4.0
9/5/02	13		10	3	3.7
9/6/02	11		10	1	3.4
9/7/02	10		10	0	3.2
9/8/02	10		7.5	2.5	3.6
9/9/02	9.5		7.5	2	3.5
9/10/02	9		7.5	1.5	3.4
9/11/02	8.5		7.5	1	3.4
9/12/02	7.5		7.5	0	3.2
9/13/02	7		7	0	3.2
9/14/02	7.4		7	0.4	3.3
9/15/02	8		7	1	3.4
9/16/02	9		7	2	3.5
9/17/02	10		7	3	3.7
9/18/02	8		7	1	3.4
9/19/02	7		7	0	3.2
9/20/02	8		7	1	3.4
9/21/02	7		7	0	3.2
9/22/02	8		7	1	3.4
9/23/02	7.5		7.5	0	3.2
9/24/02	7.5		7.5	0	3.2
9/25/02	7.7		7.5	0.2	3.2
9/26/02	17		7.5	9.5	4.7
9/27/02	67		7.5	59.5	12.8
9/28/02	45		13	32	8.4
9/29/02	19		13	6	4.2
9/30/02	15		13	2	3.5
10/1/02	14		13	1	3.4
10/2/02	13		13	0	3.2
10/3/02	12		11	1	3.4
10/4/02	12		11	1	3.4
10/5/02	12		11	1	3.4
10/6/02	11		11	0	3.2
10/7/02	11		11	0	3.2
10/8/02	11		11	0	3.2
10/9/02	11		11	0	3.2

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/10/02	188		11	177	31.8
10/11/02	345		11	334	57.2
10/12/02	132		11	121	22.7
10/13/02	41		25	16	5.8
10/14/02	28		25	3	3.7
10/15/02	25		25	0	3.2
10/16/02	113		25	88	17.4
10/17/02	97		25	72	14.8
10/18/02	39		27	12	5.1
10/19/02	31		27	4	3.8
10/20/02	29		27	2	3.5
10/21/02	27		27	0	3.2
10/22/02	29		27	2	3.5
10/23/02	26		25	1	3.4
10/24/02	25		25	0	3.2
10/25/02	27		25	2	3.5
10/26/02	72		25	47	10.8
10/27/02	41		25	16	5.8
10/28/02	31		31	0	3.2
10/29/02	35		31	4	3.8
10/30/02	93		31	62	13.2
10/31/02	78		31	47	10.8
11/1/02	49		31	18	6.1
11/2/02	40		34	6	4.2
11/3/02	35		34	1	3.4
11/4/02	34		34	0	3.2
11/5/02	34		34	0	3.2
11/6/02	80		34	46	10.6
11/7/02	49		36	13	5.3
11/8/02	40		36	4	3.8
11/9/02	38		36	2	3.5
11/10/02	36		36	0	3.2
11/11/02	43		36	7	4.3
11/12/02	88		50	38	9.3
11/13/02	125		50	75	15.3
11/14/02	55		50	5	4.0
11/15/02	50		50	0	3.2
11/16/02	80		50	30	8.0
11/17/02	330		55	275	47.6
11/18/02	232	26	55	177	31.8
11/19/02	86		55	31	8.2
11/20/02	65		55	10	4.8
11/21/02	55		55	0	3.2
11/22/02	59		48	11	5.0
11/23/02	63		48	15	5.6
11/24/02	52		48	4	3.8
11/25/02	50		48	2	3.5

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/26/02	48		48	0	3.2
11/27/02	62		46	16	5.8
11/28/02	57		46	11	5.0
11/29/02	51		46	5	4.0
11/30/02	50		46	4	3.8
12/1/02	46		46	0	3.2
12/2/02	42		34	8	4.5
12/3/02	38		34	4	3.8
12/4/02	34		34	0	3.2
12/5/02	38		34	4	3.8
12/6/02	50		34	16	5.8
12/7/02	40		38	2	3.5
12/8/02	38		38	0	3.2
12/9/02	42		38	4	3.8
12/10/02	40		38	2	3.5
12/11/02	278		38	240	42.0
12/12/02	385		101	284	49.1
12/13/02	201		101	100	19.4
12/14/02	503		101	402	68.1
12/15/02	152		101	51	11.4
12/16/02	101		101	0	3.2
12/17/02	81		67	14	5.5
12/18/02	70		67	3	3.7
12/19/02	67		67	0	3.2
12/20/02	220		67	153	27.9
12/21/02	154		67	87	17.3
12/22/02	95		71	24	7.1
12/23/02	82		71	11	5.0
12/24/02	71		71	0	3.2
12/25/02	369		71	298	51.3
12/26/02	249		71	178	32.0
12/27/02	131		87	44	10.3
12/28/02	103		87	16	5.8
12/29/02	93		87	6	4.2
12/30/02	87		87	0	3.2
12/31/02	89		87	2	3.5

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/03	305		135	170	30.7
1/2/03	270		135	135	25.0
1/3/03	187		135	52	11.6
1/4/03	264		135	129	24.0
1/5/03	135		135	0	3.2
1/6/03	122		99	23	6.9
1/7/03	109		99	10	4.8
1/8/03	105		99	6	4.2
1/9/03	117		99	18	6.1
1/10/03	99		99	0	3.2
1/11/03	85		71	14	5.5
1/12/03	78		71	7	4.3
1/13/03	76		71	5	4.0
1/14/03	75		71	4	3.8
1/15/03	71		71	0	3.2
1/16/03	65		50	15	5.6
1/17/03	60		50	10	4.8
1/18/03	56		50	6	4.2
1/19/03	54		50	4	3.8
1/20/03	50		50	0	3.2
1/21/03	46		38	8	4.5
1/22/03	44		38	6	4.2
1/23/03	42		38	4	3.8
1/24/03	40		38	2	3.5
1/25/03	38		38	0	3.2
1/26/03	36		32	4	3.8
1/27/03	36		32	4	3.8
1/28/03	34		32	2	3.5
1/29/03	34		32	2	3.5
1/30/03	32		32	0	3.2
1/31/03	30		30	0	3.2
2/1/03	70		30	40	9.7
2/2/03	66		30	36	9.0
2/3/03	62		30	32	8.4
2/4/03	104		30	74	15.2
2/5/03	90		52	38	9.3
2/6/03	63		52	11	5.0
2/7/03	60		52	8	4.5
2/8/03	54		52	2	3.5
2/9/03	52		52	0	3.2
2/10/03	50		42	8	4.5
2/11/03	48		42	6	4.2
2/12/03	46		42	4	3.8
2/13/03	44		42	2	3.5
2/14/03	42		42	0	3.2
2/15/03	40		34	6	4.2
2/16/03	34		34	0	3.2

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/03	40		34	6	4.2
2/18/03	95		34	61	13.1
2/19/03	84		34	50	11.3
2/20/03	81		81	0	3.2
2/21/03	83		81	2	3.5
2/22/03	1140		81	1059	174.3
2/23/03	1290		81	1209	198.5
2/24/03	492		81	411	69.6
2/25/03	208		85	123	23.1
2/26/03	135		85	50	11.3
2/27/03	101		85	16	5.8
2/28/03	93		85	8	4.5
3/1/03	85		85	0	3.2
3/2/03	386		152	234	41.0
3/3/03	457		152	305	52.5
3/4/03	152		152	0	3.2
3/5/03	358		152	206	36.5
3/6/03	886		152	734	121.8
3/7/03	282		143	139	25.7
3/8/03	270		143	127	23.7
3/9/03	477		143	334	57.2
3/10/03	229		143	86	17.1
3/11/03	143		143	0	3.2
3/12/03	134		124	10	4.8
3/13/03	159		124	35	8.9
3/14/03	157		124	33	8.5
3/15/03	125		124	1	3.4
3/16/03	124		124	0	3.2
3/17/03	171		108	63	13.4
3/18/03	132		108	24	7.1
3/19/03	108		108	0	3.2
3/20/03	479		108	371	63.1
3/21/03	663		108	555	92.9
3/22/03	204		120	84	16.8
3/23/03	156		120	36	9.0
3/24/03	137		120	17	5.9
3/25/03	123		120	3	3.7
3/26/03	120		120	0	3.2
3/27/03	135		112	23	6.9
3/28/03	112		112	0	3.2
3/29/03	117		112	5	4.0
3/30/03	166		112	54	11.9
3/31/03	155		112	43	10.1
4/1/03	115		98	17	5.9
4/2/03	108		98	10	4.8
4/3/03	102		98	4	3.8
4/4/03	98		98	0	3.2

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/5/03	98		98	0	3.2
4/6/03	92		92	0	3.2
4/7/03	106		92	14	5.5
4/8/03	129		92	37	9.2
4/9/03	160		92	68	14.2
4/10/03	133		92	41	9.8
4/11/03	354		105	249	43.4
4/12/03	198		105	93	18.2
4/13/03	135		105	30	8.0
4/14/03	111		105	6	4.2
4/15/03	105		105	0	3.2
4/16/03	99		91	8	4.5
4/17/03	93		91	2	3.5
4/18/03	95		91	4	3.8
4/19/03	95		91	4	3.8
4/20/03	91		91	0	3.2
4/21/03	90		83	7	4.3
4/22/03	96		83	13	5.3
4/23/03	88		83	5	4.0
4/24/03	83		83	0	3.2
4/25/03	83		83	0	3.2
4/26/03	157		83	74	15.2
4/27/03	116		83	33	8.5
4/28/03	92		83	9	4.7
4/29/03	84		83	1	3.4
4/30/03	83		83	0	3.2
5/1/03	81		76	5	4.0
5/2/03	80		76	4	3.8
5/3/03	77		76	1	3.4
5/4/03	76		76	0	3.2
5/5/03	77	4	76	1	3.4
5/6/03	81		80	1	3.4
5/7/03	80		80	0	3.2
5/8/03	83		80	3	3.7
5/9/03	84		80	4	3.8
5/10/03	86		80	6	4.2
5/11/03	84		65	19	6.3
5/12/03	75		65	10	4.8
5/13/03	67		65	2	3.5
5/14/03	65		65	0	3.2
5/15/03	65		65	0	3.2
5/16/03	81		61	20	6.4
5/17/03	93		61	32	8.4
5/18/03	69		61	8	4.5
5/19/03	65		61	4	3.8
5/20/03	61		61	0	3.2
5/21/03	75		75	0	3.2

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/22/03	92		75	17	5.9
5/23/03	78		75	3	3.7
5/24/03	96		75	21	6.6
5/25/03	85		75	10	4.8
5/26/03	408		76	332	56.8
5/27/03	145		76	69	14.3
5/28/03	104		76	28	7.7
5/29/03	87		76	11	5.0
5/30/03	76		76	0	3.2
5/31/03	67		67	0	3.2
6/1/03	112		67	45	10.5
6/2/03	84		67	17	5.9
6/3/03	68	6	67	1	3.4
6/4/03	388		67	321	55.1
6/5/03	237		120	117	22.1
6/6/03	120		120	0	3.2
6/7/03	345		120	225	39.6
6/8/03	249		120	129	24.0
6/9/03	146		120	26	7.4
6/10/03	109		97	12	5.1
6/11/03	97		97	0	3.2
6/12/03	103		97	6	4.2
6/13/03	134		97	37	9.2
6/14/03	112		97	15	5.6
6/15/03	99		81	18	6.1
6/16/03	84		81	3	3.7
6/17/03	81		81	0	3.2
6/18/03	226		81	145	26.6
6/19/03	125		81	44	10.3
6/20/03	1430		139	1291	211.8
6/21/03	890		139	751	124.5
6/22/03	239		139	100	19.4
6/23/03	172		139	33	8.5
6/24/03	139		139	0	3.2
6/25/03	118		86	32	8.4
6/26/03	105		86	19	6.3
6/27/03	98		86	12	5.1
6/28/03	91		86	5	4.0
6/29/03	86		86	0	3.2
6/30/03	83		79	4	3.8
7/1/03	80		79	1	3.4
7/2/03	79		79	0	3.2
7/3/03	120		79	41	9.8
7/4/03	92		79	13	5.3
7/5/03	80		67	13	5.3
7/6/03	78		67	11	5.0
7/7/03	80		67	13	5.3

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/8/03	74		67	7	4.3
7/9/03	67		67	0	3.2
7/10/03	70		61	9	4.7
7/11/03	83		61	22	6.8
7/12/03	68		61	7	4.3
7/13/03	64		61	3	3.7
7/14/03	61		61	0	3.2
7/15/03	60		48	12	5.1
7/16/03	54		48	6	4.2
7/17/03	48		48	0	3.2
7/18/03	49		48	1	3.4
7/19/03	52		48	4	3.8
7/20/03	48		43	5	4.0
7/21/03	45		43	2	3.5
7/22/03	43		43	0	3.2
7/23/03	49		43	6	4.2
7/24/03	58		43	15	5.6
7/25/03	46		42	4	3.8
7/26/03	42		42	0	3.2
7/27/03	42		42	0	3.2
7/28/03	42		42	0	3.2
7/29/03	43		42	1	3.4
7/30/03	41		41	0	3.2
7/31/03	48		41	7	4.3
8/1/03	46		41	5	4.0
8/2/03	46		41	5	4.0
8/3/03	44		41	3	3.7
8/4/03	54		54	0	3.2
8/5/03	61		54	7	4.3
8/6/03	74		54	20	6.4
8/7/03	54		54	0	3.2
8/8/03	58		54	4	3.8
8/9/03	103		68	35	8.9
8/10/03	465		68	397	67.3
8/11/03	116		68	48	11.0
8/12/03	91		68	23	6.9
8/13/03	68		68	0	3.2
8/14/03	60		52	8	4.5
8/15/03	52		52	0	3.2
8/16/03	65		52	13	5.3
8/17/03	99		52	47	10.8
8/18/03	59	4	52	7	4.3
8/19/03	51		47	4	3.8
8/20/03	47		47	0	3.2
8/21/03	47		47	0	3.2
8/22/03	51		47	4	3.8
8/23/03	69		47	22	6.8

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/24/03	45		43	2	3.5
8/25/03	43		43	0	3.2
8/26/03	43		43	0	3.2
8/27/03	46		43	3	3.7
8/28/03	45		43	2	3.5
8/29/03	42		42	0	3.2
8/30/03	116		42	74	15.2
8/31/03	93		42	51	11.4
9/1/03	59		42	17	5.9
9/2/03	89		42	47	10.8
9/3/03	64		49	15	5.6
9/4/03	121		49	72	14.8
9/5/03	90		49	41	9.8
9/6/03	58		49	9	4.7
9/7/03	49		49	0	3.2
9/8/03	47		41	6	4.2
9/9/03	44		41	3	3.7
9/10/03	42		41	1	3.4
9/11/03	42		41	1	3.4
9/12/03	41		41	0	3.2
9/13/03	130		129	1	3.4
9/14/03	129		129	0	3.2
9/15/03	3940		129	3811	618.9
9/16/03	286		129	157	28.6
9/17/03	129		129	0	3.2
9/18/03	167		98	69	14.3
9/19/03	664		98	566	94.6
9/20/03	156		98	58	12.6
9/21/03	116		98	18	6.1
9/22/03	98		98	0	3.2
9/23/03	995		114	881	145.5
9/24/03	201		114	87	17.3
9/25/03	138		114	24	7.1
9/26/03	117		114	3	3.7
9/27/03	114		114	0	3.2
9/28/03	189		93	96	18.7
9/29/03	120		93	27	7.6
9/30/03	110		93	17	5.9
10/1/03	96		93	3	3.7
10/2/03	93		93	0	3.2
10/3/03	87		84	3	3.7
10/4/03	91		84	7	4.3
10/5/03	94		84	10	4.8
10/6/03	87		84	3	3.7
10/7/03	84		84	0	3.2
10/8/03	83		77	6	4.2
10/9/03	83		77	6	4.2

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/10/03	83		77	6	4.2
10/11/03	80		77	3	3.7
10/12/03	77		77	0	3.2
10/13/03	74		74	0	3.2
10/14/03	89		74	15	5.6
10/15/03	402		74	328	56.2
10/16/03	111		74	37	9.2
10/17/03	96		74	22	6.8
10/18/03	103		84	19	6.3
10/19/03	90		84	6	4.2
10/20/03	84		84	0	3.2
10/21/03	86		84	2	3.5
10/22/03	85		84	1	3.4
10/23/03	82		79	3	3.7
10/24/03	79		79	0	3.2
10/25/03	80		79	1	3.4
10/26/03	82		79	3	3.7
10/27/03	1450		79	1371	224.7
10/28/03	375		144	231	40.5
10/29/03	657		144	513	86.1
10/30/03	233		144	89	17.6
10/31/03	168		144	24	7.1
11/1/03	144		144	0	3.2
11/2/03	133		122	11	5.0
11/3/03	125	2	122	3	3.7
11/4/03	122		122	0	3.2
11/5/03	122		122	0	3.2
11/6/03	160		122	38	9.3
11/7/03	175		118	57	12.4
11/8/03	129		118	11	5.0
11/9/03	118		118	0	3.2
11/10/03	118		118	0	3.2
11/11/03	118		118	0	3.2
11/12/03	228		116	112	21.3
11/13/03	153		116	37	9.2
11/14/03	124		116	8	4.5
11/15/03	117		116	1	3.4
11/16/03	116		116	0	3.2
11/17/03	117		113	4	3.8
11/18/03	113		113	0	3.2
11/19/03	436		113	323	55.4
11/20/03	536		113	423	71.5
11/21/03	186		113	73	15.0
11/22/03	154		125	29	7.9
11/23/03	139		125	14	5.5
11/24/03	135		125	10	4.8
11/25/03	141		125	16	5.8

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/26/03	125		125	0	3.2
11/27/03	122		122	0	3.2
11/28/03	214		122	92	18.1
11/29/03	389		122	267	46.3
11/30/03	159		122	37	9.2
12/1/03	142		122	20	6.4
12/2/03	131		120	11	5.0
12/3/03	121		120	1	3.4
12/4/03	120		120	0	3.2
12/5/03	142		120	22	6.8
12/6/03	155		120	35	8.9
12/7/03	139		127	12	5.1
12/8/03	129		127	2	3.5
12/9/03	127		127	0	3.2
12/10/03	197		127	70	14.5
12/11/03	1860		127	1733	283.2
12/12/03	288		201	87	17.3
12/13/03	201		201	0	3.2
12/14/03	282		201	81	16.3
12/15/03	392		201	191	34.1
12/16/03	213		201	12	5.1
12/17/03	539		172	367	62.5
12/18/03	285		172	113	21.5
12/19/03	204		172	32	8.4
12/20/03	188		172	16	5.8
12/21/03	172		172	0	3.2
12/22/03	168		168	0	3.2
12/23/03	171		168	3	3.7
12/24/03	334		168	166	30.0
12/25/03	242		168	74	15.2
12/26/03	180		168	12	5.1
12/27/03	171		151	20	6.4
12/28/03	160		151	9	4.7
12/29/03	157		151	6	4.2
12/30/03	163		151	12	5.1
12/31/03	151		151	0	3.2

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/04	151		151	0	3.2
1/2/04	151		151	0	3.2
1/3/04	153		151	2	3.5
1/4/04	151		151	0	3.2
1/5/04	188		151	37	9.2
1/6/04	174		111	63	13.4
1/7/04	141		111	30	8.0
1/8/04	133		111	22	6.8
1/9/04	140		111	29	7.9
1/10/04	111		111	0	3.2
1/11/04	116		116	0	3.2
1/12/04	135		116	19	6.3
1/13/04	135		116	19	6.3
1/14/04	130		116	14	5.5
1/15/04	123		116	7	4.3
1/16/04	104		104	0	3.2
1/17/04	119		104	15	5.6
1/18/04	163		104	59	12.7
1/19/04	150		104	46	10.6
1/20/04	120		104	16	5.8
1/21/04	110		100	10	4.8
1/22/04	105		100	5	4.0
1/23/04	100		100	0	3.2
1/24/04	110		100	10	4.8
1/25/04	105		100	5	4.0
1/26/04	105		105	0	3.2
1/27/04	120		105	15	5.6
1/28/04	120		105	15	5.6
1/29/04	110		105	5	4.0
1/30/04	110		105	5	4.0
1/31/04	100		100	0	3.2
2/1/04	100		100	0	3.2
2/2/04	110		100	10	4.8
2/3/04	389		100	289	49.9
2/4/04	568		100	468	78.8
2/5/04	237		167	70	14.5
2/6/04	1820		167	1653	270.3
2/7/04	934		167	767	127.1
2/8/04	257		167	90	17.7
2/9/04	167		167	0	3.2
2/10/04	203		132	71	14.7
2/11/04	183		132	51	11.4
2/12/04	143		132	11	5.0
2/13/04	132		132	0	3.2
2/14/04	132		132	0	3.2
2/15/04	125		106	19	6.3
2/16/04	109		106	3	3.7

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/04	106		106	0	3.2
2/18/04	110		106	4	3.8
2/19/04	115		106	9	4.7
2/20/04	120		115	5	4.0
2/21/04	128		115	13	5.3
2/22/04	123		115	8	4.5
2/23/04	115		115	0	3.2
2/24/04	116		115	1	3.4
2/25/04	110		98	12	5.1
2/26/04	102		98	4	3.8
2/27/04	101		98	3	3.7
2/28/04	98		98	0	3.2
2/29/04	98		98	0	3.2
3/1/04	99		99	0	3.2
3/2/04	107		99	8	4.5
3/3/04	106		99	7	4.3
3/4/04	110		99	11	5.0
3/5/04	109		99	10	4.8
3/6/04	337		110	227	39.9
3/7/04	186		110	76	15.5
3/8/04	151		110	41	9.8
3/9/04	118		110	8	4.5
3/10/04	110		110	0	3.2
3/11/04	108		95	13	5.3
3/12/04	104		95	9	4.7
3/13/04	95		95	0	3.2
3/14/04	96		95	1	3.4
3/15/04	99		95	4	3.8
3/16/04	130		130	0	3.2
3/17/04	161		130	31	8.2
3/18/04	152		130	22	6.8
3/19/04	248		130	118	22.3
3/20/04	177		130	47	10.8
3/21/04	139		110	29	7.9
3/22/04	118		110	8	4.5
3/23/04	110		110	0	3.2
3/24/04	110		110	0	3.2
3/25/04	114		110	4	3.8
3/26/04	110		97	13	5.3
3/27/04	110		97	13	5.3
3/28/04	106		97	9	4.7
3/29/04	99		97	2	3.5
3/30/04	97		97	0	3.2
3/31/04	119		119	0	3.2
4/1/04	182		119	63	13.4
4/2/04	174		119	55	12.1
4/3/04	238		119	119	22.4

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/4/04	268		119	149	27.3
4/5/04	177	14	111	66	13.9
4/6/04	129		111	18	6.1
4/7/04	117		111	6	4.2
4/8/04	111		111	0	3.2
4/9/04	128		111	17	5.9
4/10/04	109		106	3	3.7
4/11/04	106		106	0	3.2
4/12/04	129		106	23	6.9
4/13/04	394		106	288	49.7
4/14/04	318		106	212	37.5
4/15/04	206		120	86	17.1
4/16/04	145		120	25	7.2
4/17/04	132		120	12	5.1
4/18/04	126		120	6	4.2
4/19/04	120		120	0	3.2
4/20/04	113		107	6	4.2
4/21/04	109		107	2	3.5
4/22/04	108		107	1	3.4
4/23/04	107		107	0	3.2
4/24/04	156		107	49	11.1
4/25/04	110		110	0	3.2
4/26/04	221		110	111	21.1
4/27/04	260		110	150	27.4
4/28/04	138		110	28	7.7
4/29/04	118		110	8	4.5
4/30/04	109		105	4	3.8
5/1/04	106		105	1	3.4
5/2/04	105		105	0	3.2
5/3/04	182		105	77	15.6
5/4/04	188		105	83	16.6
5/5/04	127		110	17	5.9
5/6/04	128		110	18	6.1
5/7/04	117		110	7	4.3
5/8/04	123		110	13	5.3
5/9/04	110		110	0	3.2
5/10/04	546		104	442	74.6
5/11/04	160		104	56	12.2
5/12/04	125		104	21	6.6
5/13/04	110		104	6	4.2
5/14/04	104		104	0	3.2
5/15/04	100		97	3	3.7
5/16/04	108		97	11	5.0
5/17/04	97		97	0	3.2
5/18/04	105		97	8	4.5
5/19/04	191		97	94	18.4
5/20/04	143		96	47	10.8

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/21/04	183		96	87	17.3
5/22/04	151		96	55	12.1
5/23/04	109		96	13	5.3
5/24/04	96		96	0	3.2
5/25/04	89		81	8	4.5
5/26/04	104		81	23	6.9
5/27/04	94		81	13	5.3
5/28/04	88		81	7	4.3
5/29/04	81		81	0	3.2
5/30/04	79		79	0	3.2
5/31/04	89		79	10	4.8
6/1/04	96		79	17	5.9
6/2/04	100		79	21	6.6
6/3/04	96		79	17	5.9
6/4/04	80		80	0	3.2
6/5/04	459		80	379	64.4
6/6/04	450		80	370	63.0
6/7/04	132		80	52	11.6
6/8/04	105		80	25	7.2
6/9/04	92		92	0	3.2
6/10/04	127		92	35	8.9
6/11/04	380		92	288	49.7
6/12/04	177		92	85	16.9
6/13/04	129		92	37	9.2
6/14/04	146		146	0	3.2
6/15/04	864		146	718	119.2
6/16/04	248		146	102	19.7
6/17/04	711		146	565	94.5
6/18/04	898		146	752	124.7
6/19/04	195		120	75	15.3
6/20/04	149		120	29	7.9
6/21/04	120		120	0	3.2
6/22/04	147		120	27	7.6
6/23/04	152		120	32	8.4
6/24/04	117		104	13	5.3
6/25/04	137		104	33	8.5
6/26/04	150		104	46	10.6
6/27/04	114		104	10	4.8
6/28/04	104		104	0	3.2
6/29/04	121	11	86	35	8.9
6/30/04	97		86	11	5.0
7/1/04	92		86	6	4.2
7/2/04	90		86	4	3.8
7/3/04	86		86	0	3.2
7/4/04	83		76	7	4.3
7/5/04	82		76	6	4.2
7/6/04	76		76	0	3.2

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/7/04	198		76	122	22.9
7/8/04	163		76	87	17.3
7/9/04	91		79	12	5.1
7/10/04	80		79	1	3.4
7/11/04	79		79	0	3.2
7/12/04	989		79	910	150.2
7/13/04	263		79	184	32.9
7/14/04	169		103	66	13.9
7/15/04	162		103	59	12.7
7/16/04	116		103	13	5.3
7/17/04	103		103	0	3.2
7/18/04	302		103	199	35.4
7/19/04	193		98	95	18.5
7/20/04	125		98	27	7.6
7/21/04	104		98	6	4.2
7/22/04	98		98	0	3.2
7/23/04	99		98	1	3.4
7/24/04	98		90	8	4.5
7/25/04	91		90	1	3.4
7/26/04	90		90	0	3.2
7/27/04	210		90	120	22.6
7/28/04	1010		90	920	151.8
7/29/04	158		101	57	12.4
7/30/04	116		101	15	5.6
7/31/04	101		101	0	3.2
8/1/04	660		101	559	93.5
8/2/04	172		101	71	14.7
8/3/04	132		101	31	8.2
8/4/04	132		101	31	8.2
8/5/04	160		101	59	12.7
8/6/04	113		101	12	5.1
8/7/04	101		101	0	3.2
8/8/04	96		90	6	4.2
8/9/04	91		90	1	3.4
8/10/04	91		90	1	3.4
8/11/04	90		90	0	3.2
8/12/04	879		90	789	130.7
8/13/04	691		121	570	95.3
8/14/04	189		121	68	14.2
8/15/04	160		121	39	9.5
8/16/04	136		121	15	5.6
8/17/04	121		121	0	3.2
8/18/04	115		107	8	4.5
8/19/04	111		107	4	3.8
8/20/04	107		107	0	3.2
8/21/04	189		107	82	16.4
8/22/04	155		107	48	11.0

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/23/04	112		90	22	6.8
8/24/04	104		90	14	5.5
8/25/04	98		90	8	4.5
8/26/04	93		90	3	3.7
8/27/04	90		90	0	3.2
8/28/04	86		85	1	3.4
8/29/04	85		85	0	3.2
8/30/04	362		85	277	48.0
8/31/04	219		85	134	24.8
9/1/04	112		85	27	7.6
9/2/04	96		85	11	5.0
9/3/04	90		85	5	4.0
9/4/04	88		85	3	3.7
9/5/04	85		85	0	3.2
9/6/04	85		85	0	3.2
9/7/04	83		80	3	3.7
9/8/04	84		80	4	3.8
9/9/04	101		80	21	6.6
9/10/04	87		80	7	4.3
9/11/04	80		80	0	3.2
9/12/04	77		76	1	3.4
9/13/04	76		76	0	3.2
9/14/04	78		76	2	3.5
9/15/04	91		76	15	5.6
9/16/04	86		76	10	4.8
9/17/04	81		81	0	3.2
9/18/04	1620		81	1539	251.8
9/19/04	229		81	148	27.1
9/20/04	570		81	489	82.2
9/21/04	105		81	24	7.1
9/22/04	92		80	12	5.1
9/23/04	85		80	5	4.0
9/24/04	83		80	3	3.7
9/25/04	81		80	1	3.4
9/26/04	80		80	0	3.2
9/27/04	73		73	0	3.2
9/28/04	2320		73	2247	366.2
9/29/04	3100		73	3027	492.2
9/30/04	264		73	191	34.1
10/1/04	200		73	127	23.7
10/2/04	177		128	49	11.1
10/3/04	163		128	35	8.9
10/4/04	150		128	22	6.8
10/5/04	138	2	128	10	4.8
10/6/04	128		128	0	3.2
10/7/04	126		110	16	5.8
10/8/04	122		110	12	5.1

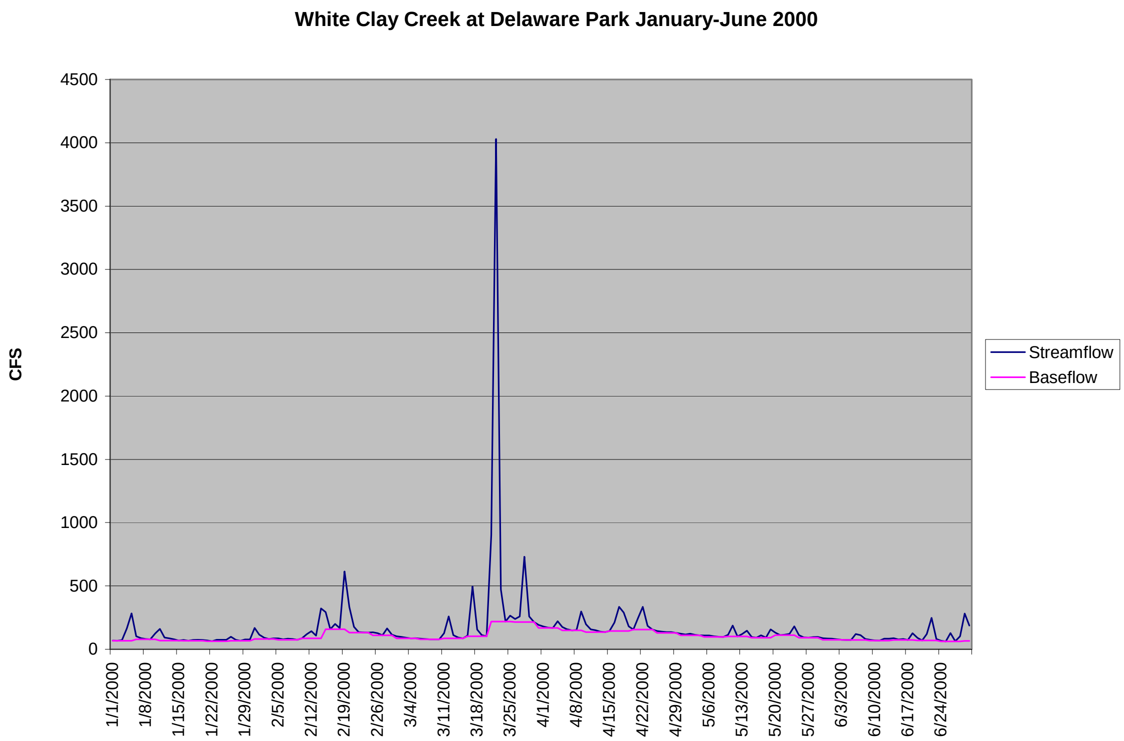
2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/9/04	120		110	10	4.8
10/10/04	115		110	5	4.0
10/11/04	110		110	0	3.2
10/12/04	115		115	0	3.2
10/13/04	115		115	0	3.2
10/14/04	153		115	38	9.3
10/15/04	163		115	48	11.0
10/16/04	210		115	95	18.5
10/17/04	134		134	0	3.2
10/18/04	134		134	0	3.2
10/19/04	261		134	127	23.7
10/20/04	163		134	29	7.9
10/21/04	147		134	13	5.3
10/22/04	134		118	16	5.8
10/23/04	134		118	16	5.8
10/24/04	122		118	4	3.8
10/25/04	119		118	1	3.4
10/26/04	118		118	0	3.2
10/27/04	118		115	3	3.7
10/28/04	115		115	0	3.2
10/29/04	115		115	0	3.2
10/30/04	141		115	26	7.4
10/31/04	128		115	13	5.3
11/1/04	118		114	4	3.8
11/2/04	115		114	1	3.4
11/3/04	114		114	0	3.2
11/4/04	225		114	111	21.1
11/5/04	288		114	174	31.3
11/6/04	106		80	26	7.4
11/7/04	91		80	11	5.0
11/8/04	91		80	11	5.0
11/9/04	80		80	0	3.2
11/10/04	80		80	0	3.2
11/11/04	80		80	0	3.2
11/12/04	172		80	92	18.1
11/13/04	341		80	261	45.4
11/14/04	127		80	47	10.8
11/15/04	105		80	25	7.2
11/16/04	101		91	10	4.8
11/17/04	92		91	1	3.4
11/18/04	91		91	0	3.2
11/19/04	91		91	0	3.2
11/20/04	91		91	0	3.2
11/21/04	93		88	5	4.0
11/22/04	90		88	2	3.5
11/23/04	88		88	0	3.2
11/24/04	93		88	5	4.0

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/25/04	144		88	56	12.2
11/26/04	103		91	12	5.1
11/27/04	91		91	0	3.2
11/28/04	1400		91	1309	214.7
11/29/04	226		91	135	25.0
11/30/04	148		91	57	12.4
12/1/04	435		117	318	54.6
12/2/04	193		117	76	15.5
12/3/04	144		117	27	7.6
12/4/04	125		117	8	4.5
12/5/04	117		117	0	3.2
12/6/04	109		109	0	3.2
12/7/04	161		109	52	11.6
12/8/04	176		109	67	14.0
12/9/04	137		109	28	7.7
12/10/04	365		109	256	44.6
12/11/04	278		114	164	29.7
12/12/04	161		114	47	10.8
12/13/04	129		114	15	5.6
12/14/04	122		114	8	4.5
12/15/04	114		114	0	3.2
12/16/04	108		101	7	4.3
12/17/04	111		101	10	4.8
12/18/04	107		101	6	4.2
12/19/04	112		101	11	5.0
12/20/04	101		101	0	3.2
12/21/04	100		100	0	3.2
12/22/04	106		100	6	4.2
12/23/04	372		100	272	47.1
12/24/04	287		100	187	33.4
12/25/04	136		100	36	9.0
12/26/04	112		97	15	5.6
12/27/04	106		97	9	4.7
12/28/04	97		97	0	3.2
12/29/04	105		97	8	4.5
12/30/04	109		97	12	5.1
12/31/04	113		113	0	3.2

APPENDIX B

Baseflow Adjustment Graphs
Data of the White Clay Creek at Delaware Park 2000-2004:
Streamflow
Baseflow Adjustment
STORET data
Turbidity Extrapolation

Figure B-1 Baseflow Adjustment White Clay Creek at Delaware Park 2000



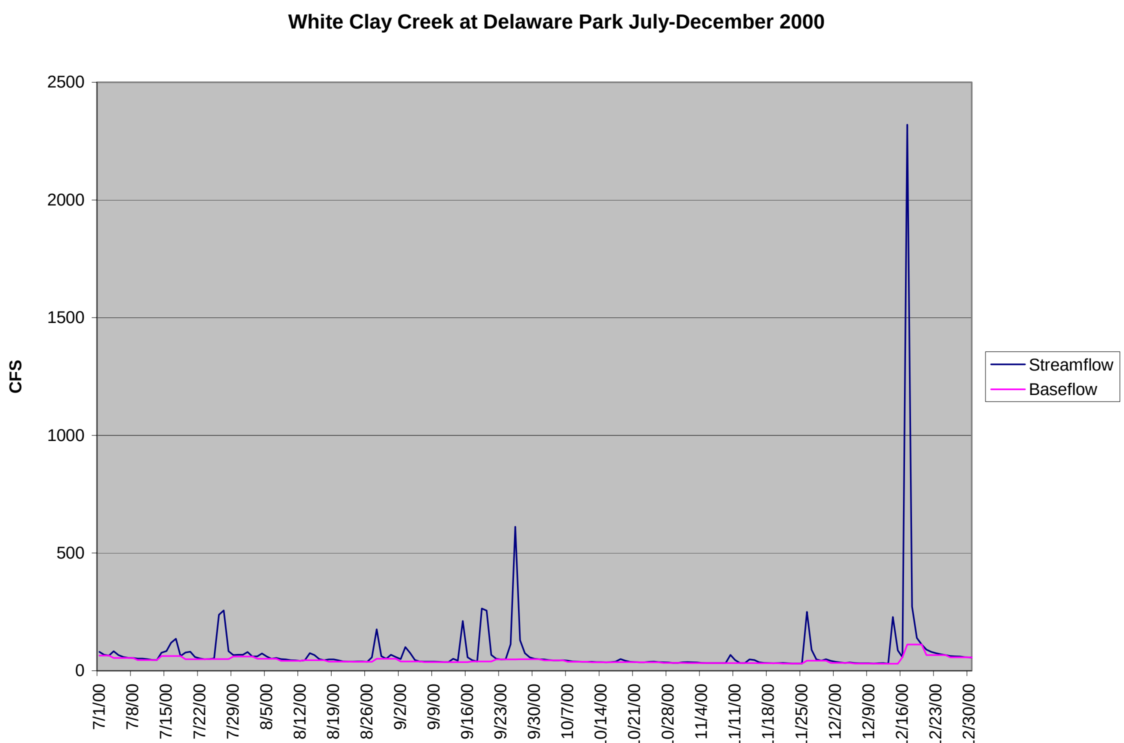
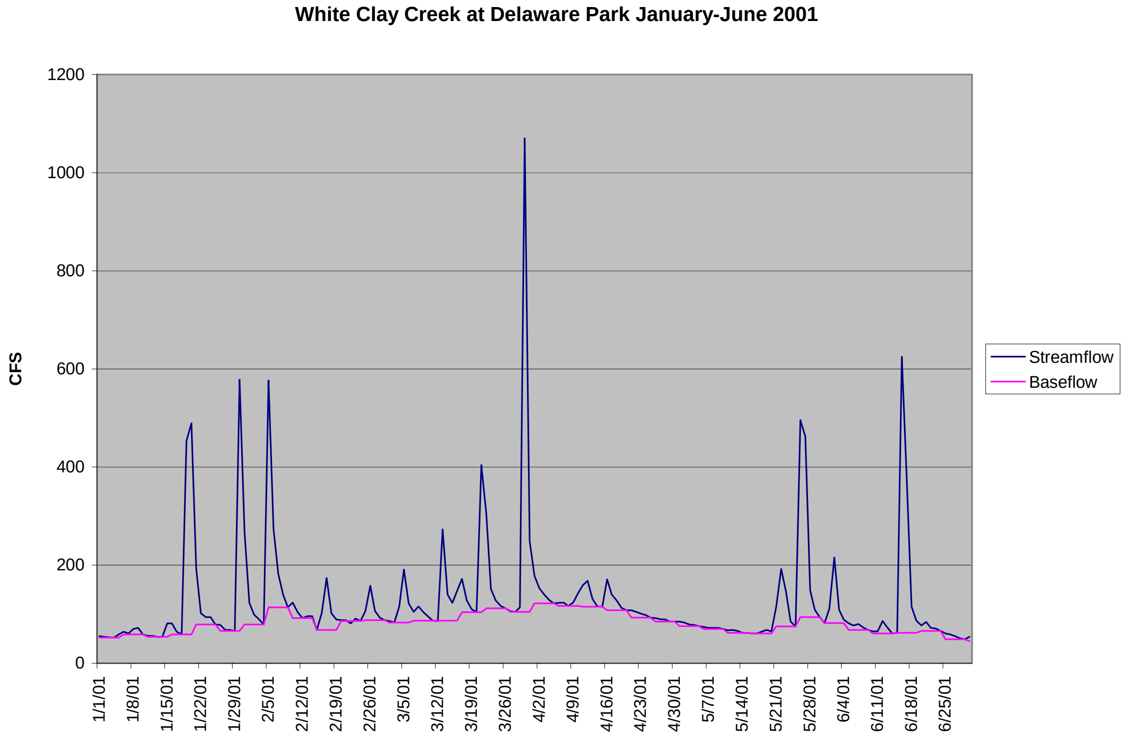


Figure B-2 Baseflow Adjustment White Clay Creek at Delaware Park 2001



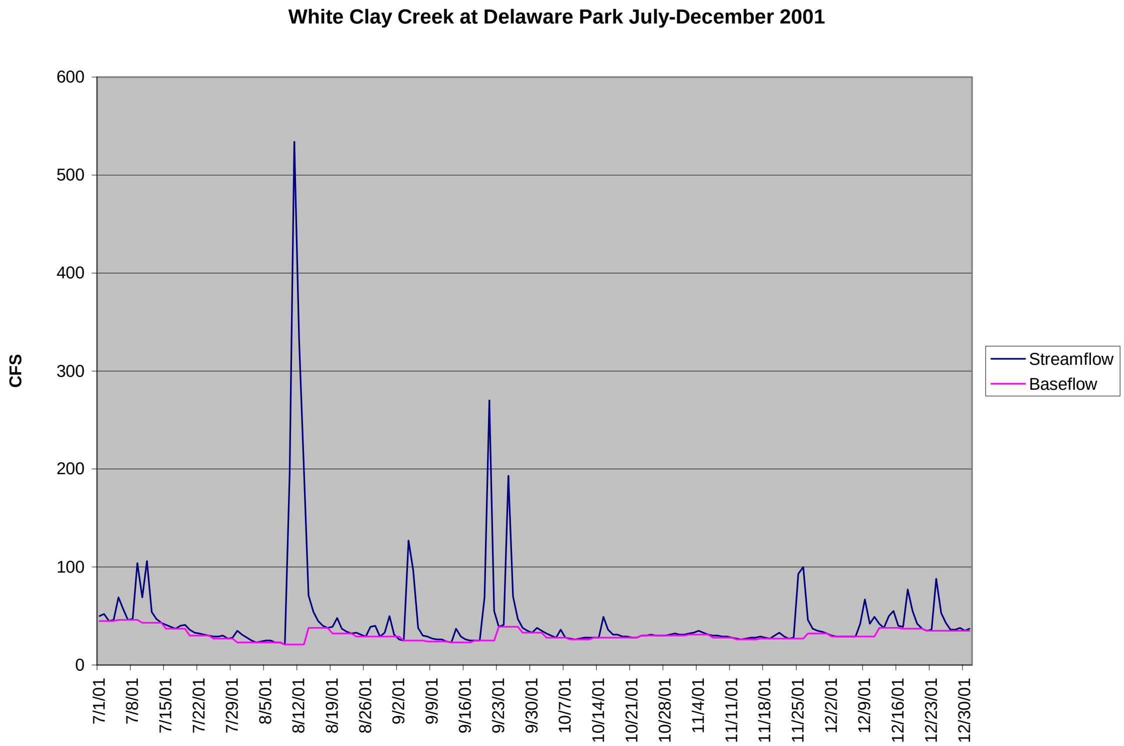
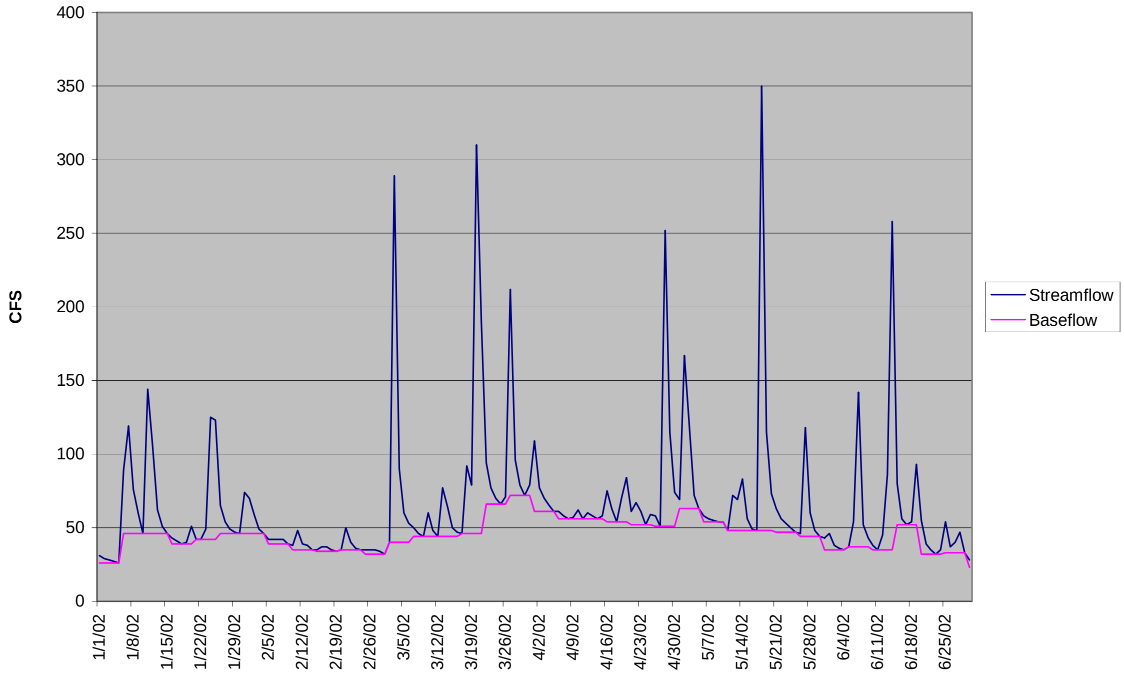


Figure B-3Baseflow Adjustment White Clay Creek at Delaware Park 2002

White Clay Creek at Delaware Park January-June 2002



White Clay Creek at Delaware Park July-December 2002

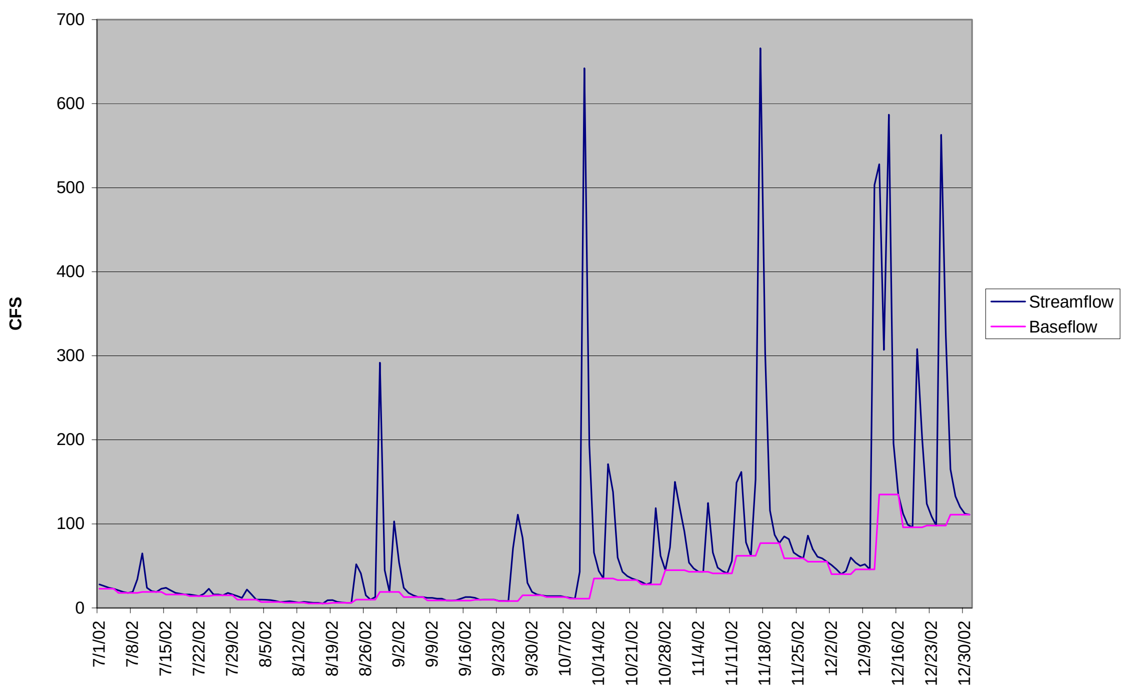
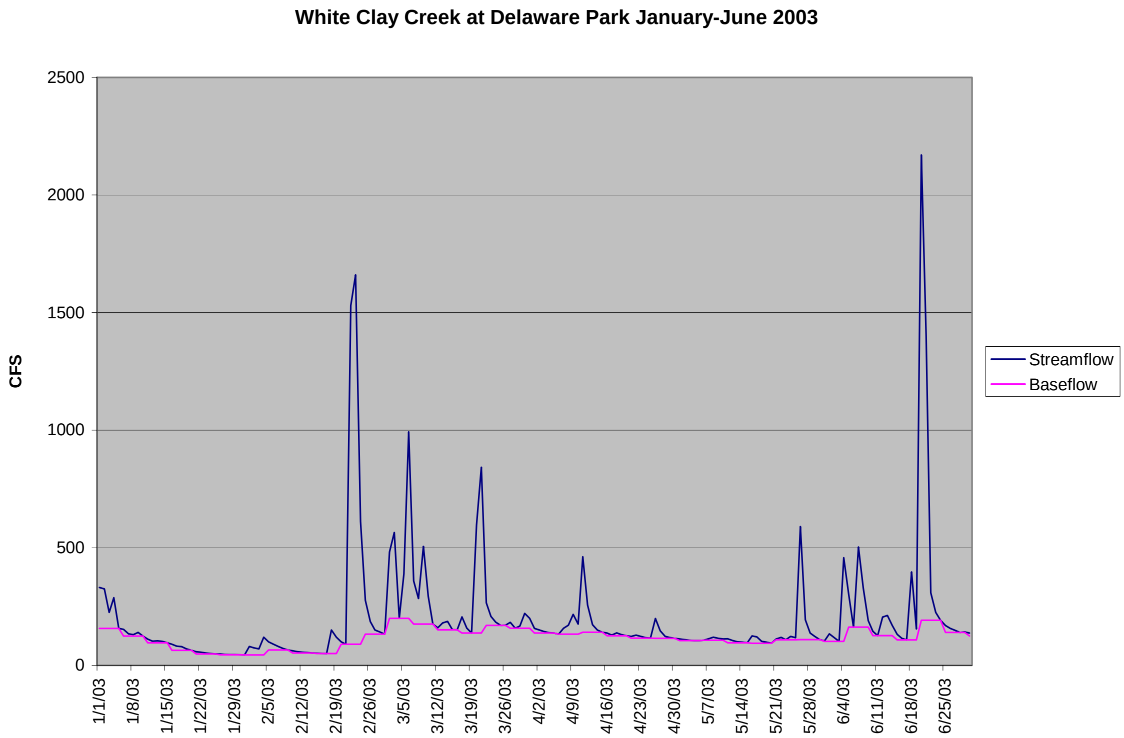


Figure B-4 Baseflow Adjustment White Clay Creek at Delaware Park 2003



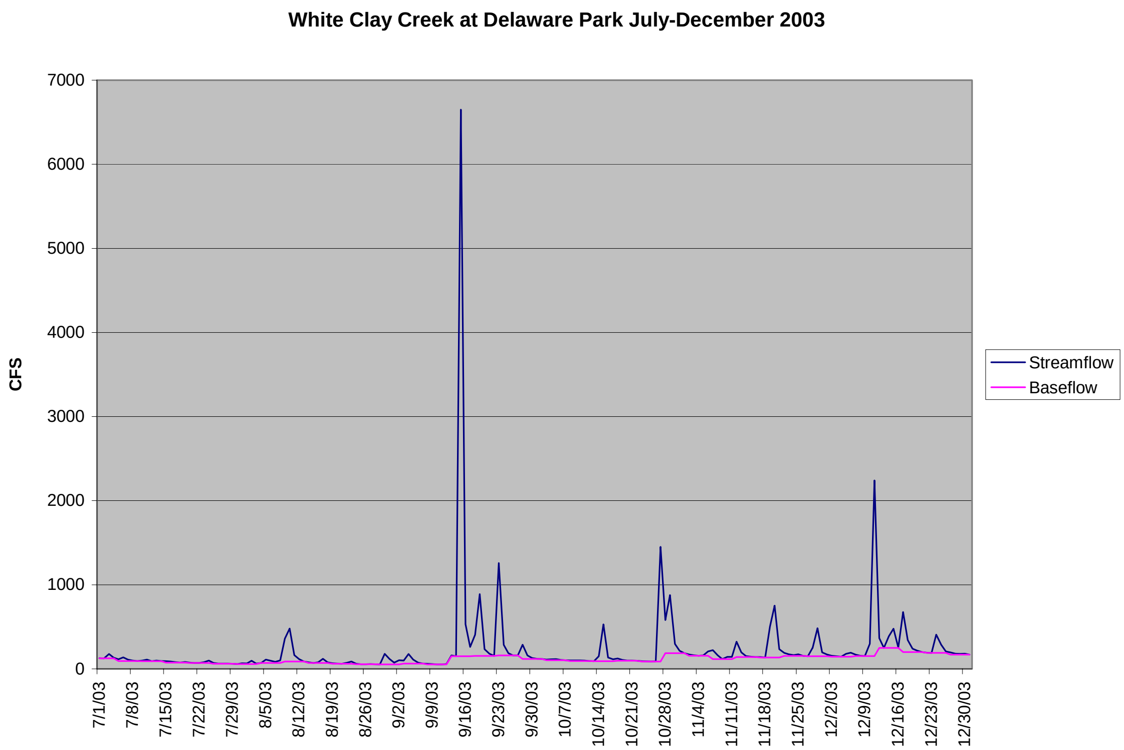
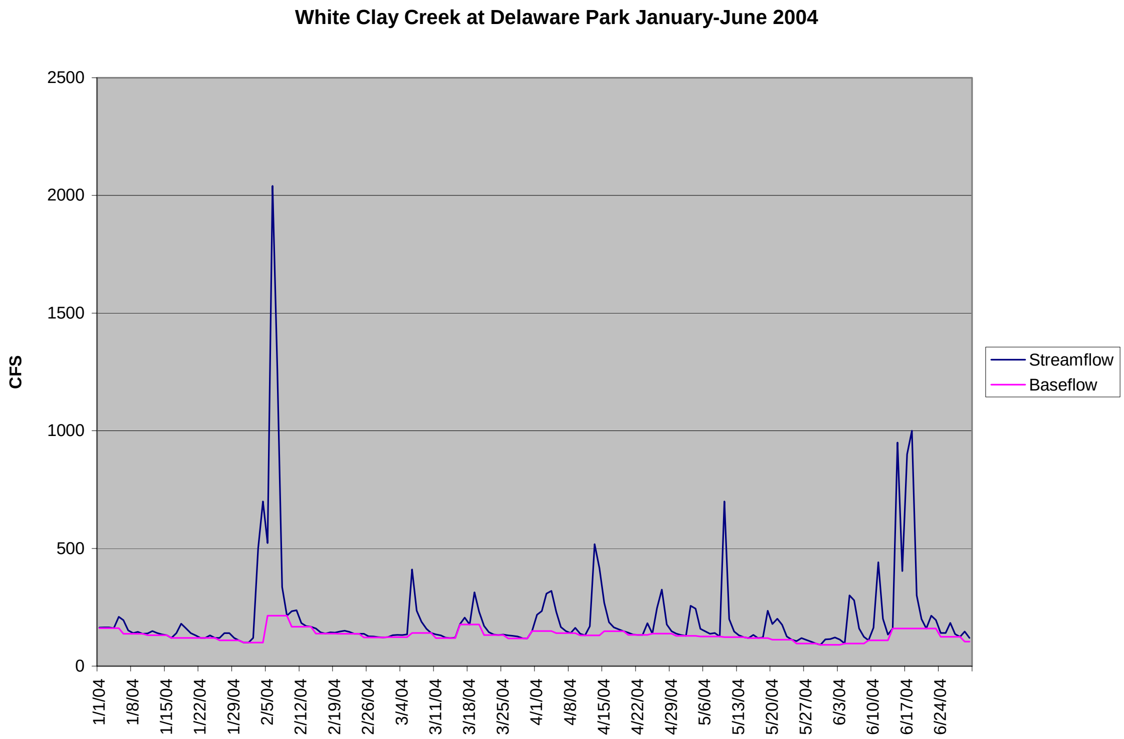
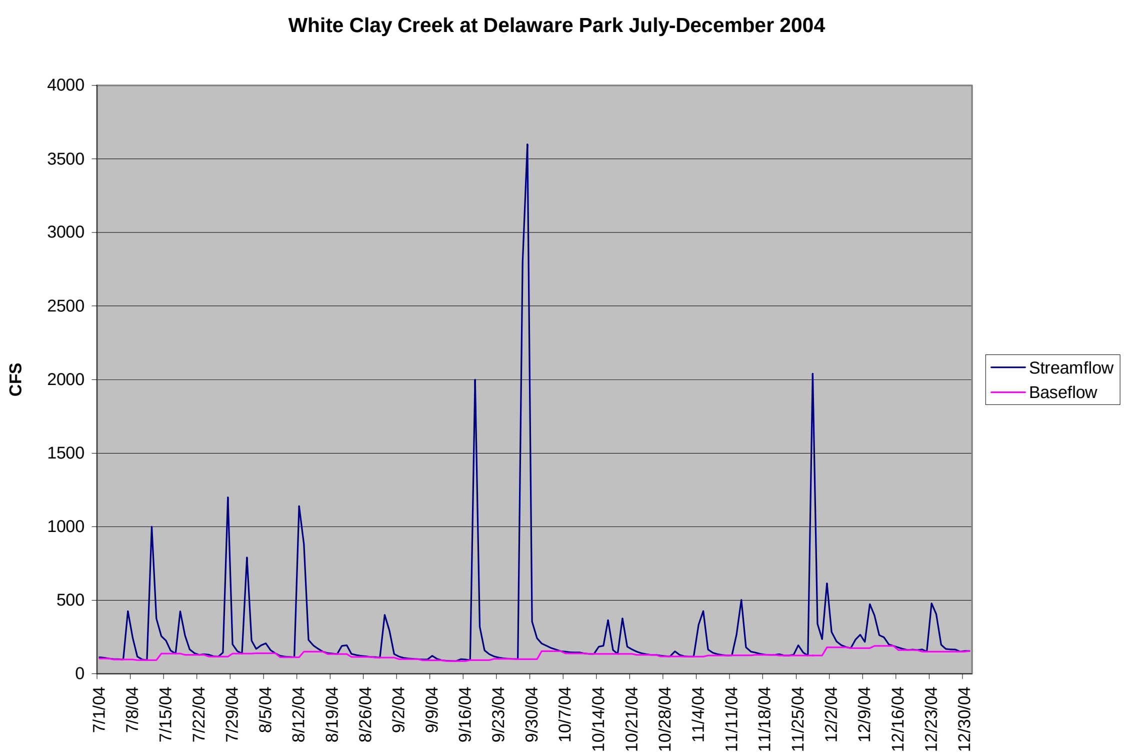


Figure B-5 Baseflow Adjustment White Clay Creek at Delaware Park 2004





2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/2000	69		68	1	4
1/2/2000	68		68	0	4
1/3/2000	72		68	4	5
1/4/2000	164		68	96	40
1/5/2000	284		68	216	85
1/6/2000	103		79	24	13
1/7/2000	88		79	9	7
1/8/2000	81		79	2	4
1/9/2000	79		79	0	4
1/10/2000	125		79	46	21
1/11/2000	160		69	91	38
1/12/2000	93		69	24	13
1/13/2000	86		69	17	10
1/14/2000	78		69	9	7
1/15/2000	69		69	0	4
1/16/2000	74		68	6	6
1/17/2000	68		68	0	4
1/18/2000	74		68	6	6
1/19/2000	75		68	7	6
1/20/2000	73		68	5	6
1/21/2000	70		64	6	6
1/22/2000	64		64	0	4
1/23/2000	76		64	12	8
1/24/2000	76		64	12	8
1/25/2000	75		64	11	8
1/26/2000	99		68	31	15
1/27/2000	76		68	8	7
1/28/2000	68		68	0	4
1/29/2000	77		68	9	7
1/30/2000	77		68	9	7
1/31/2000	169		81	88	37
2/1/2000	115		81	34	17
2/2/2000	91		81	10	7
2/3/2000	81		81	0	4
2/4/2000	87		81	6	6
2/5/2000	86		75	11	8
2/6/2000	79		75	4	5
2/7/2000	83		75	8	7
2/8/2000	81		75	6	6
2/9/2000	75		75	0	4
2/10/2000	87		87	0	4
2/11/2000	119		87	32	16
2/12/2000	143		87	56	25
2/13/2000	107		87	20	11
2/14/2000	323		87	236	92
2/15/2000	293		159	134	54

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/16/2000	159		159	0	4
2/17/2000	200		159	41	19
2/18/2000	166		159	7	6
2/19/2000	614		159	455	175
2/20/2000	334		132	202	80
2/21/2000	178		132	46	21
2/22/2000	136		132	4	5
2/23/2000	133		132	1	4
2/24/2000	132		132	0	4
2/25/2000	134		111	23	12
2/26/2000	126		111	15	9
2/27/2000	111		111	0	4
2/28/2000	165		111	54	24
2/29/2000	116		111	5	6
3/1/2000	102		87	15	9
3/2/2000	98		87	11	8
3/3/2000	91		87	4	5
3/4/2000	87		87	0	4
3/5/2000	88		87	1	4
3/6/2000	84		79	5	6
3/7/2000	81		79	2	4
3/8/2000	79		79	0	4
3/9/2000	79		79	0	4
3/10/2000	79		79	0	4
3/11/2000	127		86	41	19
3/12/2000	259		86	173	69
3/13/2000	113		86	27	14
3/14/2000	93	2	86	7	6
3/15/2000	86		86	0	4
3/16/2000	107		103	4	5
3/17/2000	496		103	393	151
3/18/2000	155		103	52	23
3/19/2000	113		103	10	7
3/20/2000	103		103	0	4
3/21/2000	902		219	683	260
3/22/2000	4030		219	3811	1436
3/23/2000	473		219	254	99
3/24/2000	219		219	0	4
3/25/2000	266		219	47	21
3/26/2000	239		215	24	13
3/27/2000	259		215	44	20
3/28/2000	731		215	516	198
3/29/2000	259		215	44	20
3/30/2000	215		215	0	4
3/31/2000	193		169	24	13
4/1/2000	180		169	11	8
4/2/2000	172		169	3	5

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/3/2000	169		169	0	4
4/4/2000	221		169	52	23
4/5/2000	176		149	27	14
4/6/2000	158		149	9	7
4/7/2000	149		149	0	4
4/8/2000	152		149	3	5
4/9/2000	298		149	149	60
4/10/2000	197		137	60	26
4/11/2000	157		137	20	11
4/12/2000	151		137	14	9
4/13/2000	140		137	3	5
4/14/2000	137		137	0	4
4/15/2000	145		145	0	4
4/16/2000	212		145	67	29
4/17/2000	335		145	190	75
4/18/2000	291		145	146	59
4/19/2000	181		145	36	17
4/20/2000	156		156	0	4
4/21/2000	246		156	90	38
4/22/2000	335		156	179	71
4/23/2000	184		156	28	14
4/24/2000	156		156	0	4
4/25/2000	145		130	15	9
4/26/2000	139		130	9	7
4/27/2000	137		130	7	6
4/28/2000	137		130	7	6
4/29/2000	130		130	0	4
4/30/2000	124		111	13	9
5/1/2000	117		111	6	6
5/2/2000	123	2	111	12	8
5/3/2000	114		111	3	5
5/4/2000	111		111	0	4
5/5/2000	109		98	11	8
5/6/2000	109		98	11	8
5/7/2000	103		98	5	6
5/8/2000	100		98	2	4
5/9/2000	98		98	0	4
5/10/2000	114		101	13	9
5/11/2000	188		101	87	36
5/12/2000	101		101	0	4
5/13/2000	120		101	19	11
5/14/2000	148		101	47	21
5/15/2000	96		91	5	6
5/16/2000	91		91	0	4
5/17/2000	110		91	19	11
5/18/2000	93		91	2	4
5/19/2000	157		91	66	29

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/20/2000	131		113	18	11
5/21/2000	113		113	0	4
5/22/2000	116		113	3	5
5/23/2000	122		113	9	7
5/24/2000	181		113	68	29
5/25/2000	112		91	21	12
5/26/2000	94		91	3	5
5/27/2000	91		91	0	4
5/28/2000	97		91	6	6
5/29/2000	98		91	7	6
5/30/2000	88		76	12	8
5/31/2000	85		76	9	7
6/1/2000	83		76	7	6
6/2/2000	79		76	3	5
6/3/2000	76		76	0	4
6/4/2000	74		73	1	4
6/5/2000	73		73	0	4
6/6/2000	121		73	48	22
6/7/2000	112		73	39	18
6/8/2000	82		73	9	7
6/9/2000	76		69	7	6
6/10/2000	71		69	2	4
6/11/2000	69		69	0	4
6/12/2000	84		69	15	9
6/13/2000	83		69	14	9
6/14/2000	89		73	16	10
6/15/2000	77		73	4	5
6/16/2000	81		73	8	7
6/17/2000	73		73	0	4
6/18/2000	126		73	53	24
6/19/2000	90		70	20	11
6/20/2000	70		70	0	4
6/21/2000	121		70	51	23
6/22/2000	248		70	178	71
6/23/2000	82		70	12	8
6/24/2000	68		63	5	6
6/25/2000	63		63	0	4
6/26/2000	128		63	65	28
6/27/2000	64		63	1	4
6/28/2000	102		63	39	18
6/29/2000	283		65	218	86
6/30/2000	188		65	123	50
7/1/2000	80		65	15	9
7/2/2000	68		65	3	5
7/3/2000	65		65	0	4
7/4/2000	83		54	29	15
7/5/2000	66		54	12	8

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/6/2000	59		54	5	6
7/7/2000	55		54	1	4
7/8/2000	54		54	0	4
7/9/2000	52		46	6	6
7/10/2000	52		46	6	6
7/11/2000	50		46	4	5
7/12/2000	47		46	1	4
7/13/2000	46		46	0	4
7/14/2000	77		63	14	9
7/15/2000	84		63	21	12
7/16/2000	119		63	56	25
7/17/2000	136		63	73	31
7/18/2000	63		63	0	4
7/19/2000	78		49	29	15
7/20/2000	81		49	32	16
7/21/2000	59		49	10	7
7/22/2000	53		49	4	5
7/23/2000	49		49	0	4
7/24/2000	50		50	0	4
7/25/2000	53		50	3	5
7/26/2000	238		50	188	74
7/27/2000	256		50	206	81
7/28/2000	83		50	33	16
7/29/2000	66		60	6	6
7/30/2000	68		60	8	7
7/31/2000	68		60	8	7
8/1/2000	79		60	19	11
8/2/2000	60		60	0	4
8/3/2000	61		51	10	7
8/4/2000	73		51	22	12
8/5/2000	60		51	9	7
8/6/2000	51		51	0	4
8/7/2000	54	4	51	3	5
8/8/2000	50		42	8	7
8/9/2000	48		42	6	6
8/10/2000	45		42	3	5
8/11/2000	44		42	2	4
8/12/2000	42		42	0	4
8/13/2000	45		45	0	4
8/14/2000	75		45	30	15
8/15/2000	66		45	21	12
8/16/2000	50		45	5	6
8/17/2000	45		45	0	4
8/18/2000	48		39	9	7
8/19/2000	48		39	9	7
8/20/2000	44		39	5	6
8/21/2000	40		39	1	4

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/22/2000	39		39	0	4
8/23/2000	39		38	1	4
8/24/2000	40		38	2	4
8/25/2000	40		38	2	4
8/26/2000	38		38	0	4
8/27/2000	57		38	19	11
8/28/2000	176		51	125	51
8/29/2000	62		51	11	8
8/30/2000	51		51	0	4
8/31/2000	68		51	17	10
9/1/2000	59		51	8	7
9/2/2000	50		40	10	7
9/3/2000	101		40	61	27
9/4/2000	76		40	36	17
9/5/2000	46		40	6	6
9/6/2000	40		40	0	4
9/7/2000	39		37	2	4
9/8/2000	39		37	2	4
9/9/2000	39		37	2	4
9/10/2000	38		37	1	4
9/11/2000	37		37	0	4
9/12/2000	37		37	0	4
9/13/2000	51		37	14	9
9/14/2000	43		37	6	6
9/15/2000	211		37	174	69
9/16/2000	57		37	20	11
9/17/2000	45		40	5	6
9/18/2000	40		40	0	4
9/19/2000	265		40	225	88
9/20/2000	255		40	215	85
9/21/2000	67		40	27	14
9/22/2000	51		48	3	5
9/23/2000	48		48	0	4
9/24/2000	49		48	1	4
9/25/2000	113		48	65	28
9/26/2000	612		48	564	216
9/27/2000	130		49	81	34
9/28/2000	75		49	26	14
9/29/2000	57		49	8	7
9/30/2000	51		49	2	4
10/1/2000	49		49	0	4
10/2/2000	48		44	4	5
10/3/2000	46		44	2	4
10/4/2000	44		44	0	4
10/5/2000	44		44	0	4
10/6/2000	45		44	1	4
10/7/2000	43		38	5	6

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/8/2000	40		38	2	4
10/9/2000	39		38	1	4
10/10/2000	38		38	0	4
10/11/2000	38		38	0	4
10/12/2000	38		36	2	4
10/13/2000	37		36	1	4
10/14/2000	37		36	1	4
10/15/2000	36		36	0	4
10/16/2000	37		36	1	4
10/17/2000	39		37	2	4
10/18/2000	50		37	13	9
10/19/2000	43		37	6	6
10/20/2000	38		37	1	4
10/21/2000	37		37	0	4
10/22/2000	36		36	0	4
10/23/2000	36		36	0	4
10/24/2000	38	1	36	2	4
10/25/2000	39		36	3	5
10/26/2000	37		36	1	4
10/27/2000	36		34	2	4
10/28/2000	35		34	1	4
10/29/2000	34		34	0	4
10/30/2000	34		34	0	4
10/31/2000	36		34	2	4
11/1/2000	37		33	4	5
11/2/2000	36		33	3	5
11/3/2000	35		33	2	4
11/4/2000	34		33	1	4
11/5/2000	33		33	0	4
11/6/2000	33		33	0	4
11/7/2000	33		33	0	4
11/8/2000	33		33	0	4
11/9/2000	33		33	0	4
11/10/2000	67		33	34	17
11/11/2000	46		33	13	9
11/12/2000	33		33	0	4
11/13/2000	33		33	0	4
11/14/2000	48		33	15	9
11/15/2000	46		33	13	9
11/16/2000	36		32	4	5
11/17/2000	34		32	2	4
11/18/2000	33		32	1	4
11/19/2000	32		32	0	4
11/20/2000	33		32	1	4
11/21/2000	34		31	3	5
11/22/2000	32		31	1	4
11/23/2000	31		31	0	4

2000	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/24/2000	31		31	0	4
11/25/2000	31		31	0	4
11/26/2000	250		43	207	82
11/27/2000	89		43	46	21
11/28/2000	48		43	5	6
11/29/2000	43		43	0	4
11/30/2000	49		43	6	6
12/1/2000	42		34	8	7
12/2/2000	38		34	4	5
12/3/2000	35		34	1	4
12/4/2000	34		34	0	4
12/5/2000	35		34	1	4
12/6/2000	33		31	2	4
12/7/2000	32		31	1	4
12/8/2000	32		31	1	4
12/9/2000	32		31	1	4
12/10/2000	31		31	0	4
12/11/2000	32		30	2	4
12/12/2000	33		30	3	5
12/13/2000	30		30	0	4
12/14/2000	229		30	199	79
12/15/2000	86		30	56	25
12/16/2000	58		58	0	4
12/17/2000	2320		111	2209	834
12/18/2000	273		111	162	65
12/19/2000	140		111	29	15
12/20/2000	111		111	0	4
12/21/2000	90		66	24	13
12/22/2000	80		66	14	9
12/23/2000	75		66	9	7
12/24/2000	70		66	4	5
12/25/2000	66		66	0	4
12/26/2000	63		57	6	6
12/27/2000	61		57	4	5
12/28/2000	60		57	3	5
12/29/2000	58		57	1	4
12/30/2000	57		57	0	4
12/31/2000	56		56	0	4

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/2001	55		52	3	5
1/2/2001	54		52	2	4
1/3/2001	53		52	1	4
1/4/2001	52		52	0	4
1/5/2001	59		52	7	6
1/6/2001	64		59	5	6
1/7/2001	61		59	2	4
1/8/2001	70		59	11	8
1/9/2001	72		59	13	9
1/10/2001	59		59	0	4
1/11/2001	56		54	2	4
1/12/2001	56		54	2	4
1/13/2001	54		54	0	4
1/14/2001	54		54	0	4
1/15/2001	81		54	27	14
1/16/2001	81		59	22	12
1/17/2001	64		59	5	6
1/18/2001	59		59	0	4
1/19/2001	453		59	394	152
1/20/2001	489		59	430	165
1/21/2001	193		79	114	47
1/22/2001	102		79	23	12
1/23/2001	94		79	15	9
1/24/2001	94		79	15	9
1/25/2001	79		79	0	4
1/26/2001	78		66	12	8
1/27/2001	68		66	2	4
1/28/2001	68		66	2	4
1/29/2001	66		66	0	4
1/30/2001	578		66	512	196
1/31/2001	267		79	188	74
2/1/2001	123		79	44	20
2/2/2001	99		79	20	11
2/3/2001	90		79	11	8
2/4/2001	79		79	0	4
2/5/2001	576		114	462	177
2/6/2001	274		114	160	64
2/7/2001	182		114	68	29
2/8/2001	139		114	25	13
2/9/2001	114		114	0	4
2/10/2001	124		92	32	16
2/11/2001	104		92	12	8
2/12/2001	92		92	0	4
2/13/2001	96		92	4	5
2/14/2001	96		92	4	5
2/15/2001	68		68	0	4
2/16/2001	103		68	35	17

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/2001	174		68	106	44
2/18/2001	102		68	34	17
2/19/2001	89		68	21	12
2/20/2001	88		86	2	4
2/21/2001	88		86	2	4
2/22/2001	81		86	-5	2
2/23/2001	91		86	5	6
2/24/2001	86		86	0	4
2/25/2001	106		88	18	11
2/26/2001	158		88	70	30
2/27/2001	107		88	19	11
2/28/2001	93		88	5	6
3/1/2001	88		88	0	4
3/2/2001	86		83	3	5
3/3/2001	83		83	0	4
3/4/2001	116		83	33	16
3/5/2001	191		83	108	44
3/6/2001	122		83	39	18
3/7/2001	105		87	18	11
3/8/2001	116		87	29	15
3/9/2001	104		87	17	10
3/10/2001	95		87	8	7
3/11/2001	87		87	0	4
3/12/2001	86		86	0	4
3/13/2001	273		87	186	74
3/14/2001	140		87	53	24
3/15/2001	123		87	36	17
3/16/2001	148		87	61	27
3/17/2001	172		104	68	29
3/18/2001	128		104	24	13
3/19/2001	110		104	6	6
3/20/2001	104		104	0	4
3/21/2001	404		104	300	116
3/22/2001	305		112	193	76
3/23/2001	151		112	39	18
3/24/2001	128		112	16	10
3/25/2001	117		112	5	6
3/26/2001	112	2	112	0	4
3/27/2001	106		105	1	4
3/28/2001	105		105	0	4
3/29/2001	114		105	9	7
3/30/2001	1070		105	965	366
3/31/2001	249		105	144	58
4/1/2001	178		122	56	25
4/2/2001	153		122	31	15
4/3/2001	140		122	18	11
4/4/2001	129		122	7	6

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/5/2001	122		122	0	4
4/6/2001	123		117	6	6
4/7/2001	124		117	7	6
4/8/2001	117		117	0	4
4/9/2001	124		117	7	6
4/10/2001	143		117	26	14
4/11/2001	159		115	44	20
4/12/2001	168		115	53	24
4/13/2001	131		115	16	10
4/14/2001	116		115	1	4
4/15/2001	115		115	0	4
4/16/2001	171		108	63	27
4/17/2001	140		108	32	16
4/18/2001	128		108	20	11
4/19/2001	113		108	5	6
4/20/2001	108		108	0	4
4/21/2001	108		93	15	9
4/22/2001	105		93	12	8
4/23/2001	101		93	8	7
4/24/2001	98		93	5	6
4/25/2001	93		93	0	4
4/26/2001	92		85	7	6
4/27/2001	90		85	5	6
4/28/2001	89		85	4	5
4/29/2001	85		85	0	4
4/30/2001	85		85	0	4
5/1/2001	85		76	9	7
5/2/2001	83		76	7	6
5/3/2001	79		76	3	5
5/4/2001	78		76	2	4
5/5/2001	76		76	0	4
5/6/2001	74		70	4	5
5/7/2001	72		70	2	4
5/8/2001	72		70	2	4
5/9/2001	72		70	2	4
5/10/2001	70		70	0	4
5/11/2001	67		62	5	6
5/12/2001	68		62	6	6
5/13/2001	66		62	4	5
5/14/2001	62		62	0	4
5/15/2001	62		62	0	4
5/16/2001	61		61	0	4
5/17/2001	61		61	0	4
5/18/2001	64		61	3	5
5/19/2001	68		61	7	6
5/20/2001	65		61	4	5
5/21/2001	115		75	40	19

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/22/2001	192		75	117	48
5/23/2001	148		75	73	31
5/24/2001	85		75	10	7
5/25/2001	75		75	0	4
5/26/2001	496		94	402	155
5/27/2001	462		94	368	142
5/28/2001	149		94	55	24
5/29/2001	109		94	15	9
5/30/2001	94		94	0	4
5/31/2001	82		82	0	4
6/1/2001	111		82	29	15
6/2/2001	216		82	134	54
6/3/2001	109		82	27	14
6/4/2001	89		82	7	6
6/5/2001	81		68	13	9
6/6/2001	77		68	9	7
6/7/2001	80		68	12	8
6/8/2001	73		68	5	6
6/9/2001	68		68	0	4
6/10/2001	65		61	4	5
6/11/2001	65		61	4	5
6/12/2001	86	22	61	25	13
6/13/2001	73		61	12	8
6/14/2001	61		61	0	4
6/15/2001	62		62	0	4
6/16/2001	625		62	563	215
6/17/2001	382		62	320	124
6/18/2001	115		62	53	24
6/19/2001	87		62	25	13
6/20/2001	77		66	11	8
6/21/2001	84		66	18	11
6/22/2001	72		66	6	6
6/23/2001	71		66	5	6
6/24/2001	66		66	0	4
6/25/2001	61		49	12	8
6/26/2001	59		49	10	7
6/27/2001	55		49	6	6
6/28/2001	51		49	2	4
6/29/2001	49		49	0	4
6/30/2001	54		45	9	7
7/1/2001	50		45	5	6
7/2/2001	52		45	7	6
7/3/2001	45		45	0	4
7/4/2001	46		45	1	4
7/5/2001	69		46	23	12
7/6/2001	57		46	11	8
7/7/2001	46		46	0	4

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/8/2001	47		46	1	4
7/9/2001	104		46	58	26
7/10/2001	69		43	26	14
7/11/2001	106		43	63	27
7/12/2001	54		43	11	8
7/13/2001	47		43	4	5
7/14/2001	43		43	0	4
7/15/2001	41		37	4	5
7/16/2001	39		37	2	4
7/17/2001	37		37	0	4
7/18/2001	40		37	3	5
7/19/2001	41		37	4	5
7/20/2001	36		30	6	6
7/21/2001	33		30	3	5
7/22/2001	32		30	2	4
7/23/2001	31		30	1	4
7/24/2001	30		30	0	4
7/25/2001	29		27	2	4
7/26/2001	29		27	2	4
7/27/2001	30		27	3	5
7/28/2001	27		27	0	4
7/29/2001	28		27	1	4
7/30/2001	35		23	12	8
7/31/2001	31		23	8	7
8/1/2001	28		23	5	6
8/2/2001	25		23	2	4
8/3/2001	23		23	0	4
8/4/2001	24		23	1	4
8/5/2001	25		23	2	4
8/6/2001	25		23	2	4
8/7/2001	23		23	0	4
8/8/2001	23		23	0	4
8/9/2001	21		21	0	4
8/10/2001	195		21	174	69
8/11/2001	534		21	513	196
8/12/2001	332		21	311	121
8/13/2001	200		21	179	71
8/14/2001	71		38	33	16
8/15/2001	54		38	16	10
8/16/2001	45		38	7	6
8/17/2001	40		38	2	4
8/18/2001	38		38	0	4
8/19/2001	39		32	7	6
8/20/2001	48		32	16	10
8/21/2001	37		32	5	6
8/22/2001	34		32	2	4
8/23/2001	32		32	0	4

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/24/2001	33		29	4	5
8/25/2001	31		29	2	4
8/26/2001	29		29	0	4
8/27/2001	39		29	10	7
8/28/2001	40	7	29	11	8
8/29/2001	29		29	0	4
8/30/2001	33		29	4	5
8/31/2001	50		29	21	12
9/1/2001	31		29	2	4
9/2/2001	26		29	-3	3
9/3/2001	25		25	0	4
9/4/2001	127		25	102	42
9/5/2001	97		25	72	31
9/6/2001	38		25	13	9
9/7/2001	30		25	5	6
9/8/2001	29		24	5	6
9/9/2001	27		24	3	5
9/10/2001	26		24	2	4
9/11/2001	26		24	2	4
9/12/2001	24		24	0	4
9/13/2001	23		23	0	4
9/14/2001	37		23	14	9
9/15/2001	29		23	6	6
9/16/2001	26		23	3	5
9/17/2001	25		23	2	4
9/18/2001	25		25	0	4
9/19/2001	25		25	0	4
9/20/2001	69		25	44	20
9/21/2001	270		25	245	96
9/22/2001	55		25	30	15
9/23/2001	39		39	0	4
9/24/2001	41		39	2	4
9/25/2001	193		39	154	62
9/26/2001	70		39	31	15
9/27/2001	47		39	8	7
9/28/2001	38		33	5	6
9/29/2001	35		33	2	4
9/30/2001	33		33	0	4
10/1/2001	38		33	5	6
10/2/2001	35		33	2	4
10/3/2001	32		28	4	5
10/4/2001	30		28	2	4
10/5/2001	28		28	0	4
10/6/2001	36		28	8	7
10/7/2001	28		28	0	4
10/8/2001	27		26	1	4
10/9/2001	26	2	26	0	4

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/10/2001	27		26	1	4
10/11/2001	28		26	2	4
10/12/2001	28		26	2	4
10/13/2001	28		28	0	4
10/14/2001	28		28	0	4
10/15/2001	49		28	21	12
10/16/2001	36		28	8	7
10/17/2001	31		28	3	5
10/18/2001	31		28	3	5
10/19/2001	29		28	1	4
10/20/2001	29		28	1	4
10/21/2001	28		28	0	4
10/22/2001	28		28	0	4
10/23/2001	30		30	0	4
10/24/2001	30		30	0	4
10/25/2001	31		30	1	4
10/26/2001	30		30	0	4
10/27/2001	30		30	0	4
10/28/2001	30		30	0	4
10/29/2001	31		30	1	4
10/30/2001	32		30	2	4
10/31/2001	31		30	1	4
11/1/2001	31		30	1	4
11/2/2001	32		31	1	4
11/3/2001	33		31	2	4
11/4/2001	35		31	4	5
11/5/2001	33		31	2	4
11/6/2001	31		31	0	4
11/7/2001	30		28	2	4
11/8/2001	30		28	2	4
11/9/2001	29		28	1	4
11/10/2001	29		28	1	4
11/11/2001	28		28	0	4
11/12/2001	27		26	1	4
11/13/2001	26		26	0	4
11/14/2001	27		26	1	4
11/15/2001	28		26	2	4
11/16/2001	28		26	2	4
11/17/2001	29		27	2	4
11/18/2001	28		27	1	4
11/19/2001	27		27	0	4
11/20/2001	30		27	3	5
11/21/2001	33		27	6	6
11/22/2001	29		27	2	4
11/23/2001	27		27	0	4
11/24/2001	28		27	1	4
11/25/2001	93		27	66	29

2001	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/26/2001	100		27	73	31
11/27/2001	46		32	14	9
11/28/2001	37		32	5	6
11/29/2001	35		32	3	5
11/30/2001	34		32	2	4
12/1/2001	32		32	0	4
12/2/2001	30		29	1	4
12/3/2001	29		29	0	4
12/4/2001	29		29	0	4
12/5/2001	29		29	0	4
12/6/2001	29		29	0	4
12/7/2001	29		29	0	4
12/8/2001	42		29	13	9
12/9/2001	67		29	38	18
12/10/2001	42		29	13	9
12/11/2001	49		29	20	11
12/12/2001	42		38	4	5
12/13/2001	38		38	0	4
12/14/2001	50		38	12	8
12/15/2001	55		38	17	10
12/16/2001	40		38	2	4
12/17/2001	39		37	2	4
12/18/2001	77		37	40	19
12/19/2001	55		37	18	11
12/20/2001	42		37	5	6
12/21/2001	37		37	0	4
12/22/2001	35		35	0	4
12/23/2001	36		35	1	4
12/24/2001	88		35	53	24
12/25/2001	53		35	18	11
12/26/2001	43		35	8	7
12/27/2001	36		35	1	4
12/28/2001	36		35	1	4
12/29/2001	38		35	3	5
12/30/2001	35		35	0	4
12/31/2001	37		35	2	4

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/2002	31		26	5	6
1/2/2002	29		26	3	5
1/3/2002	28		26	2	4
1/4/2002	27		26	1	4
1/5/2002	26		26	0	4
1/6/2002	89		46	43	20
1/7/2002	119		46	73	31
1/8/2002	76		46	30	15
1/9/2002	60		46	14	9
1/10/2002	46		46	0	4
1/11/2002	144		46	98	41
1/12/2002	106		46	60	26
1/13/2002	62		46	16	10
1/14/2002	51		46	5	6
1/15/2002	46		46	0	4
1/16/2002	43		39	4	5
1/17/2002	41		39	2	4
1/18/2002	39		39	0	4
1/19/2002	40		39	1	4
1/20/2002	51		39	12	8
1/21/2002	42		42	0	4
1/22/2002	42		42	0	4
1/23/2002	49		42	7	6
1/24/2002	125		42	83	35
1/25/2002	123		42	81	34
1/26/2002	65		46	19	11
1/27/2002	54		46	8	7
1/28/2002	49		46	3	5
1/29/2002	47		46	1	4
1/30/2002	46		46	0	4
1/31/2002	74		46	28	14
2/1/2002	70		46	24	13
2/2/2002	59		46	13	9
2/3/2002	49		46	3	5
2/4/2002	46		46	0	4
2/5/2002	42		39	3	5
2/6/2002	42		39	3	5
2/7/2002	42		39	3	5
2/8/2002	42		39	3	5
2/9/2002	39		39	0	4
2/10/2002	38		35	3	5
2/11/2002	48		35	13	9
2/12/2002	39		35	4	5
2/13/2002	38		35	3	5
2/14/2002	35		35	0	4
2/15/2002	35		34	1	4
2/16/2002	37		34	3	5

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/2002	37		34	3	5
2/18/2002	35		34	1	4
2/19/2002	34		34	0	4
2/20/2002	35		35	0	4
2/21/2002	50		35	15	9
2/22/2002	40		35	5	6
2/23/2002	36		35	1	4
2/24/2002	35		35	0	4
2/25/2002	35		32	3	5
2/26/2002	35		32	3	5
2/27/2002	35		32	3	5
2/28/2002	34		32	2	4
3/1/2002	32		32	0	4
3/2/2002	40		40	0	4
3/3/2002	289		40	249	97
3/4/2002	90		40	50	23
3/5/2002	60		40	20	11
3/6/2002	53		40	13	9
3/7/2002	50		44	6	6
3/8/2002	46		44	2	4
3/9/2002	44		44	0	4
3/10/2002	60		44	16	10
3/11/2002	48		44	4	5
3/12/2002	44		44	0	4
3/13/2002	77		44	33	16
3/14/2002	64		44	20	11
3/15/2002	50		44	6	6
3/16/2002	47		44	3	5
3/17/2002	46		46	0	4
3/18/2002	92		46	46	21
3/19/2002	79		46	33	16
3/20/2002	310		46	264	103
3/21/2002	190		46	144	58
3/22/2002	94		66	28	14
3/23/2002	77		66	11	8
3/24/2002	70		66	4	5
3/25/2002	66		66	0	4
3/26/2002	71		66	5	6
3/27/2002	212		72	140	56
3/28/2002	96		72	24	13
3/29/2002	79		72	7	6
3/30/2002	72		72	0	4
3/31/2002	79		72	7	6
4/1/2002	109		61	48	22
4/2/2002	77		61	16	10
4/3/2002	70		61	9	7
4/4/2002	65		61	4	5

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/5/2002	61		61	0	4
4/6/2002	61		56	5	6
4/7/2002	58		56	2	4
4/8/2002	56		56	0	4
4/9/2002	57		56	1	4
4/10/2002	62		56	6	6
4/11/2002	56		56	0	4
4/12/2002	60		56	4	5
4/13/2002	58		56	2	4
4/14/2002	56		56	0	4
4/15/2002	58		56	2	4
4/16/2002	75		54	21	12
4/17/2002	63		54	9	7
4/18/2002	54		54	0	4
4/19/2002	70		54	16	10
4/20/2002	84		54	30	15
4/21/2002	61		52	9	7
4/22/2002	67		52	15	9
4/23/2002	61		52	9	7
4/24/2002	52		52	0	4
4/25/2002	59		52	7	6
4/26/2002	58		51	7	6
4/27/2002	51		51	0	4
4/28/2002	252		51	201	79
4/29/2002	115	11	51	64	28
4/30/2002	74		51	23	12
5/1/2002	69		63	6	6
5/2/2002	167		63	104	43
5/3/2002	119		63	56	25
5/4/2002	72		63	9	7
5/5/2002	63		63	0	4
5/6/2002	58		54	4	5
5/7/2002	56		54	2	4
5/8/2002	55		54	1	4
5/9/2002	54		54	0	4
5/10/2002	54		54	0	4
5/11/2002	48		48	0	4
5/12/2002	72		48	24	13
5/13/2002	69		48	21	12
5/14/2002	83		48	35	17
5/15/2002	56		48	8	7
5/16/2002	49		48	1	4
5/17/2002	48		48	0	4
5/18/2002	350		48	302	117
5/19/2002	115		48	67	29
5/20/2002	73		48	25	13
5/21/2002	63		47	16	10

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/22/2002	56		47	9	7
5/23/2002	53		47	6	6
5/24/2002	50		47	3	5
5/25/2002	47		47	0	4
5/26/2002	46		44	2	4
5/27/2002	118		44	74	32
5/28/2002	60		44	16	10
5/29/2002	48		44	4	5
5/30/2002	44		44	0	4
5/31/2002	43		35	8	7
6/1/2002	46		35	11	8
6/2/2002	38		35	3	5
6/3/2002	36	4	35	1	4
6/4/2002	35		35	0	4
6/5/2002	37		37	0	4
6/6/2002	54		37	17	10
6/7/2002	142		37	105	43
6/8/2002	52		37	15	9
6/9/2002	43		37	6	6
6/10/2002	38		35	3	5
6/11/2002	35		35	0	4
6/12/2002	45		35	10	7
6/13/2002	86		35	51	23
6/14/2002	258		35	223	88
6/15/2002	80		52	28	14
6/16/2002	56		52	4	5
6/17/2002	52		52	0	4
6/18/2002	54		52	2	4
6/19/2002	93		52	41	19
6/20/2002	55		32	23	12
6/21/2002	39		32	7	6
6/22/2002	35		32	3	5
6/23/2002	32		32	0	4
6/24/2002	35		32	3	5
6/25/2002	54		33	21	12
6/26/2002	37		33	4	5
6/27/2002	40		33	7	6
6/28/2002	47		33	14	9
6/29/2002	33		33	0	4
6/30/2002	28		23	5	6
7/1/2002	28		23	5	6
7/2/2002	26		23	3	5
7/3/2002	24		23	1	4
7/4/2002	23		23	0	4
7/5/2002	21		18	3	5
7/6/2002	19		18	1	4
7/7/2002	18		18	0	4

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/8/2002	19		18	1	4
7/9/2002	34		18	16	10
7/10/2002	65		19	46	21
7/11/2002	24		19	5	6
7/12/2002	20		19	1	4
7/13/2002	19		19	0	4
7/14/2002	23		19	4	5
7/15/2002	24		16	8	7
7/16/2002	21		16	5	6
7/17/2002	18		16	2	4
7/18/2002	17		16	1	4
7/19/2002	16		16	0	4
7/20/2002	16		14	2	4
7/21/2002	15		14	1	4
7/22/2002	14		14	0	4
7/23/2002	17		14	3	5
7/24/2002	23		14	9	7
7/25/2002	16		15	1	4
7/26/2002	16		15	1	4
7/27/2002	15		15	0	4
7/28/2002	18		15	3	5
7/29/2002	16		15	1	4
7/30/2002	14		10	4	5
7/31/2002	12		10	2	4
8/1/2002	22		10	12	8
8/2/2002	16		10	6	6
8/3/2002	10		10	0	4
8/4/2002	9.8		7.1	2.7	5
8/5/2002	9.6		7.1	2.5	5
8/6/2002	9.5		7.1	2.4	5
8/7/2002	8.4		7.1	1.3	4
8/8/2002	7.1		7.1	0	4
8/9/2002	7.5		6.3	1.2	4
8/10/2002	7.9		6.3	1.6	4
8/11/2002	7.3		6.3	1	4
8/12/2002	6.3		6.3	0	4
8/13/2002	7.3	4	6.3	1	4
8/14/2002	6.7		5.4	1.3	4
8/15/2002	6.1		5.4	0.7	4
8/16/2002	6.1		5.4	0.7	4
8/17/2002	5.4		5.4	0	4
8/18/2002	9.1		5.4	3.7	5
8/19/2002	9.5		6.1	3.4	5
8/20/2002	7.3		6.1	1.2	4
8/21/2002	6.5		6.1	0.4	4
8/22/2002	6.1		6.1	0	4
8/23/2002	6.1		6.1	0	4

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/24/2002	52		10	42	20
8/25/2002	41		10	31	15
8/26/2002	15		10	5	6
8/27/2002	10		10	0	4
8/28/2002	13		10	3	5
8/29/2002	292		19	273	106
8/30/2002	45		19	26	14
8/31/2002	19		19	0	4
9/1/2002	103		19	84	35
9/2/2002	54		19	35	17
9/3/2002	24		13	11	8
9/4/2002	18		13	5	6
9/5/2002	15		13	2	4
9/6/2002	13		13	0	4
9/7/2002	13		13	0	4
9/8/2002	12		9	3	5
9/9/2002	12		9	3	5
9/10/2002	11		9	2	4
9/11/2002	11		9	2	4
9/12/2002	9		9	0	4
9/13/2002	8.7		8.7	0	4
9/14/2002	9.3		8.7	0.6	4
9/15/2002	11		8.7	2.3	5
9/16/2002	13		8.7	4.3	5
9/17/2002	13		8.7	4.3	5
9/18/2002	12		9.6	2.4	5
9/19/2002	9.6		9.6	0	4
9/20/2002	10		9.6	0.4	4
9/21/2002	10		9.6	0.4	4
9/22/2002	9.8		9.6	0.2	4
9/23/2002	8.5		8.2	0.3	4
9/24/2002	8.4		8.2	0.2	4
9/25/2002	8.2		8.2	0	4
9/26/2002	71		8.2	62.8	27
9/27/2002	111		8.2	102.8	42
9/28/2002	83		15	68	29
9/29/2002	30		15	15	9
9/30/2002	19		15	4	5
10/1/2002	16		15	1	4
10/2/2002	15		15	0	4
10/3/2002	14		13	1	4
10/4/2002	14		13	1	4
10/5/2002	14		13	1	4
10/6/2002	14		13	1	4
10/7/2002	13		13	0	4
10/8/2002	12		11	1	4
10/9/2002	11		11	0	4

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/10/2002	43		11	32	16
10/11/2002	642		11	631	241
10/12/2002	194		11	183	72
10/13/2002	66		35	31	15
10/14/2002	44		35	9	7
10/15/2002	35		35	0	4
10/16/2002	171		35	136	55
10/17/2002	138		35	103	42
10/18/2002	60		33	27	14
10/19/2002	43		33	10	7
10/20/2002	38		33	5	6
10/21/2002	35		33	2	4
10/22/2002	33		33	0	4
10/23/2002	31		28	3	5
10/24/2002	28		28	0	4
10/25/2002	30		28	2	4
10/26/2002	119		28	91	38
10/27/2002	62		28	34	17
10/28/2002	45		45	0	4
10/29/2002	72		45	27	14
10/30/2002	150		45	105	43
10/31/2002	120		45	75	32
11/1/2002	91		45	46	21
11/2/2002	54		43	11	8
11/3/2002	47		43	4	5
11/4/2002	43		43	0	4
11/5/2002	43		43	0	4
11/6/2002	125		43	82	35
11/7/2002	66		41	25	13
11/8/2002	48		41	7	6
11/9/2002	44		41	3	5
11/10/2002	41		41	0	4
11/11/2002	56		41	15	9
11/12/2002	149		62	87	36
11/13/2002	162		62	100	41
11/14/2002	78		62	16	10
11/15/2002	62		62	0	4
11/16/2002	153		62	91	38
11/17/2002	666		77	589	225
11/18/2002	303	24	77	226	89
11/19/2002	116		77	39	18
11/20/2002	87		77	10	7
11/21/2002	77		77	0	4
11/22/2002	85		59	26	14
11/23/2002	82		59	23	12
11/24/2002	66		59	7	6
11/25/2002	62		59	3	5

2002	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/26/2002	59		59	0	4
11/27/2002	86		55	31	15
11/28/2002	70		55	15	9
11/29/2002	61		55	6	6
11/30/2002	59		55	4	5
12/1/2002	55		55	0	4
12/2/2002	51		40	11	8
12/3/2002	46		40	6	6
12/4/2002	40		40	0	4
12/5/2002	44		40	4	5
12/6/2002	60		40	20	11
12/7/2002	54		46	8	7
12/8/2002	50		46	4	5
12/9/2002	52		46	6	6
12/10/2002	46		46	0	4
12/11/2002	503		46	457	175
12/12/2002	528		135	393	151
12/13/2002	307		135	172	68
12/14/2002	587		135	452	174
12/15/2002	196		135	61	27
12/16/2002	135		135	0	4
12/17/2002	112		96	16	10
12/18/2002	99		96	3	5
12/19/2002	96		96	0	4
12/20/2002	308		96	212	83
12/21/2002	202		96	106	44
12/22/2002	124		98	26	14
12/23/2002	109		98	11	8
12/24/2002	98		98	0	4
12/25/2002	563		98	465	178
12/26/2002	324		98	226	89
12/27/2002	165		111	54	24
12/28/2002	133		111	22	12
12/29/2002	120		111	9	7
12/30/2002	112		111	1	4
12/31/2002	111		111	0	4

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/2003	331		157	174	69
1/2/2003	325		157	168	67
1/3/2003	225		157	68	29
1/4/2003	287		157	130	53
1/5/2003	157		157	0	4
1/6/2003	153		124	29	15
1/7/2003	134		124	10	7
1/8/2003	130		124	6	6
1/9/2003	140		124	16	10
1/10/2003	124		124	0	4
1/11/2003	111		96	15	9
1/12/2003	103		96	7	6
1/13/2003	104		96	8	7
1/14/2003	102		96	6	6
1/15/2003	96		96	0	4
1/16/2003	90		64	26	14
1/17/2003	82		64	18	11
1/18/2003	79		64	15	9
1/19/2003	70		64	6	6
1/20/2003	64		64	0	4
1/21/2003	58		48	10	7
1/22/2003	56		48	8	7
1/23/2003	53		48	5	6
1/24/2003	50		48	2	4
1/25/2003	48		48	0	4
1/26/2003	48		45	3	5
1/27/2003	47		45	2	4
1/28/2003	46		45	1	4
1/29/2003	46		45	1	4
1/30/2003	45		45	0	4
1/31/2003	44		44	0	4
2/1/2003	80		44	36	17
2/2/2003	74		44	30	15
2/3/2003	70		44	26	14
2/4/2003	120		44	76	32
2/5/2003	100		66	34	17
2/6/2003	90		66	24	13
2/7/2003	80		66	14	9
2/8/2003	72		66	6	6
2/9/2003	66		66	0	4
2/10/2003	62		53	9	7
2/11/2003	58		53	5	6
2/12/2003	56		53	3	5
2/13/2003	54		53	1	4
2/14/2003	53		53	0	4
2/15/2003	52		50	2	4
2/16/2003	51		50	1	4

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/2003	50		50	0	4
2/18/2003	150		50	100	41
2/19/2003	120		50	70	30
2/20/2003	100		90	10	7
2/21/2003	90		90	0	4
2/22/2003	1530		90	1440	545
2/23/2003	1660		90	1570	594
2/24/2003	612		90	522	200
2/25/2003	277		133	144	58
2/26/2003	186		133	53	24
2/27/2003	150		133	17	10
2/28/2003	142		133	9	7
3/1/2003	133		133	0	4
3/2/2003	482		200	282	110
3/3/2003	565		200	365	141
3/4/2003	200		200	0	4
3/5/2003	389		200	189	75
3/6/2003	992		200	792	301
3/7/2003	359		175	184	73
3/8/2003	284		175	109	45
3/9/2003	506		175	331	128
3/10/2003	294		175	119	48
3/11/2003	175		175	0	4
3/12/2003	160		151	9	7
3/13/2003	180		151	29	15
3/14/2003	187		151	36	17
3/15/2003	152		151	1	4
3/16/2003	151		151	0	4
3/17/2003	206		137	69	30
3/18/2003	159		137	22	12
3/19/2003	137		137	0	4
3/20/2003	597		137	460	177
3/21/2003	842		137	705	269
3/22/2003	266		170	96	40
3/23/2003	208		170	38	18
3/24/2003	184		170	14	9
3/25/2003	170		170	0	4
3/26/2003	171		170	1	4
3/27/2003	183		158	25	13
3/28/2003	158		158	0	4
3/29/2003	167		158	9	7
3/30/2003	221		158	63	27
3/31/2003	200		158	42	20
4/1/2003	157		137	20	11
4/2/2003	150		137	13	9
4/3/2003	143		137	6	6
4/4/2003	139		137	2	4

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/5/2003	137		137	0	4
4/6/2003	133		133	0	4
4/7/2003	158		133	25	13
4/8/2003	171		133	38	18
4/9/2003	217		133	84	35
4/10/2003	175		133	42	20
4/11/2003	462		141	321	124
4/12/2003	256		141	115	47
4/13/2003	173		141	32	16
4/14/2003	150		141	9	7
4/15/2003	141		141	0	4
4/16/2003	137		126	11	8
4/17/2003	129		126	3	5
4/18/2003	138		126	12	8
4/19/2003	130		126	4	5
4/20/2003	126		126	0	4
4/21/2003	123		116	7	6
4/22/2003	129		116	13	9
4/23/2003	123		116	7	6
4/24/2003	117		116	1	4
4/25/2003	116		116	0	4
4/26/2003	199		115	84	35
4/27/2003	147		115	32	16
4/28/2003	123		115	8	7
4/29/2003	118		115	3	5
4/30/2003	115		115	0	4
5/1/2003	112		105	7	6
5/2/2003	110		105	5	6
5/3/2003	107		105	2	4
5/4/2003	105		105	0	4
5/5/2003	105		105	0	4
5/6/2003	107	1	107	0	4
5/7/2003	113		107	6	6
5/8/2003	120		107	13	9
5/9/2003	115		107	8	7
5/10/2003	112		107	5	6
5/11/2003	113		96	17	10
5/12/2003	105		96	9	7
5/13/2003	100		96	4	5
5/14/2003	98		96	2	4
5/15/2003	96		96	0	4
5/16/2003	125		94	31	15
5/17/2003	121		94	27	14
5/18/2003	102		94	8	7
5/19/2003	98		94	4	5
5/20/2003	94		94	0	4
5/21/2003	112		109	3	5

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/22/2003	119		109	10	7
5/23/2003	109		109	0	4
5/24/2003	123		109	14	9
5/25/2003	117		109	8	7
5/26/2003	590		110	480	184
5/27/2003	194		110	84	35
5/28/2003	137		110	27	14
5/29/2003	123		110	13	9
5/30/2003	110		110	0	4
5/31/2003	104		102	2	4
6/1/2003	134		102	32	16
6/2/2003	117		102	15	9
6/3/2003	102	4	102	0	4
6/4/2003	457		102	355	137
6/5/2003	302		162	140	56
6/6/2003	162		162	0	4
6/7/2003	503		162	341	132
6/8/2003	329		162	167	66
6/9/2003	191		162	29	15
6/10/2003	145		127	18	11
6/11/2003	127		127	0	4
6/12/2003	205		127	78	33
6/13/2003	212		127	85	36
6/14/2003	170		127	43	20
6/15/2003	132		108	24	13
6/16/2003	115		108	7	6
6/17/2003	108		108	0	4
6/18/2003	397		108	289	112
6/19/2003	155		108	47	21
6/20/2003	2170		192	1978	747
6/21/2003	1400		192	1208	458
6/22/2003	309		192	117	48
6/23/2003	225		192	33	16
6/24/2003	192		192	0	4
6/25/2003	169		140	29	15
6/26/2003	157		140	17	10
6/27/2003	149		140	9	7
6/28/2003	140		140	0	4
6/29/2003	142		140	2	4
6/30/2003	137		125	12	8
7/1/2003	128		125	3	5
7/2/2003	125		125	0	4
7/3/2003	176		125	51	23
7/4/2003	133		125	8	7
7/5/2003	114		95	19	11
7/6/2003	138		95	43	20
7/7/2003	112		95	17	10

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/8/2003	98		95	3	5
7/9/2003	95		95	0	4
7/10/2003	98		92	6	6
7/11/2003	110		92	18	11
7/12/2003	92		92	0	4
7/13/2003	98		92	6	6
7/14/2003	95		92	3	5
7/15/2003	91		76	15	9
7/16/2003	86		76	10	7
7/17/2003	79		76	3	5
7/18/2003	76		76	0	4
7/19/2003	81		76	5	6
7/20/2003	74		71	3	5
7/21/2003	71		71	0	4
7/22/2003	71		71	0	4
7/23/2003	79		71	8	7
7/24/2003	100		71	29	15
7/25/2003	70		61	9	7
7/26/2003	63		61	2	4
7/27/2003	62		61	1	4
7/28/2003	63		61	2	4
7/29/2003	61		61	0	4
7/30/2003	58		58	0	4
7/31/2003	68		58	10	7
8/1/2003	66		58	8	7
8/2/2003	96		58	38	18
8/3/2003	62		58	4	5
8/4/2003	71		71	0	4
8/5/2003	111		71	40	19
8/6/2003	97		71	26	14
8/7/2003	85		71	14	9
8/8/2003	101		71	30	15
8/9/2003	360		88	272	106
8/10/2003	480		88	392	151
8/11/2003	164		88	76	32
8/12/2003	117		88	29	15
8/13/2003	88		88	0	4
8/14/2003	78		70	8	7
8/15/2003	70		70	0	4
8/16/2003	78		70	8	7
8/17/2003	122		70	52	23
8/18/2003	77	4	70	7	6
8/19/2003	68		61	7	6
8/20/2003	64		61	3	5
8/21/2003	61		61	0	4
8/22/2003	73		61	12	8
8/23/2003	88		61	27	14

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/24/2003	60		55	5	6
8/25/2003	56		55	1	4
8/26/2003	55		55	0	4
8/27/2003	58		55	3	5
8/28/2003	56		55	1	4
8/29/2003	54		54	0	4
8/30/2003	178		54	124	50
8/31/2003	118		54	64	28
9/1/2003	76		54	22	12
9/2/2003	105		54	51	23
9/3/2003	98		64	34	17
9/4/2003	177		64	113	46
9/5/2003	110		64	46	21
9/6/2003	74		64	10	7
9/7/2003	64		64	0	4
9/8/2003	60		53	7	6
9/9/2003	57		53	4	5
9/10/2003	54		53	1	4
9/11/2003	53		53	0	4
9/12/2003	57		53	4	5
9/13/2003	160		150	10	7
9/14/2003	150		150	0	4
9/15/2003	6650		150	6500	2446
9/16/2003	531		150	381	147
9/17/2003	260		150	110	45
9/18/2003	405		155	250	98
9/19/2003	888		155	733	279
9/20/2003	235		155	80	34
9/21/2003	181		155	26	14
9/22/2003	155		155	0	4
9/23/2003	1260		160	1100	417
9/24/2003	285		160	125	51
9/25/2003	187		160	27	14
9/26/2003	160		160	0	4
9/27/2003	160		160	0	4
9/28/2003	288		118	170	68
9/29/2003	160		118	42	20
9/30/2003	130		118	12	8
10/1/2003	122		118	4	5
10/2/2003	118		118	0	4
10/3/2003	112		104	8	7
10/4/2003	113		104	9	7
10/5/2003	117		104	13	9
10/6/2003	107		104	3	5
10/7/2003	104		104	0	4
10/8/2003	102		95	7	6
10/9/2003	102		95	7	6

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/10/2003	101		95	6	6
10/11/2003	99		95	4	5
10/12/2003	95		95	0	4
10/13/2003	92		92	0	4
10/14/2003	151		92	59	26
10/15/2003	529		92	437	168
10/16/2003	136		92	44	20
10/17/2003	114		92	22	12
10/18/2003	123		97	26	14
10/19/2003	106		97	9	7
10/20/2003	99		97	2	4
10/21/2003	98		97	1	4
10/22/2003	97		97	0	4
10/23/2003	92		87	5	6
10/24/2003	89		87	2	4
10/25/2003	87		87	0	4
10/26/2003	90		87	3	5
10/27/2003	1450		87	1363	516
10/28/2003	580		186	394	152
10/29/2003	876		186	690	263
10/30/2003	298		186	112	46
10/31/2003	215		186	29	15
11/1/2003	186		186	0	4
11/2/2003	171		156	15	9
11/3/2003	162	2	156	6	6
11/4/2003	156		156	0	4
11/5/2003	159		156	3	5
11/6/2003	207		156	51	23
11/7/2003	223		117	106	44
11/8/2003	163		117	46	21
11/9/2003	117		117	0	4
11/10/2003	143		117	26	14
11/11/2003	143		117	26	14
11/12/2003	324		141	183	72
11/13/2003	195		141	54	24
11/14/2003	152		141	11	8
11/15/2003	144		141	3	5
11/16/2003	141		141	0	4
11/17/2003	140		136	4	5
11/18/2003	136		136	0	4
11/19/2003	505		136	369	142
11/20/2003	752		136	616	235
11/21/2003	234		136	98	41
11/22/2003	192		155	37	18
11/23/2003	173		155	18	11
11/24/2003	165		155	10	7
11/25/2003	174		155	19	11

2003	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/26/2003	155		155	0	4
11/27/2003	151		151	0	4
11/28/2003	253		151	102	42
11/29/2003	483		151	332	128
11/30/2003	196		151	45	21
12/1/2003	172		151	21	12
12/2/2003	157		146	11	8
12/3/2003	149		146	3	5
12/4/2003	146		146	0	4
12/5/2003	180		146	34	17
12/6/2003	194		146	48	22
12/7/2003	170		153	17	10
12/8/2003	156		153	3	5
12/9/2003	153		153	0	4
12/10/2003	300		153	147	59
12/11/2003	2240		153	2087	788
12/12/2003	364		248	116	47
12/13/2003	248		248	0	4
12/14/2003	390		248	142	57
12/15/2003	479		248	231	91
12/16/2003	254		248	6	6
12/17/2003	676		200	476	183
12/18/2003	343		200	143	57
12/19/2003	240		200	40	19
12/20/2003	218		200	18	11
12/21/2003	200		200	0	4
12/22/2003	194		192	2	4
12/23/2003	192		192	0	4
12/24/2003	409		192	217	85
12/25/2003	288		192	96	40
12/26/2003	208		192	16	10
12/27/2003	195		168	27	14
12/28/2003	182		168	14	9
12/29/2003	178		168	10	7
12/30/2003	181		168	13	9
12/31/2003	168		168	0	4

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
1/1/2004	164		161	3	5
1/2/2004	165		161	4	5
1/3/2004	165		161	4	5
1/4/2004	161		161	0	4
1/5/2004	210		161	49	22
1/6/2004	195		137	58	26
1/7/2004	152		137	15	9
1/8/2004	140		137	3	5
1/9/2004	146		137	9	7
1/10/2004	137		137	0	4
1/11/2004	139		131	8	7
1/12/2004	149		131	18	11
1/13/2004	141		131	10	7
1/14/2004	135		131	4	5
1/15/2004	131		131	0	4
1/16/2004	120		120	0	4
1/17/2004	140		120	20	11
1/18/2004	180		120	60	26
1/19/2004	160		120	40	19
1/20/2004	140		120	20	11
1/21/2004	130		120	10	7
1/22/2004	120		120	0	4
1/23/2004	120		120	0	4
1/24/2004	130		120	10	7
1/25/2004	120		120	0	4
1/26/2004	120		110	10	7
1/27/2004	140		110	30	15
1/28/2004	140		110	30	15
1/29/2004	120		110	10	7
1/30/2004	110		110	0	4
1/31/2004	100		100	0	4
2/1/2004	100		100	0	4
2/2/2004	120		100	20	11
2/3/2004	500		100	400	154
2/4/2004	700		100	600	229
2/5/2004	523		214	309	120
2/6/2004	2040		214	1826	690
2/7/2004	1260		214	1046	397
2/8/2004	336		214	122	50
2/9/2004	214		214	0	4
2/10/2004	233		167	66	29
2/11/2004	237		167	70	30
2/12/2004	183		167	16	10
2/13/2004	170		167	3	5
2/14/2004	167		167	0	4
2/15/2004	160		138	22	12
2/16/2004	143		138	5	6

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
2/17/2004	138		138	0	4
2/18/2004	143		138	5	6
2/19/2004	142		138	4	5
2/20/2004	147		137	10	7
2/21/2004	150		137	13	9
2/22/2004	146		137	9	7
2/23/2004	137		137	0	4
2/24/2004	137		137	0	4
2/25/2004	137		122	15	9
2/26/2004	127		122	5	6
2/27/2004	126		122	4	5
2/28/2004	123		122	1	4
2/29/2004	122		122	0	4
3/1/2004	123		123	0	4
3/2/2004	131		123	8	7
3/3/2004	133		123	10	7
3/4/2004	132		123	9	7
3/5/2004	135		123	12	8
3/6/2004	411		141	270	105
3/7/2004	236		141	95	39
3/8/2004	188		141	47	21
3/9/2004	159		141	18	11
3/10/2004	141		141	0	4
3/11/2004	135		119	16	10
3/12/2004	130		119	11	8
3/13/2004	121		119	2	4
3/14/2004	119		119	0	4
3/15/2004	121		119	2	4
3/16/2004	179		177	2	4
3/17/2004	206		177	29	15
3/18/2004	177		177	0	4
3/19/2004	313		177	136	55
3/20/2004	231		177	54	24
3/21/2004	171		132	39	18
3/22/2004	144		132	12	8
3/23/2004	134		132	2	4
3/24/2004	132		132	0	4
3/25/2004	134		132	2	4
3/26/2004	130		117	13	9
3/27/2004	129		117	12	8
3/28/2004	126		117	9	7
3/29/2004	118		117	1	4
3/30/2004	117		117	0	4
3/31/2004	149		149	0	4
4/1/2004	218		149	69	30
4/2/2004	234		149	85	36
4/3/2004	308		149	159	63

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
4/4/2004	319		149	170	68
4/5/2004	231	31	140	91	38
4/6/2004	166		140	26	14
4/7/2004	149		140	9	7
4/8/2004	140		140	0	4
4/9/2004	162		140	22	12
4/10/2004	137		130	7	6
4/11/2004	130		130	0	4
4/12/2004	169		130	39	18
4/13/2004	518		130	388	150
4/14/2004	417		130	287	112
4/15/2004	269		148	121	49
4/16/2004	186		148	38	18
4/17/2004	165		148	17	10
4/18/2004	156		148	8	7
4/19/2004	148		148	0	4
4/20/2004	142		133	9	7
4/21/2004	134		133	1	4
4/22/2004	133		133	0	4
4/23/2004	133		133	0	4
4/24/2004	182		133	49	22
4/25/2004	138		138	0	4
4/26/2004	247		138	109	45
4/27/2004	325		138	187	74
4/28/2004	177		138	39	18
4/29/2004	148		138	10	7
4/30/2004	138		129	9	7
5/1/2004	132		129	3	5
5/2/2004	129		129	0	4
5/3/2004	256		129	127	51
5/4/2004	244		129	115	47
5/5/2004	159		126	33	16
5/6/2004	148		126	22	12
5/7/2004	137		126	11	8
5/8/2004	141		126	15	9
5/9/2004	126		126	0	4
5/10/2004	700		123	577	221
5/11/2004	200		123	77	33
5/12/2004	147		123	24	13
5/13/2004	131		123	8	7
5/14/2004	123		123	0	4
5/15/2004	119		119	0	4
5/16/2004	133		119	14	9
5/17/2004	119		119	0	4
5/18/2004	122		119	3	5
5/19/2004	236		119	117	48
5/20/2004	179		112	67	29

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
5/21/2004	201		112	89	37
5/22/2004	175		112	63	27
5/23/2004	126		112	14	9
5/24/2004	112		112	0	4
5/25/2004	106		96	10	7
5/26/2004	119		96	23	12
5/27/2004	111		96	15	9
5/28/2004	104		96	8	7
5/29/2004	96		96	0	4
5/30/2004	91		91	0	4
5/31/2004	114		91	23	12
6/1/2004	115		91	24	13
6/2/2004	122		91	31	15
6/3/2004	113		91	22	12
6/4/2004	96		96	0	4
6/5/2004	300		96	204	80
6/6/2004	280		96	184	73
6/7/2004	160		96	64	28
6/8/2004	124		96	28	14
6/9/2004	110		110	0	4
6/10/2004	163		110	53	24
6/11/2004	441		110	331	128
6/12/2004	201		110	91	38
6/13/2004	134		110	24	13
6/14/2004	160		160	0	4
6/15/2004	950		160	790	301
6/16/2004	404		160	244	95
6/17/2004	900		160	740	282
6/18/2004	1000		160	840	319
6/19/2004	300		160	140	56
6/20/2004	200		160	40	19
6/21/2004	160		160	0	4
6/22/2004	214		160	54	24
6/23/2004	196		160	36	17
6/24/2004	141		124	17	10
6/25/2004	141		124	17	10
6/26/2004	184		124	60	26
6/27/2004	136		124	12	8
6/28/2004	124		124	0	4
6/29/2004	147	9	104	43	20
6/30/2004	120		104	16	10
7/1/2004	112		104	8	7
7/2/2004	109		104	5	6
7/3/2004	104		104	0	4
7/4/2004	99		96	3	5
7/5/2004	100		96	4	5
7/6/2004	96		96	0	4

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
7/7/2004	425		96	329	127
7/8/2004	244		96	148	59
7/9/2004	116		92	24	13
7/10/2004	97		92	5	6
7/11/2004	92		92	0	4
7/12/2004	1000		92	908	345
7/13/2004	375		92	283	110
7/14/2004	256		137	119	48
7/15/2004	225		137	88	37
7/16/2004	157		137	20	11
7/17/2004	137		137	0	4
7/18/2004	424		137	287	112
7/19/2004	259		129	130	53
7/20/2004	166		129	37	18
7/21/2004	140		129	11	8
7/22/2004	129		129	0	4
7/23/2004	132		129	3	5
7/24/2004	130		116	14	9
7/25/2004	119		116	3	5
7/26/2004	116		116	0	4
7/27/2004	144		116	28	14
7/28/2004	1200		116	1084	411
7/29/2004	200		137	63	27
7/30/2004	153		137	16	10
7/31/2004	137		137	0	4
8/1/2004	791		137	654	249
8/2/2004	225		137	88	37
8/3/2004	168		140	28	14
8/4/2004	193		140	53	24
8/5/2004	207		140	67	29
8/6/2004	160		140	20	11
8/7/2004	140		140	0	4
8/8/2004	121		112	9	7
8/9/2004	116		112	4	5
8/10/2004	114		112	2	4
8/11/2004	112		112	0	4
8/12/2004	1140		112	1028	390
8/13/2004	881		151	730	278
8/14/2004	229		151	78	33
8/15/2004	192		151	41	19
8/16/2004	170		151	19	11
8/17/2004	151		151	0	4
8/18/2004	141		134	7	6
8/19/2004	137		134	3	5
8/20/2004	134		134	0	4
8/21/2004	189		134	55	24
8/22/2004	193		134	59	26

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
8/23/2004	136		115	21	12
8/24/2004	127		115	12	8
8/25/2004	122		115	7	6
8/26/2004	119		115	4	5
8/27/2004	115		115	0	4
8/28/2004	113		111	2	4
8/29/2004	111		111	0	4
8/30/2004	400		111	289	112
8/31/2004	292		111	181	72
9/1/2004	134		111	23	12
9/2/2004	116		99	17	10
9/3/2004	108		99	9	7
9/4/2004	104		99	5	6
9/5/2004	101		99	2	4
9/6/2004	99		99	0	4
9/7/2004	97		91	6	6
9/8/2004	97		91	6	6
9/9/2004	121		91	30	15
9/10/2004	101		91	10	7
9/11/2004	91		91	0	4
9/12/2004	89		86	3	5
9/13/2004	87		86	1	4
9/14/2004	86		86	0	4
9/15/2004	100		86	14	9
9/16/2004	96		86	10	7
9/17/2004	92		92	0	4
9/18/2004	2000		92	1908	721
9/19/2004	320		92	228	89
9/20/2004	159		92	67	29
9/21/2004	132		92	40	19
9/22/2004	118		101	17	10
9/23/2004	110		101	9	7
9/24/2004	105		101	4	5
9/25/2004	102		101	1	4
9/26/2004	101		101	0	4
9/27/2004	99		99	0	4
9/28/2004	2800		99	2701	1019
9/29/2004	3600		99	3501	1319
9/30/2004	355		99	256	100
10/1/2004	241		99	142	57
10/2/2004	206		153	53	24
10/3/2004	190		153	37	18
10/4/2004	175		153	22	12
10/5/2004	164	2	153	11	8
10/6/2004	153		153	0	4
10/7/2004	150		138	12	8
10/8/2004	147		138	9	7

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
10/9/2004	145		138	7	6
10/10/2004	145		138	7	6
10/11/2004	138		138	0	4
10/12/2004	135		135	0	4
10/13/2004	135		135	0	4
10/14/2004	184		135	49	22
10/15/2004	191		135	56	25
10/16/2004	364		135	229	90
10/17/2004	162		136	26	14
10/18/2004	136		136	0	4
10/19/2004	377		136	241	94
10/20/2004	184		136	48	22
10/21/2004	165		136	29	15
10/22/2004	150		128	22	12
10/23/2004	139		128	11	8
10/24/2004	132		128	4	5
10/25/2004	128		128	0	4
10/26/2004	128		128	0	4
10/27/2004	123		118	5	6
10/28/2004	120		118	2	4
10/29/2004	118		118	0	4
10/30/2004	152		118	34	17
10/31/2004	129		118	11	8
11/1/2004	119		116	3	5
11/2/2004	116		116	0	4
11/3/2004	116		116	0	4
11/4/2004	334		116	218	86
11/5/2004	427		116	311	121
11/6/2004	164		124	40	19
11/7/2004	142		124	18	11
11/8/2004	133		124	9	7
11/9/2004	127		124	3	5
11/10/2004	124		124	0	4
11/11/2004	125		125	0	4
11/12/2004	267		125	142	57
11/13/2004	503		125	378	146
11/14/2004	180		125	55	24
11/15/2004	151		125	26	14
11/16/2004	143		128	15	9
11/17/2004	135		128	7	6
11/18/2004	130		128	2	4
11/19/2004	128		128	0	4
11/20/2004	129		128	1	4
11/21/2004	133		124	9	7
11/22/2004	124		124	0	4
11/23/2004	124		124	0	4
11/24/2004	130		124	6	6

2004	CFS	STORET Turbidity	Baseflow	Runoff	Extrapolated NTU
11/25/2004	193		124	69	30
11/26/2004	143		124	19	11
11/27/2004	124		124	0	4
11/28/2004	2040		124	1916	724
11/29/2004	340		124	216	85
11/30/2004	235		124	111	45
12/1/2004	614		180	434	167
12/2/2004	285		180	105	43
12/3/2004	219		180	39	18
12/4/2004	194		180	14	9
12/5/2004	182		180	2	4
12/6/2004	174		174	0	4
12/7/2004	233		174	59	26
12/8/2004	265		174	91	38
12/9/2004	217		174	43	20
12/10/2004	474		174	300	116
12/11/2004	397		189	208	82
12/12/2004	262		189	73	31
12/13/2004	249		189	60	26
12/14/2004	199		189	10	7
12/15/2004	189		189	0	4
12/16/2004	178		161	17	10
12/17/2004	169		161	8	7
12/18/2004	162		161	1	4
12/19/2004	164		161	3	5
12/20/2004	161		161	0	4
12/21/2004	165		151	14	9
12/22/2004	151		151	0	4
12/23/2004	479		151	328	127
12/24/2004	406		151	255	100
12/25/2004	197		151	46	21
12/26/2004	168		150	18	11
12/27/2004	166		150	16	10
12/28/2004	164		150	14	9
12/29/2004	150		150	0	4
12/30/2004	154		150	4	5
12/31/2004	154		154	0	4

APPENDIX C

Delaware Park Source Water Area and Land Use Analysis

Map C-1 Delaware Park Source Water Area

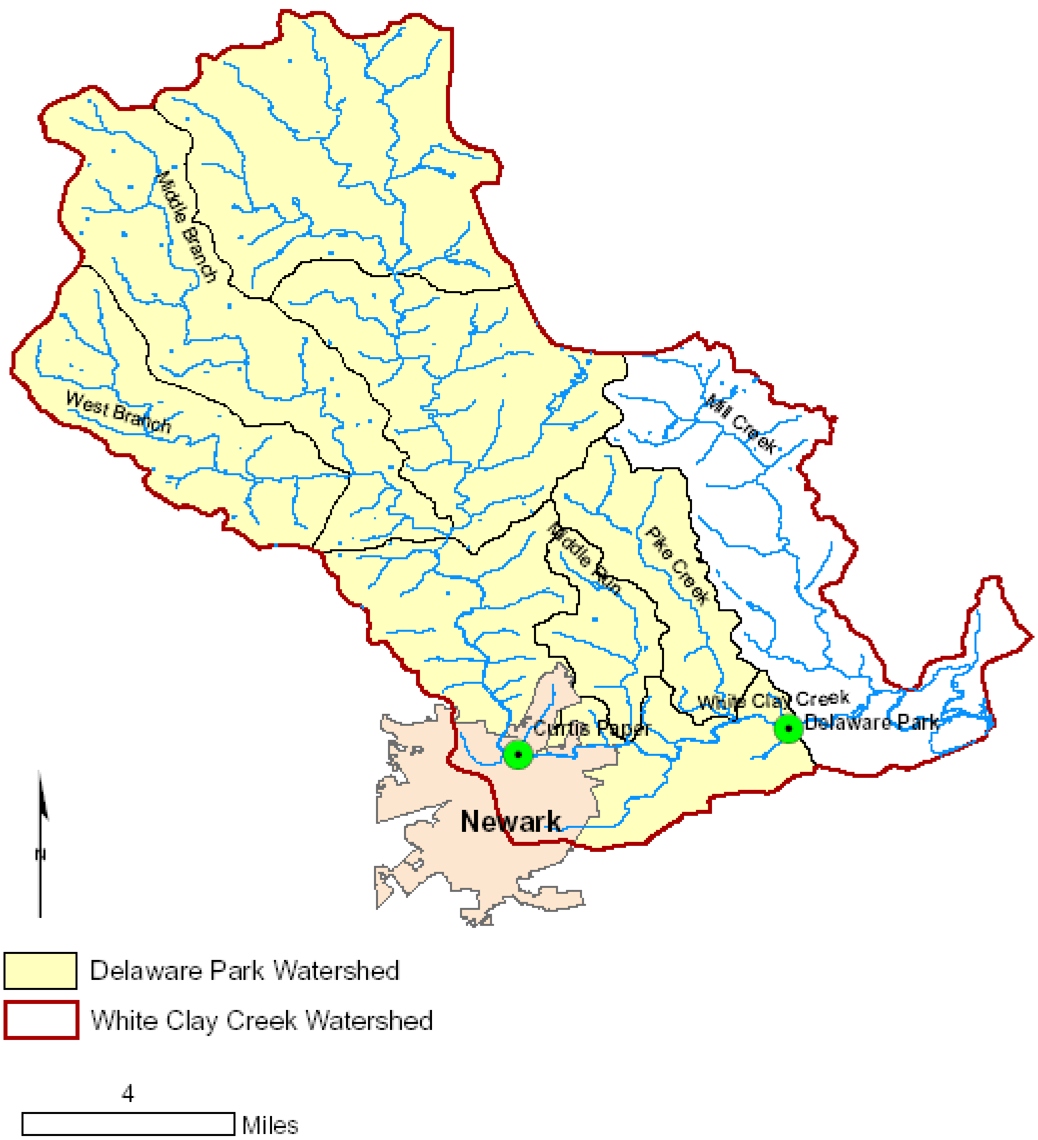


Table C-1 Delaware Park Land Use Analysis

	Square Miles				
	Total Square Miles	**PA**	**DE**	**Total Area**	**Total IC %**
Single Family Residential	7.3	12.37	1.78	21.45	6.435
Multi Family Residential	1.1	0.13	0.05	1.28	0.8294
Commercial	1.44	0.85	0.18	2.47	2.0995
Industrial	0.43	0.16	0.05	0.64	0.46224
Utility/Transportation	0.31	0.59	0.004	0.90	0.8136
Mixed Urban	0.37	0.00	0.126	0.50	0.248
Institutional/Governmental	0.91	0.28	0.1	1.29	0.7095
Recreational	0.66	0.81	0.36	1.83	0
Agriculture	2.48	29.56	1.34	33.38	0
Rangeland	0.3	0.00	0.1	0.40	0
Forest	3.62	14.57	4.34	22.53	0
Water	0.08	0.39	0.084	0.55	0
Wetlands	0.15	1.00	0.054	1.20	0
Barren	0.026	1.00	0	1.03	0.0513

DP sourcewater area   88.316 square miles   13.2% impervious