2011

Effects of Solids Loadings and Particle Size Distribution on Siphon Ceramic Candle Filters

Danielle Renzi
University of South Florida, danielle.renzi@gmail.com

Effects of Solids Loadings and Particle Size Distribution

on Siphon Ceramic Candle Filters

by

Danielle Renzi

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
Department of Civil and Environmental Engineering
College of Engineering
University of South Florida

Co-Major Professor: James R. Mihelcic, Ph.D.
Co-Major Professor: Maya A. Trotz, Ph.D.
Nancy Romero-Daza, Ph.D.

Date of Approval:
October 21, 2011

Keywords: point-of-use treatment, Tulip filter, developing world,
Basic Water Needs, *E. coli* removal

ACKNOWLEDGEMENTS

I would like to thank, first and foremost, Dr. James Mihelcic for developing the Master's International program and allowing me to be a part of this great experiment in international development. I would also like to thank committee members Dr. Maya Trotz and Dr. Nancy Romero-Daza for their helpful insight and perspective.

Thanks to my colleagues in Madagascar, Jonathan Annis and Luke Barrett for their technical help, support and interest in the project.

Also, I would like to thank Jeff Novoa, Benjamin Yoakum and Sarah Ness for their help collecting data during the summer of 2011. I would not have been able to complete this project without their help.

Finally, I'd like to thank my friends and family for all their support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES iii

LIST OF FIGURES v

ABSTRACT vii

CHAPTER 1 INTRODUCTION 1
- 1.1 Access to Clean Water 1
- 1.2 Madagascar and RANO HP Project 3

CHAPTER 2 LITERATURE REVIEW ON WATER AND DISEASE 6
- 2.1 Pathogens Affecting Water Quality 7
- 2.2 Benefits of Point-of-Use Treatment 10
- 2.3 Types of Point-of-Use Technologies 11
  - 2.3.1 Comparative Analysis 14
- 2.4 The Tulip Filter 18
  - 2.4.1 Mechanisms for Removing Pathogens 19
  - 2.4.2 Previous Laboratory Studies Performed on the Tulip Filters 20
  - 2.4.3 Field Studies 23

CHAPTER 3 METHODS 24
- 3.1 Set-Up 24
- 3.2 Water Quality Measurements 28
  - 3.2.1 Turbidity 29
  - 3.2.2 Coliform Testing 30
  - 3.2.3 Total Suspended Solids and Solids Loading 32
- 3.3 Particle Size Distribution 35
  - 3.3.1 Scrubbing Procedure 36

CHAPTER 4 RESULTS AND DISCUSSION 37
- 4.1 Baseline Data and Overall Results 37
- 4.2 Solids Loading 39
  - 4.2.1 Flow Rate as a Function of Solids Loading 42
  - 4.2.2 Turbidity Removal as a Function of Solids Loading 44
  - 4.2.3 Coliform Removal as a Function of Solids Loading 48
- 4.3 Hydraulic Loading 53

4.3.1 Turbidity Removal as a Function of Hydraulic Loading 54
4.4 Particle Size Distribution 57
4.5 Synthetic and Pond Water pH Values 59
4.6 Comment on User Acceptability and Limitations of Study 61

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS 63
5.1 Conclusions for Implementation of Tulip Filter 63
5.2 Recommendations for Future Research 65

REFERENCES 67

APPENDICES 71
Appendix I. Instructions for Use of the Tulip Filter Provided by BWN 72
Appendix II. Standard Curve Between TSS and Turbidity 73
Appendix III. Turbidity vs. Time for Synthetic Water Samples 76
Appendix IV. Raw Data 77

LIST OF TABLES

Table 1. Types of water supply as defined by the World Health Organization (WHO). 2

Table 2. Types of sanitation as defined by the World Health Organization (WHO). 3

Table 3. List of common water-borne pathogens, their diseases, and their sources. 8

Table 4. Prominent waterborne pathogens, their associated percentages of global incidences of gastroenteritis, and the range of their sizes. 9

Table 5. Various POU technologies. 17

Table 6. Studies provided by Basic Water Needs suggest high levels of coliform and turbidity removal. 22

Table 7. A description of organization of the experiment. 27

Table 8. Four basic water quality measurements were taken throughout the experiment. 28

Table 9. Cumulative suspended solids loading and hydraulic loading received by each filter over the complete experiment. 37

Table 10. First-hour flow rate using only tap water for each of the initial seven filters. 39

Table 11. Average influent turbidity for synthetic waters for each of the filters. 41

Table 12. Average flow rate, Q (L/hr) of each filter. 44

Table 13. The average influent and effluent turbidities are shown in the table below. 45

Table 14. The average influent and effluent turbidities are shown in the table below for all of the pond water trials. 46

Table 15. The average influent and effluent turbidities are shown in the table below for only the synthetic water trials. 47

Table 16. Number of samples that conform to the World Health Organization's (WHO) guidelines for turbidity for each filter. 47

Table 17. Log removal values for total coliforms and the associated average influent concentration. 50

Table 18. Log removal values for *E. coli* and the associated average influent concentration. 51

Table 19. Guidelines for risk levels developed by the World Health Organization (WHO, 2011). 51

Table 20. Number of samples that are "low risk" according to the World Health Organization (WHO) guidelines for *E.coli*. 52

Table 21. Number of influent and effluent samples that are classified as "low risk" according to the World Health Organization (WHO) guidelines for total coliforms. 53

Table 22. The cumulative volume of water processed by each filter. 54

Table 23. Values of pH for pond water and each category of turbidity water after 30 minutes of settling. 60

Table II.1 Data used to relate turbidity and TSS 74

Table II.2 Statistical parameters for standard curve 75

Table II.3 Regression line with 95% confidence intervals for standard curve 75

Table IV.1 Turbidity and flow rate data 77

Table IV.2 Particle size data 138

Table IV.3 Particle size data for three influent samples 143

LIST OF FIGURES

Figure 1. Communities in Eastern Madagascar serviced by the RANO HP project. 4

Figure 2. Ceramic pot filters from Potters for Peace and FilterPure. 13

Figure 3. Photo of a Tulip filter used in this study. 18

Figure 4. Tulip filter taken out of the blue container with ceramic candle element exposed. 18

Figure 5. Initial set-up with all seven filters sitting in 20 L buckets and dispensing into 20 L buckets below. 25

Figure 6. Diagram of how a turbidimeter makes a measurement. 29

Figure 7. Turbidity measurement using Hach 2100Q Portable Turbidimeter 30

Figure 8. IDEXX Colilert® results. 31

Figure 9. Total suspended solids (TSS) set-up pictured here. 33

Figure 10. Relationship between total suspended solids (TSS) and turbidity for synthetic water (tap water with Sil-Co-Sil® 75 silica sand). 34

Figure 11. Scrubbing ceramic candle using the green scrubbing pad. 36

Figure 12. Filter 7 after the glue failed. 38

Figure 13. Influent samples after settling for 30 minutes. 40

Figure 14. Log removal values for Filters 1.1, 2, 3, 4, and 6 for total coliforms and *E. coli*. 48

Figure 15. Turbidity removal as percent removal versus the cumulative volume filtered for low turbidity filters, Filters 2 and 3. 55

Figure 16. Turbidity removal as percent removal versus the cumulative volume filtered for medium turbidity filters, Filters 4 and 5. 55

Figure 17. Turbidity removal as percent removal versus the cumulative volume filtered for high turbidity filters, Filters 6 and 7. 56

Figure 18. Filter 6 influent and effluent sample of pond water and the cumulative percent distribution. 57

Figure 19. A comparison of the percent distribution for synthetic water and two pond water samples. 58

Figure 20. Percent reduction in particle size for pond water for each range of particle sizes and compared with the overall. 59

Figure 21. Backwashing the Tulip filter after using pond water. 62

Figure II.1 95% confidence intervals of regression line and all direct measurements 73

ABSTRACT

In the rural areas of Madagascar only 29% of the population has access to clean water and 10% has access to improved sanitation. It has been estimated that environmental risk factors, such as inadequate access to clean drinking water and proper sanitation, are responsible for 94% of the diarrheal disease burden. This study was focused on testing a point-of-use technology called the Tulip filter, which is a siphon ceramic candle filter impregnated with silver. The purpose is to assess its feasibility for implementation in rural regions of Madagascar through a laboratory study performed at the University of South Florida.

The study tested the Tulip filters for turbidity, total coliform, and *E. coli* removal for various types of water. Each filter processed synthetic water classified as control (tap water, <1 NTU), low turbidity (5-7 NTU), medium turbidity (25-35 NTU), or high turbidity (60-80 NTU). Approximately once every 100 L the filters processed pond water to test coliform removal. Furthermore, the particle size distribution was measured to analyze the effectiveness of filter to remove various particle sizes. Two of the seven Tulip filters tested had some quality control issues with the glue connecting the ceramic candle to the plastic cap and failed at 350 L.

Of the functioning filters, the turbidity removal ranged from 93% to 98% with none of the 779 samples taken from 4 filters above the WHO recommended 5 NTU for drinking water. The log removal of total coliforms was about 3.90 to 4.16 and achieved an average of 1 CFU/100mL of *E. coli* in the filtered water. WHO guidelines consider water with 1-10 CFU/100 mL a "low risk" and all but one of the working filters had *E. coli* and total coliform concentrations within, or below, this range for all samples (n=20 for each filter). The filters also showed an average of 96% removal of particles of all size ranging from 0.5 to 10 µm.

This study finds that the Tulip filter is an appropriate of point-of-use technology that enables rural areas access to "low risk" water, at a low cost and with minimal maintenance. This study also reinforces the importance of adding silver or another biocide to ceramic filters because particles of sizes up to 10 µm are able to pass through the filter. This is particularly a problem because pathogens can range from 0.01 µm to 100 µm.

CHAPTER 1 INTRODUCTION

1.1 Access to Clean Water

Lack of clean drinking water and appropriate sanitation facilities have long been associated with diarrheal disease. In fact, an estimated 94% of the diarrheal disease burden is associated with environmental risk factors such as inadequate access to clean drinking water and proper sanitation (Prüss-üstün & Corvalán, 2006). Pathogens that cause diarrheal disease, or organisms that can cause diseases, are primarily transmitted to humans through the fecal-oral route (Black, 2001). This places populations with limited access to sanitation, hygiene and water supply at higher risk for diarrheal infections. Furthermore, diarrhea is the second-leading cause of death in children under five years old, accounting for 21% of deaths in children of this age (WHO, 2010).

In order to address environmental and health issues, a group of representatives from 189 countries came together in 2000 and endorsed the Millennium Declaration (United Nations, 2010). From this declaration, eight Millennium Development Goals (MDGs) were established to be used as a metric of progress in reducing poverty, hunger, poor health, gender inequalities, access to education, and clean water and sanitation. Goal 7 of the MDGs was to ensure environmental sustainability and Target 7C was to halve the proportion of people without clean water and sanitation by 2015. Currently, it is estimated that 884 million people worldwide still lack access to clean water (WHO & UNICEF, 2010). Thus, 884 million people are at risk every day of drinking water potentially contaminated with pathogens.

Table 1. Types of water supply as defined by the World Health Organization (WHO). The estimated percentage of the Madagascar population, total population, and rural population, with access to each type of water supply is provided.

Water Supply	Improved	Piped water into dwelling Piped water to yard/plot Public tap or standpipe Tubewell or borehole Protected spring Rainwater	41% of Total Madagascar Pop. 29% of Rural Madagascar Pop.
	Unimproved	Unprotected spring Unprotected dug well Cart with small tank/drum Tanker-truck Surface water Bottled water	59% of Total Madagascar Pop. 61% of Rural Madagascar Pop.

(Adapted from WHO 2008 and WHO & UNICEF, 2010)

In the country of Madagascar, lack of clean water and sanitation is a tremendous problem. About 59% of the total population lacks access to improved water sources and 89% of the population lacks access to improved sanitation sources (WHO, 2008). Furthermore, only about 10% of the rural population has access to improved sanitation facilities (WHO, 2008). As shown in Table 1 and Table 2, the World Health Organization (WHO) classifies various types of water supply and sanitation technologies as either “improved” or “unimproved” to be used as a metric for determining access to safe water. Even most types of improved water sources and sanitation are unacceptable by First World standards and do not guarantee water quality.

Table 2. Types of sanitation as defined by the World Health Organization (WHO). The estimated percentage of the Madagascar population, total population, and rural population, with access to each type of sanitation technology is provided.

Sanitation	Improved	Flush water Piped sewer system Septic tank Flush/pour flush to pit latrine Ventilated Improved Pit latrine (VIP) Pit latrine with slab Composting toilet Special case	11% of Total Madagascar Pop. 10% of Rural Madagascar Pop.
	Unimproved	Flush/pour flush to elsewhere Pit latrine without slab Bucket Hanging toilet or hanging latrine No facilities or bush or field	89% of Total Madagascar Pop. 90% of Rural Madagascar Pop

(Adapted from WHO 2008 and WHO & UNICEF, 2010)

1.2 Madagascar and RANO HP Project

In December 2009, the Rural Access to New Opportunities for Health and Prosperity (RANO HP) project was launched in an effort to combat lack of access to water and sanitation in rural Malagasy communities. The program intends to target approximately 340,000 people in 42 rural communities on the east coast of Madagascar to be supplied with economically sustainable water and sanitation services. The communities are shown in Figure 1. Furthermore, the project plans to promote a holistic approach by incorporating education of water and sanitation practices that are healthy for both humans and the environment.

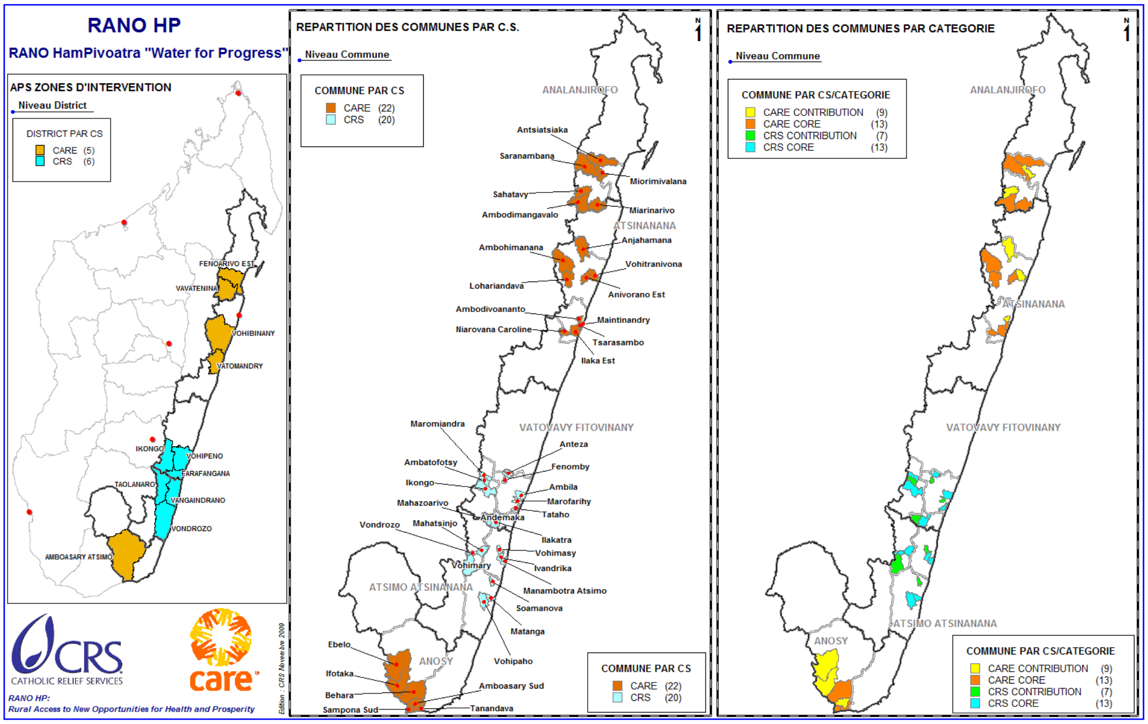


Figure 1. Communities in Eastern Madagascar serviced by the RANO HP project. CARE and Catholic Relief Services (CRS) are partnering to bringing sustainable water and sanitation projects to these areas.

The project is funded in part by the United States Agency for International Development (USAID). USAID is partnering with non-governmental organizations (NGOs) as well as some private sector companies to accomplish the project. RANO HP is led by Catholic Relief Services (CRS) with non-governmental organizations CARE Madagascar, Caritas Madagascar, Voahary Salama, as well as private sector companies BushProof and Sandandrano.

BushProof is a Madagascar and United Kingdom humanitarian-based enterprise that is designed to sell drinking water and renewable energy products (http://bushproof.biosandfilter.org/). The company is considering adding a siphon ceramic candle filter to their portfolio of products. This product is produced by the Dutch company, Basic Water Needs (BWN) (Arnhem, The Netherlands) and is currently manufactured in India. This siphon ceramic candle filter is branded the Tulip filter and is being considered for sale in Madagascar as part of the RANO HP project. The filter is priced at $5.30 and the ceramic candle filter can be replaced for only $2.10 (K. van der Ven, personal communication, July-Sept. 2011).

This study was developed to assess if the Tulip filter technology should be implemented in the RANO HP program. In this capacity, the study aims to answer three major research questions:

1. How does the hydraulic loading affect the flow rate, turbidity removal and pathogen removal?
2. How do various solids loadings affect the water quality of the effluent produced by the Tulip filter?
3. How does the Tulip filter remove particles of various sizes?

CHAPTER 2 LITERATURE REVIEW ON WATER AND DISEASE

Water and disease are inextricably linked. There are various ways that water can facilitate the transmission of disease. There are four water disease categories: water-borne, water-washed, water-based, and water-related (Cairncross & Feachem, 1993). Water-borne diseases result from pathogen transmission directly through water. Water-borne diseases can be viruses, bacteria, parasitic protozoa or helminths and include cholera, typhoid, infectious hepatitis, gastroenteritis, and giardiasis. Water-based diseases are due to infecting agents spread by contact with, or ingestion of, water. These diseases include schistosomiasis, dracunculosis and treadworm. Water-washed diseases are caused by lack of sufficient amounts of water for drinking and personal hygiene such as scabies, leprosy and ascariasis. Finally, water-related diseases are caused by vectors or insects that live in or close to standing water. Examples of water-related disease include yellow fever, dengue fever and malaria (Ashbolt, 2004). Water-washed, water-based, and water-related diseases cannot be directly mitigated by water quality interventions such as the RANO HP project. These types of diseases are better serviced by hygiene education and improving availability of water. Water-borne disease can be avoided or mitigated by some water quality interventions.

2.1 Pathogens Affecting Water Quality

A pathogen is an organism that causes disease in humans, and water-borne pathogens, of which there are many, describe organisms that are transferred via water. The most common pathogens of concern in developing areas are listed in Table 3. Water quality interventions must destroy viral, bacterial, parasitic protozoan, and helminth pathogens to ensure safe drinking water. Interventions aim to eliminate the risk of all water-borne diseases. Of particular interest, however, are water-borne diseases that cause gastroenteritis (diarrhea). As can be seen in Table 3 gastroenteritis is caused by a significant number of viruses and bacteria. Some of the major diarrheal pathogens are Cryptosporidium parvum, Giardia Lamblia, rotavirus, Campylobacter jejuni, enterotoxigenic *E. coli*, enteropathogenic *E. coli*, Shigella spp. and Vibrio cholera O1 or O139. As mentioned previously, diarrheal disease is the second-leading cause of death in children under five years old and there are an estimated four billion cases of diarrheal disease every year worldwide (WHO, 2002). Diarrheal disease also contributes to 4% of all deaths and 5.7% of the total disease burden, or Disability Adjusted Life Years† (DALYs) (Prüss et al., 2002). Of all causes of diarrheal disease, *E. coli* and rotavirus are the two most common in developing countries (WHO, 2009).

In addition to diarrheal disease, ascariasis is a dangerous infection of the small intestine caused by a helminth, parasitic worm, called Ascaris lumbircoides. Ascariasis is transmitted by consumption of food or water contaminated with worm eggs. An estimated 10% of the developing world is infected with intestinal worms resulting in up to 60,000 deaths per year, the majority of which are children (Ashbolt 2004).

Table 3. List of common water-borne pathogens, their diseases, and their sources. The pathogens are clustered by type of organism: bacteria, virus, protozoa and helminth.

	Micro-organisms	Diseases	Sources
Bacteria	Salmonella typhi Salmonella paratyphi Other Salmonella Shigella spp Vibrio cholera *E. coli* Yersinia enterocolitica Campylobacter jejuni Legionella pneumophila Leptospira spp. Mycobacteria And opportunistic bacteria	Typhoid fever Paratyphoid fever Salmonellosis Bacillary dysentery Cholera Gastroenteritis Gastroenteritis Gastroenteritis Acute respiratory illness Leptospirosis Pulmonary illness varies	Human feces Human feces Human and animal feces Human feces Human feces and freshwater zooplankton Human and animal feces Human and animal feces Human and animal feces Thermally enriched water Human and animal urine Soil and water Natural waters
Enteric Viruses	Enteroviruses Polio viruses Coxsackie viruses A Coxsackie viruses B Echo viruses Other entero viruses Rotaviruses Adenoviruse Hepatitis A virus Hepatits E virus Norovirus	 Poliomyelities Aseptic meningitis Aseptic meningitis Aseptic meningitis Encephalities Gastroenteritis Upper respiratory and gastrointestinal illness Infetious hepatitis Infectious hepatitis; miscarriage and death Gastroenteritis	 Human feces Human feces Human feces Human feces Human feces Human feces Human feces Human feces Human feces Fomites and water
Protozoa	Acanthamocba castellani Balantidium coli Cryptosporidium homonis, C. parvum Entamoeba histolytica Giardia lamblia Naegleria fowleri	Amoebic meningoencephalitis Balantidosis (dysentery) Amoebic dysentery Giardiasis (gastroenteritis) Primary amoebic minigoenchephalitis	Human feces Human and animal feces Water, human and other mamma feces Human and animal feces Water and animal feces Warm water
Helminth	Ascaris lumbridcoides	Ascariasis	Human and animal feces

Adapted from Ashbolt, 2004

Hepatitis A (HAV) and Hepatitis E (HEV) can also be transmitted via water. Early infection of HAV can lead to protection against severe symptoms later in life (50 years or older). HEV typically has a low mortality rate but can be particularly dangerous for pregnant women with a mortality rate up to 25% (Ashbolt 2004). Table 4 lists some of the most prominent types of pathogens that cause waterborne disease) along with their size. A significant portion of reported cases of gastroenteritis have an unknown etiology (43%). This is followed by cryptosporidium (20%), viral pathogens (15%), giardia (11%), and bacteria (10%). Of these, viral pathogens are by far the smallest organisms, ranging from 0.01 to 0.1µm in size.

Table 4. Prominent waterborne pathogens, their associated percentages of global incidences of gastroenteritis, and the range of their sizes.

Type of Pathogen	Cases of Waterborne Disease	Range of Size (µm)
Gastroenteritis of unknown etiology	43%	unknown
Cryptosporidium	20%	0.6-0.8
Viral	15%	0.01-0.1
Giardia	11%	1-100
Bacterial	10%	0.1-10
Miscellaneous	1%	unknown

Adapted from Straub, 2003 and Mihelcic et al. 2009

Because of the diversity in the size and type of pathogens, they are not likely to behave exactly the same way or even in the same way as a single indicator. For water quality testing purposes, however, it is impossible to test for each pathogen individually. Common practice has been established to test for indicator pathogens to identify presence of potentially dangerous organisms (Ashbolt, 2001). The most frequently used indicator in the literature is *E. coli*. This is used as an indicator because *E. coli* is excreted by all warm-blooded animals. Therefore, it has been established as the best indicator for fecal contamination (Ashbolt, 2001).

2.2 Benefits of Point-of-Use Treatment

Water quality studies have been performed on a number of technologies in various locations around the world and used many types of treatment technologies. Typically, water is treated either at the source or in the household (point-of-use). There are benefits to both types of treatment. For example, source treatment only requires the training of only a few people, needs monitoring at only one system, can usually treat larger volumes of water, and allows for community interaction. Point-of-use treatment provides more control to the individual, presents a smaller risk of recontamination, and affects fewer people if there is a breach in the system.

Recent studies have shown that point-of-use technology is more effective than treatment at the source for reduction of diarrheal disease incidence (Fewtrell, 2005; Clasen et al., 2007). There is a reduction in relative risk as well as DALYs. Relative risk in this context is a measure of diarrhea incidence after an intervention (in this case either point-of-use or source improvement) as compared to the baseline incidence. Any relative risk less than one indicates a reduction in diarrhea incidence. The smaller the number, the less common diarrhea incidence is in the community. For example, in a meta-analysis of 46 different studies in various locations, the relative risk of diarrheal incidence for point-of-use treatment was 0.65 whereas the risk associated with source interventions was 0.89 (Fewtrell, 2005). Furthermore, a study by Clasen et al. (2007) shows that household treatment is also more cost-effective than treatment at the source and averts more DALYs in a study comparing two subregions defined by the WHO: Afr-E and Sear-D. The Afr-E region is classified as Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe. The Sear-D subregion is composed of Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal, and Timor-Leste (WHO, 2004). The Clasen et al. (2007) study found that the annual DALYs averted from source interventions were 1.05 million and 1.56 million for the Afr-E and Sear-D regions, respectively. Conversely, for household filtration interventions the annual DALYs averted were 3.39 million and 5.13 million for the same two regions, respectively.

2.3 Types of Point-of-Use Technologies

There are various types of POU technology (for descriptions see Mihelcic et al., 2009): for example, solar disinfection (SODIS), chlorination, flocculation and disinfection, filtration, and boiling. Boiling is a common practice in the developing world for treatment of water. Boiling water eliminates almost all viruses, bacteria, fungi, protozoa, and helminthes. It is usually recommended to bring the water to a rolling boil for 1 to 5 minutes as an indication that a high enough temperature has been reached. Heating water to only 55°C, however, can reduce many bacterial, viral and parasitic pathogens (Sobsey, 2002).

SODIS utilizes UV light and/or heat to inactivate pathogens in water. It requires leaving a clear or opaque bottle on a reflective surface for an extended period of time. This type of treatment has been shown in the field to obtain 3, 2, and 1 log removals of bacteria, viruses and protozoa, respectively. In a laboratory setting it can achieve log removals of 5.5+, 4+, and 3+ of bacteria, viruses and protozoa, respectively. It has also been shown to reduce diarrhea incidence by 16% to 76% (Sobsey et al., 2008).

Chlorination can be achieved by adding either sodium hypchlorite or calcium hypochlorite to water as either a tablet, liquid, or powder. An additional benefit of chlorination is that any residual chlorine can work to prevent recontamination. Chlorination can be done either at the point-of-use or at the source. It has been shown to reduce 3 log removals of bacteria, viruses and protozoa in the field and above 6 log removals of bacteria and viruses in the laboratory setting (Sobsey et al., 2008).

Chlorination is less effective in very turbid water and on its own is not as effective against Cryptosporidium parvum, which affects many communities in the developing world (Souter, 2003). A combined approach, called flocculation/disinfection, uses a coagulant, flocculation aids, and chlorine-based disinfectant. This type of treatment was found to be effective against microbial contaminants and Cryptosporidium parvum (Souter, 2003). The coagulants and flocculation aids assist in settling out particles and then treats the remaining particles with a chlorine-based disinfectant. The treatment product was distributed in individual sachets to treat 10 L of water and contained a coagulant, an alkaline agent, flocculation aids, a flocculent and a chlorine-based disinfectant. Flocculation disinfection was found to achieve a 7 log removal of bacteria, 2-4.5 log removal of viruses and 3 log removal of protozoa (Souter, 2003).

Biosand filtration treats water through physical and biological mechanisms. Water flows through sand media that remove unwanted particles and pathogens. The top part of the filter is called the Schmutzdeke layer which includes microbes that process and remove pathogens from the water. Biosand filtration can result in 1 log removal of bacteria, 0.5 log removals of viruses, and 2 log removals of protozoa (Sobsey et al., 2008).

Ceramic filtration is the type of mechanism employed by the Tulip Filter. Often there are two types of ceramic filters: pot filters and candle filters. A ceramic pot filter is most famously used by groups such as FilterPure (http://www.filterpurefilters.org/) and Potters for Peace (http://www.pottersforpeace.org/). A ceramic pot is a large cylindrical ceramic piece that typically fits inside a 5-gallon bucket. Water is poured in the ceramic and gravity pushes the water through the ceramic media and into the bucket below, where the water is stored until the user extracts it.

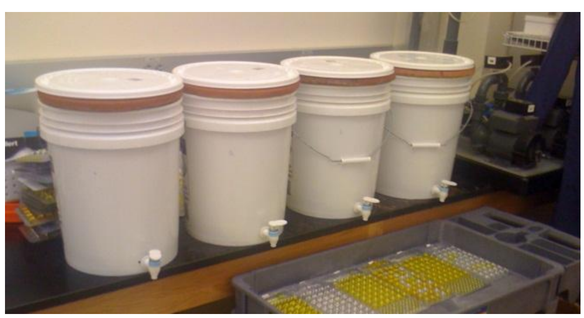


Figure 2. Ceramic pot filters from Potters for Peace and FilterPure

Ceramic candles are smaller cylindrical ceramic filters that often protrude upwards into the bucket. Water is poured on top of them and, again, the weight of the water pushes it through the ceramic media. The Tulip filter uses a ceramic candle but also uses a siphon mechanism to increase the pressure and, thus, the flow rate of the filter. All of these types of ceramic filters employ size exclusion to remove turbidity and pathogens from water. Antibacterial silver can also be added to the ceramic filter element to assist in deactivation of pathogens, in either ceramic pots or candles. Studies have shown that ceramic filters are very effective in reducing diarrheal disease (Clasen et al., 2004; Clasen et al., 2005). Studies have also identified a 60% to 70% reduction in diarrheal disease incidence from candle filter interventions conducted in Bolivia (Clasen et al., 2004) and Colombia (Clasen et al., 2005). Furthermore, field studies have shown a 2 log removal of bacteria, a 0.5 log removal of viruses and 4 log removal of protozoa. Laboratory studies have shown up to a 6 log removal of bacteria, 4 log removal of viruses and 6 log removal of protozoa.

2.3.1 Comparative Analysis

Various studies have measured the different types of point-of-use technologies. Meta-analyses have been performed on the abilities of these types of technologies to reduce diarrhea, be sustained in the community, and also compare cost-effectiveness with varying results. Typically filtration methods, both biosand and ceramic, fair very well in these types of studies. For example, in a field comparison performed by Sobsey et al. (2008) assessing various technologies in various places around the world, the biosand filter was found to be the most sustainable and ceramic filters were the second-most sustainable. Sobsey et al.'s (2008) analysis was based on the quantity of water the filter was able to treat, the quality of water produced, ease of use, cost, and supply chain requirements. The filters were also compared with chlorination, flocculation/chlorination, and SODIS. Sobsey et al. also found, however, that ceramic candle filters had one of the highest compliance rates, with 88% still in use in an intervention in Bolivia over six months. This is compared to biosand filtration at approximately 85% compliance, chlorination ranging from 60% to 73% compliance and 78% to as low as 9% for SODIS (Sobsey et al., 2008). This indicates that ceramic filtration could be used sustainably in an economic and maintenance capacity, but also is user-friendly, as shown by the high compliance rates.

Another meta-analysis determined that ceramic filtration was the most-effective at removing diarrheal disease (Hunter, 2009). Hunter's study supported the idea that ceramic filters have the lowest risk for diarrheal disease over all time periods and with a significant margin. The relative risk of diarrheal incidence for ceramic filter interventions in the field has a median of 0.37 in this analysis. The next lowest relative risk is biosand filtration which has a median of 0.65 (Hunter, 2009).

Table 5 compiles data from six major types of POU technologies. The table compares the log removal values (LRV) at a baseline and a maximum level as well as percent reduction in diarrhea incidence in the field and cost per liter of water filtered. From this table it is clear that solar radiation (SODIS) is the cheapest option requiring almost no cost to the consumer. Boiling and chlorination are then the next cheapest. Filtration is slightly more expensive, both slow sand and ceramic, with costs ranging from 0.068 cents/L and 0.034-0.14 cents/L respectively. Filtration methods, particularly ceramic filtration, have shown more consistent results in diarrhea reduction. SODIS ranges from 16-76% diarrhea reduction and chlorination ranges from 12-85% and while flocculation and disinfection ranges form 18-42% reduction. Ceramic filtration shows a diarrheal disease reduction as 46-74%.

Table 5. Various POU technologies. The first column gives a description of the mechanisms used by the technology to remove water of pathogens. Three types of organisms are analyzed: bacteria, viruses and protozoa and their Log Removal Values (LRVs) are reported. The United States Environmental Protection Agency (EPA) LRVs are also reported for comparison. The maximum LRV reported is intended to show the capability of the technology of removing various sizes and types of pathogens. The diarrhea reduction is intended to serve as an indicator of how easy it was to implement in the field, and how acceptable it was to the intended user. Finally the cost is also listed to compare how expensive each technology is to implement.

POU Technology	Organism type (EPA LRV)	Baseline LRV	Max. LRV	Diarrhea Reduction (%)	Cost (US cents/Liter)
Boiling	Bacteria (6) Viruses (4) Protozoa (3)	unknown	unknown	44[3]-62[4]	0.015-0.096B, [1]
Solar Radiation-SODIS/ SOPAS	Bacteria (6) Viruses (4) Protozoa (3)	3 2 1	5.5+ 4+ 3+	16[6]-76[7]	noneC
Slow Sand Filtration	Bacteria (6) Viruses (4) Protozoa (3)	1 0.5 2	3 3 4	44[12]-47[8]	0.068
Ceramic Filtration	Bacteria (6) Viruses (4) Protozoa (3)	2 0.5 4	6 4 6	46[15]-74[16]	0.034-0.14
Chlorination	Bacteria (6) Viruses (4) Protozoa *(3)	3 3 3	6+ 6+ 5+	12[19]-85[20]	0.01-0.05
Flocculation / Disinfection	Bacteria (6) Viruses (4) Protozoa (3)	7 2-4.5 3	9 6 5	18-42	0.3-1

Adapted from Fry et al., 2011; Sobsey et al., 2008; and Souter et al., 2003
* Note: chlorination is not as effective against Cryptosporidium parvum as other protozoa
*All superscripts([#]) are references associated with the table in Fry et al., 2011.

There is no consensus among the scientific community regarding a "best" point-of-use technology. There are various advantages and disadvantages to each type of technology. The type of POU intervention implemented ultimately needs to be determined by the community requiring the intervention. What is clear from the literature, however, is that ceramic filter interventions have been well-received because of the extremely high compliance rates and large reduction in diarrheal disease (Sobsey et al., 2008).

2.4 The Tulip Filter

The Tulip filter is a siphon ceramic candle filter. The ceramic element is covered in a cloth pre-filter to exclude any large particles from clogging the filter and it is placed inside a blue cartridge. The whole cartridge is placed into a bucket of water and the tap is placed at a recommended distance of 70 cm below the cartridge Figure 3 and Figure 4.

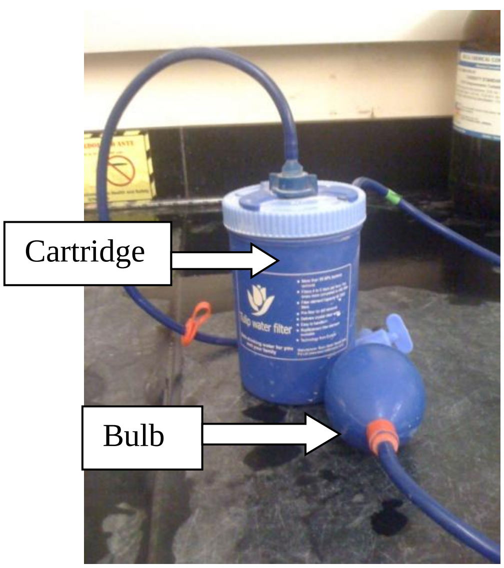


Figure 3. Photo of a Tulip filter used in this study. Inside the blue cartridge is a ceramic candle element. Pumping the bulb started the siphon mechanism.

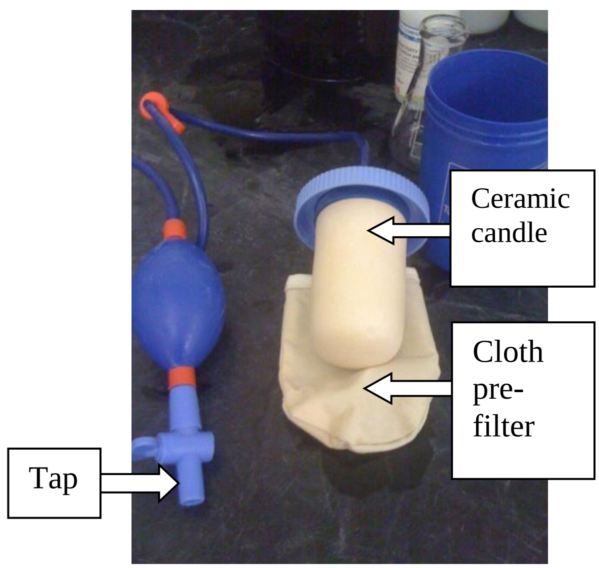


Figure 4. Tulip filter taken out of the blue container with ceramic candle element exposed. Cloth pre-filter sitting below the candle element.

Basic Water Needs purchases the plastic pieces (tube, tap, cap, cartridge, bulb) and ceramic element separately. The ceramic candle is manufactured through a process called slip casting. This method involves pouring liquid clay into a plastic mold and is subsequently surrounded by plaster. The details of the exact method of forming the candle is the company's intellectual property. Once the ceramic piece is made, it is then attached to the plastic cap. Pre-glue is applied to ensure the elements are bonded. After the pre-glue, a hotmelt glue attaches the ceramic element to the plastic (K. van der Ven, personal communication, July-Sept. 2011).

2.4.1 Mechanisms for Removing Pathogens

The Tulip filter is a ceramic candle siphon filter, as mentioned previously. The goal of the Tulip filter is to reduce turbidity and remove pathogens from source water. The Tulip filter uses the mechanism of siphon pressure to pull water through a ceramic candle. The Tulip filter is submerged in a bucket of source water, which creates a pressure on the filter equivalent to the weight of the water. The tap should be about 70 cm below the filter, as specified by the manufacturer, and exposed to the open atmosphere. Because the tap is at atmospheric pressure, and the inside of the ceramic element is at a higher pressure (the pressure head of the water), water flows from high pressure (outside the ceramic element) to low pressure (through the ceramic element, over the edge of the bucket and down into the tap).

The Tulip siphon ceramic filters target removal of pathogens by size exclusion and the presence of silver as a bactericide (Ashbolt, 2001). As discussed above, various sizes of pathogens can contaminate water. Clay ceramic filters used by a company called Potters for Peace (PFP) have been measured to have pore sizes of 0.6 to 3 μm (Bielefeldt et al., 2010). Other studies report pore sizes of ceramic pots that range from 0.02 to 200 μm with a median of 14 μm (van Halem, 2006). Some dangerous pathogens, however, are smaller than these pore sizes, thus illustrating the importance of adding silver to ceramic filters. For example, viruses range from 0.01 to 0.1 μm and bacteria can range from 0.1 to 10 μm.

Silver has been shown to inactivate bacterial, viral, and eukaryotic microorganisms for centuries. Silver can also be used to treat burns, wounds, and skin ulcers in low concentrations and was also used on the Russian space station to remove pathogens from drinking water (Silver, 2003). The biocide effects of applying silver have been shown to assist in removing pathogens. One study found a five order of magnitude reduction in bacteria in filters that had silver applied and only a 3 order of magnitude reduction in filters with no silver added (Ovanedel-Craver, 2008). It is not clear whether this is due to clogging pores or the contact of silver with the pathogen (Oyanedel-Craver, 2008; Bielefeldt et al., 2010; Van Halem, 2006).

2.4.2 Previous Laboratory Studies Performed on the Tulip Filters

Basic Water Needs claims a four log removal of *E. coli* (BWN, 2009) when using the Tulip Filter. They have eight independent reports on their website and additionally report a 4 log removal of *E. coli* directly on the site regarding test results on the Tulip filter (http://www.basicwaterneeds.com/download.php) and these results are tabulated in Table 6.

In this comparison it appears that most of the studies pumped water through the filters and did not use the siphon mechanism. In these studies five of the eight reported no *E. coli* present in the effluent water (Sargam Laboratory in India found 0.0030 CFU/100mL as the most probable number and this was interpreted as no *E. coli* by the researchers). Other studies reported 10 CFU/100mL or less in effluent water. The Water-laboratorium Noord found up to 4.5 *E. coli* log removal. These studies are presented in Table 6.

These independent studies illustrate the basic capabilities of the Tulip filter. They are limited, however, in the small sample size. To the author's knowledge, each of the studies published on the BWN website used four or less filters.

Also, only one of the studies reports the volume of water filtered through the filter and compares water quality at the beginning and end of the life cycle (WLN, 2010). Furthermore, it appears that the flow rate was controlled in most studies, which leads the author to believe that the water was not being siphoned through the ceramic candle, but pumped by a mechanical pump, which could have an effect on water quality results. Additionally, there is no explanation of backwashing, pre-filter cleaning or scrubbing procedures in any of these experiments. Finally, it is not clear which iteration of the Tulip filter is being tested in these studies.

Table 6. Studies provided by Basic Water Needs suggest high levels of coliform and turbidity removal. All of the studies shown here have sample size of 4 or less. All studies can be found at the Basic Water Needs website at www.basicwaterneeds.com/download.php.

Study	# of Filters	Influent Coliform Conc.	Coliform Removal	Inf. Turb. (NTU)	Eff. Turb. (NTU)
WLN (Water-laboratorium Noord), Netherlands, 2010	4	>10^5 CFU/ 100mL (*E. coli*)	>4.5 *E. coli* log removal	--	--
Sargam Laboratory, India, 2010	--	10^5 CFU/mL (*E. coli*)	0.30 CFU/mL (Concluded that 0.30 CFU/mL can be taken as no *E. coli* present)	--	---
Berhanu Kiber Import & Expert Enterprise, Ethiopia, 2010	--	Many (*E. coli*)	No *E. coli* reported in effluent (5mL and 10mL samples)	146-806 NTU	2-20 NTU
Ministry of Water, Tanzania, 2011	2	2-39,000 CFU/100mL (Total coliforms)	1 of 14 samples showed 1 CFU, the rest showed 0 colonies	14-113 NTU	0.02-1.16 NTU
EMS ** (Environmental Monitoring Services Lab) India, 2008	2	350 CFU/ 100mL (Total coliforms) 620 CFU/ 100mL (*E. coli*)	F1 – 0 TC, 10 *E. coli* F2 – 0 TC, 0 *E. coli* (CFU/100 mL)	--	--
CTE (Centre Technique d'Exploitation), Haiti, 2011	1	--	TC, FC and *E. coli* all reported as <1 CFU/100 mL	--	--
Environmental Mircobiological Lab, Bangladesh	--	530,000 CFU/ 100mL (*E. coli*)	2 CFU/ 100mL	--	--
Council for Scientific and Industrial Research, Ghana	--	255 CFU/ 100mL (Total coliforms) 20 CFU/ 100mL (*E. coli*)	0 CFU/100mL (TC) and 0 CFU/ 100mL (*E. coli*)	--	--

2.4.3. Field Studies

To the author's knowledge, there has only been one study using this type of filter in a water quality study performed in the field. This study took place in 24 households in Ghana over a three-week period using an earlier version of the Tulip filter (Ziff, 2009). This study found that there were some issues with recontamination. Often the filter tap was stored in the dirty bucket when the filter was not on. Because of this, many of the turbidity and coliform removal data showed negative removals. When just positive removals were analyzed there was a 1.7 log removal of total coliforms, 1.3 log removal of *E. coli*, and 81.2% removal of turbidity. This was found using influent contaminated water with an average of 4,585 CFU/100mL of total coliforms, 274 CFU/100mL of *E. coli* and had an average turbidity of 42.7 NTU (Ziff, 2009). In a companion laboratory study, the results were more favorable. Ziff found 1.3 log removal of *E. coli* with an average influent concentration ranging from 99-300 CFU/100mL and observed a 94% removal. The log removal values are very conservative and it is likely the filters are able to achieve higher log removals. This is because the method of testing for coliforms (IDEXX Colilert®) was only accurate to 10 CFU/100mL so all undetectable results were reported as 9 CFU/100mL. Turbidity removal in the lab was 98.9% with an average influent turbidity of 329 NTU.

CHAPTER 3 METHODS

This experiment was designed to test the ceramic candle filters under various influent turbidity in the untreated water. As the research questions provided in the Introduction state, the goal of this experiment was to determine how solids loading, hydraulic loading, and particle-size distribution affect the water quality of the filters. Each filter was initially set to process over 1,000 L of water. The majority of the water was synthetic water and approximately once every 100 L the filters processed pond water obtained from a local pond located at the Botanical Gardens on the University of South Florida's campus (Tampa, FL). Water quality was determined by measuring the turbidity and was recorded in Nephelometric Turbidity Units (NTUs). When pond water was processed the total coliform and *E. coli* removal was tested using a most probable number method (MPN) to determine the Tulip filter's capability to remove pathogens. Finally, in order to further characterize the particles that the Tulip filter is capable of removing, the particle size distribution was tested after 575 L of water had been passed through Filter 6. This is further discussed in a later section.

3.1 Set-Up

There were initially seven filters: one control, two at low turbidity (<10 initial NTU), two at medium turbidity (20-30 NTU) and two at high turbidity (60-80 NTU). This turbidity was achieved synthetically by adding 0.50 g, 3.00 g and 6.00 g of U.S. Silica's Sil-Co-Sil® (Frederick, MD) 75 silica sand to 17 L of tap water. A picture of all seven filters in use in the laboratory is shown in Figure 5.

Figure 5. Initial set-up with all seven filters sitting in 20 L buckets and dispensing into 20 L buckets below. On the far left is the control filter with increasing turbidities from left to right.

After the silica sand was added to the upper bucket reservoir, it was mixed by a Cole Parmer ® Stir Pak® Laboratory Stirrer (Vernon Hills, IL) at one revolution per minute (rpm). The resulting aqueous sample in the bucket was then allowed to settle for 30 minutes. Allowing water to settle for up to one hour has been shown to have a better performance and is encouraged by the manufacturer (Ziff, 2009). It was found, however, that the silica sand in this experiment remained suspended at a relatively consistent turbidity after 30 minutes, thus, a settling time of 30 minutes for each trial of this study. More information on this is found in Appendix IV. The siphon was placed in the upper bucket 5 minutes before starting the siphon because a wet filter is more likely to work quickly, according to the manufacture, BWN. The filter sat at the bottom of the upper bucket, although this height could be adjusted so that the filter does not sit in the most turbid part of the bucket. If the filter is adjusted so it is at the top of the bucket, however, there is less pressure on the ceramic element which will translate to a slower flow rate. After the water settled for 30 minutes, the bulb at the bottom of the siphon was pumped until filled with water as per the instructions from Basic Water Needs. A copy of these instructions can be found in Appendix I.

There were two parts to the experiment: Part I, which recorded data as a function of the volume filtered and Part 2, which took measurements as a function of time. Table 7 indicates when measurements were taken and describes the experimental layout. A trial referred to one bucket of water. For Part 1 of the experiment, a trial was the amount of time for the filter to process 12 L of water, for Part 2, a trial was defined as 120 minutes of filtering.

Once the siphon mechanism was started, the filters would process water on their own, without any additional work required by the user. For the first 45 trials (one bucket of water of 17 L) measurements were taken after the filter had processed 2, 6, 8, and 12 L. The time was recorded at each volume. Turbidity was measured at 2 L and 12 L, and total suspended solids (TSS) and measured were recorded at 8 L.

After 12 liters of water had been filtered, the Tulip filter was turned off. The filter was then backwashed according to manufacturer instructions and the cloth pre-filter was rinsed out with tap water. The pre-filter was filled with tap water and emptied twice to ensure a good cleaning.

Table 7. A description of organization of the experiment. The first 45 trials analyzed data after the filter had processed 2, 6, 8 and 12 L of water. The second part of the experiment recorded water quality measurements at 0, 60 and 120 minutes of filtering. One trial is defined as one bucket of solids loading (17 L of water at either control, low turbidity, medium turbidity or high turbidity).

		Part 1: Trials 1-45			Part 2: Trials 46-91		
Synthetic Water Classification		# of Syn. Trials	# of Pond Trials	Procedure	# of Syn. Trials	# of Pond Trials	Procedure
Control (tap water)	Filter 1	19	0	@ 2L – time, turbidity and inst. flow rate	0	0	@ 0min (30 min after settling) – turbidity, inst. flow rate
	Filter 1.1	26	1		52	1	
Low Turbidity (0.05 g sand)	Filter 2	40	5	@ 6L – time, inst. flow rate	42	4	
	Filter 3	40	5		42	4	
Medium Turbidity (3.0 g sand)	Filter 4	42	3	@ 8L – time, turbidity, inst. flow rate, TSS*	17	3	@60 min– TSS, turbidity*
	Filter 5	28	3		0	0	
High Turbidity (6 g sand)	Filter 6	40	5	@ 12L – time, turbidity, inst. flow rate, turn filter off	42	4	@ 120 min – turbidity, inst. flow rate, turn filter off
	Filter 7	26	5		0	0	

*TSS was not measured for each trial, but approximately once every 5 trials of synthetic water and was measured for every trial of pond water.

For the subsequent 45 trials, measurements of instantaneous flow rate, turbidity and cumulative volume were taken only at the very beginning, at the time the siphon was turned on (at 0 minutes of filtering, 30 minutes after silica sand had been mixed) and at the end (at 120 minutes of filtering, 150 minutes after silica sand had been mixed). At 60 minutes of filtering (90 minutes after mixing silica sand), TSS measurements were taken for every five synthetic trials and each pond water trial. After 120 minutes of filtering, the filter was backwashed and the cloth pre-filter was rinsed with tap water.

Approximately once every 100 L, the filters processed pond water from a local pond instead of synthetic water in order to measure coliform removal. This water was also mixed for one minute, and then allowed to stand for 30 minutes before starting the siphon.

3.2 Water Quality Measurements

Four water quality measurements were recorded throughout both parts of the experiment: the amount of coliforms and *E. coli*, TSS, turbidity, and the particle size distribution. The first three, coliforms, TSS and turbidity were all performed on campus and the particle size distribution was done by Particle Sizing Systems (New Port Richey, FL). An array of the tests performed is provided as Table 8.

Table 8. Four basic water quality measurements were taken throughout the experiment. The parameter, method and appropriate equipment are provided in the table below.

Water Quality Parameter	Method	Equipment Used
Coliforms/*E. coli*	Standard Methods 9223B	IDEXX Colilert®, IDEXX sealer, Quanti-Tray®/2000, Quanti-Tray®
TSS	Standard Methods 2540D	Whatman® microfiber glass filters, vacuum pump, oven at 103-105, dessicator, balance accurate to +/-0.0001 g
Turbidity	Standard Methods 2130B	Hach 2100Q Portable Turbidimeter
Particle Size Distribution	Single Particle Optical Sizing (SPOS)	Accusizer 780/AD Autodilutor

3.2.1 Turbidity

Turbidity was measured by a Hach (Loveland, CO) 2100Q Portable Turbidimeter pictured in Figure 7. Turbidity is a measurement of the intensity of light scattered by the sample in comparison to the intensity of light scattered by standard reference. The higher the intensity of scattered light indicates a more turbid sample. The turbidimeter had a lower detection level of 0.01 NTU and a range of 0-1,000 NTU. The result was always given with three significant digits. The measurement method determines turbidity by using a nephelometric light scatter signal at 90 degrees to the transmitted light scatter signal. This is illustrated in Figure 6.

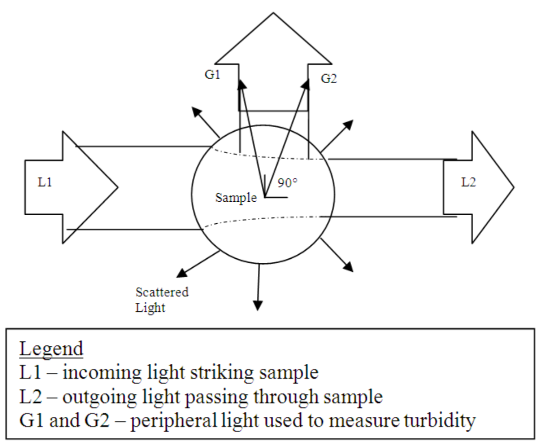


Figure 6. Diagram of how a turbidimeter makes a measurement. A light beam passes through the sample and is measured at a 90° angle from incoming light beam.

Turbidity was measured using a BHG 50mL pipette from the influent water and simultaneously, a sample was taken directly from the tap of the Tulip filter. A turbidity measurement performed on a sample taken from the tap of the lower reservoir associated with Filter 6 is shown in Figure 7.

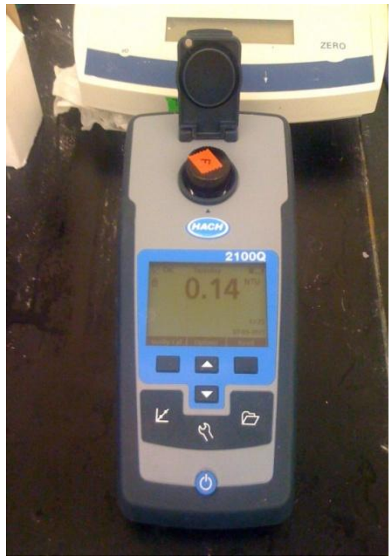


Figure 7. Turbidity measurement using Hach 2100Q Portable Turbidimeter

3.2.2 Coliform Testing

The filters were tested for total coliform removal as well as *E. coli* removal. This was done by running pond water through the filters nine times throughout the course of the experiment. The total coliforms and *E. coli* counts were determined using their patented Defined Substrate Technology® (DST®) developed by IDEXX Laboratories, Inc (Westbrooke, Maine) to determine the most probable number (MPN). The Colilert® reagent, available in a snap pack, was added to a 100mL sample of water. Two types of trays were used; the Quanti-Tray®/2000 and the Quanti-Tray®. The Quanti-Tray®/2000 can read up to a MPN of 1011.2 coliform forming units (CFUs) so this tray was used for the influent pond water. The Quanti-Tray® only reads up to 200.5 CFUs, so this tray was used for effluent water. Figure 8 shows both types of trays.

Figure 8. IDEXX Colilert® results. On the left is a Quanti-Tray® /2000 showing a positive result for total coliforms of influent pond water from Filter 4. There are 48 positive large wells (out of 48 total large wells) and 46 positive smaller wells (out of 48 total smaller wells) which result in a most probable number of 913.9 CFU. On the right there is a sample of effluent water of Filter 4 in a Quanti-Tray®. This sample has zero positive wells which correlates to a most probable number of <1 total coliform forming units.

The Colilert/Quanti-Tray® method requires a 100 mL sample for the wells to appropriately display the MPN of CFUs. The Quanti-Tray®/2000, however, was not able to accurately show the number of CFUs in 100 mL of pond water, so all influent samples were diluted. For the influent water, a combination of 5 mL of pond water and 95 mL of deionized water was used. Unless the Tulip filter showed positive results for coliforms and *E. coli*, all effluent samples tested 100 mL of water directly from the filter tap.

After 100 mL of sample were placed in the Quanti-Tray® or Quanti-Tray® /2000, the Colilert® reagent was added and shaken until completely dissolved. The trays were then sealed using an IDEXX Laboratories, Inc Quanti-Tray® Sealer Model 2X and placed in an incubator at 35.0°C. The trays were incubated for 24-28 hours. The number of positive (yellow) wells was recorded and the MPN of total coliforms was determined based on the given tables developed by IDEXX Laboratories, Inc. In order to determine the quantity of *E. coli* in the sample, the tray was placed under a fluorescent light. Each well that fluoresced under the light was considered positive for *E. coli*. Again the tables provided by IDEXX were used to convert the number of positive wells to MPN.

3.2.3 Total Suspended Solids and Solids Loading

The total suspended solids (TSS) measurement was used to determine the amount of solids in the influent water samples. Whatman™ 934-AH glass microfiber filters with a 1.5 μm retention rating were used in this analysis pictured in Figure 9. The measurement of the suspended solids in the influent sample was then used to assess the cumulative solids loading on each of the filters.

Figure 9. Total suspended solids (TSS) set-up pictured here. The vacuum pump pulls water from the top through the dried glass microfiber filter. The glass filter is weighed before and after the sample is run. By using the difference in weight and the volume of the water processed, the total suspended solids can be determined.

In order to more easily determine the overall solids loading for each of the filters, a relationship was developed for the total suspended solids as a function of turbidity. Two buckets of water at each turbidity level (six buckets in total) were made with 17 L of tap water and 0.50 g, 3.00 g, and 6.00 g silica sand for low, medium and high turbidity, respectively. Measurements of both TSS and turbidity were taken at 15, 30, 60 and 120 minutes. Once every five buckets, 500 mL of influent water and 1,000 mL of effluent water was sampled to be analyzed for TSS. This resulted in 25 data points that were used to develop the linear relationship shown in Figure 10. The TSS (mg/L) was found to be a factor of 1.2651 and turbidity (NTU) for turbidities ranging from 0-80 NTU with a coefficient of determination of 0.9323.

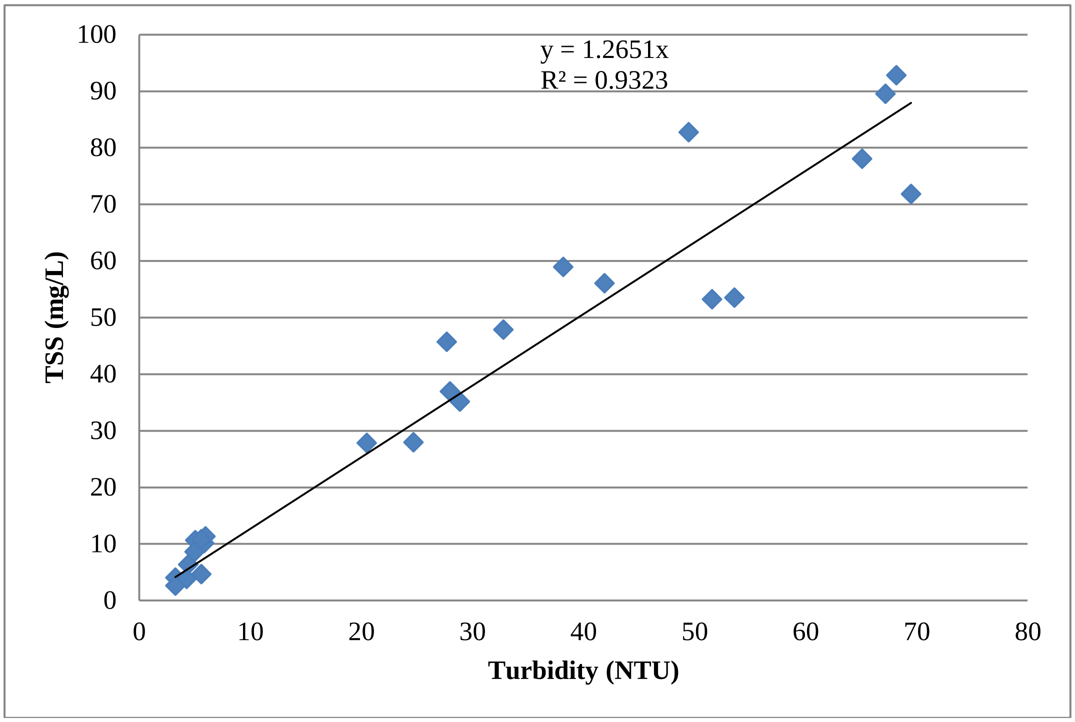


Figure 10. Relationship between total suspended solids (TSS) and turbidity for synthetic water (tap water with Sil-Co-Sil® 75 silica sand).

Equation 1 was used to estimate the TSS concentration from turbidity measurements to assist estimation of solids loadings for each of the trials, where one trial is considered a bucket of 17 L of water.

$$\text{TSS}\ \left(\frac{\text{mg}}{\text{L}}\right) = 1.2651 * \text{Turbidity}\ (\text{NTU}) \qquad [1]$$

In Equation 1 TSS represents the total suspended solids (mg/L) and turbidity is the turbidity in NTU. Equation 2 was subsequently verified by measuring the TSS approximately every five trials. More information on how the regression line and 95% confidence intervals were calculated can be found in Appendix III. The loading (kg) was then calculated as the product of the average of the suspended solids (mg/L) and the flow rate (L/hr) during the course of one trial (min) and is shown in Equation 2.

$$SL = TSS_{avg} * Q_{avg} * t_{total} * \frac{1\ hr}{60\ min}\frac{1\ kg}{1000\ mg} \qquad [2]$$

For the trials in which pond water was used instead of synthetic water, the direct measurement of total suspended solids was used to calculate the solids loading for that trial.

3.3 Particle Size Distribution

The particle size distribution of influent and effluent pond water was analyzed by Particle Sizing Systems (New Port Richey, FL) approximately 5 days after the sample was taken. The sample was stored in a refrigerator to slow any organisms from growing or reproducing. The samples were analyzed using an Accusizer 780/AD Autodilutor through a method called Single Particle Optical Sizing (SPOS), also known as light obscuration (P. O'Hagan, personal communication, July-Sept. 2011). This method uses a vacuum to pull particles across a detector while a laser beam is emitted perpendicularly. There is a baseline voltage that is received by the detector when there is no sample. When particles cross the laser beam, they create a shadow, which then changes the voltage output from the detector. The particle size is then related to the output voltage. Once the cross-sectional area is determined, it is related to the equivalent spherical diameter (White, 2002).

3.3.1 Scrubbing Procedure

Basic Water Needs provides a convenient scrubbing pad and a measuring device to ensure that the ceramic filter has not been scrubbed too much. In Figure 11, the scrubbing pad is shown on the left. In this experiment scrubbing the filter once was defined as scrubbing up and down the candle four times (up and down was one time), then rotating 90° and going up and down four more times. Then the very tip of the ceramic candle was scrubbed in a circular motion four times.

Figure 11. Scrubbing ceramic candle using the green scrubbing pad. On the right, shows measuring the ceramic candle to ensure that it is still going to effectively remove pathogens.

Scrubbing was done when needed since minimal scrubbing lengthens the lifetime of the filter, and this is also what is recommended by BWN.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Baseline Data and Overall Results

The mass of solids loaded on each filter over the course of the experiment was calculated cumulatively over the course of processing over 1,000 L of water. This was analyzed based on the amount of suspended solids estimated per trial. One trial is defined as a bucket of 17 L of water. Table 9 shows the cumulative solids loading, average flow rate and hydraulic loading for the duration of the experiment. Filter 6 (High Turbidity) shows the highest solids loading and hydraulic loading.

Table 9. Cumulative suspended solids loading and hydraulic loading received by each filter over the complete experiment.

	Filter Number	Hydraulic Loading (L)	Mass of Solids Loaded for Total Study (kg)	Avg Q (L/hr)
Control (~ 0.5 NTU)	Filter 1	222	0.24	10.43
	Filter 1.1	1,014	0.40	6.10
Low Turb. (~ 5 NTU)	Filter 2	1,023	4.63	5.58
	Filter 3	1,035	4.49	5.58
Med. Turb. (~30 NTU)	Filter 4	740	20.9	6.01
	Filter 5*	350	17.5	8.36
High Turb. (~60 NTU)	Filter 6	1,047	47.7	6.23
	Filter 7*	346	32.1	9.8

The filters with a star (*) placed next to them were determined to break at some point during the study and were removed before they reached 1,000 liters of processed influent. The first control filter (Filter 1) was broken by our laboratory during the course of the experiment, so it was replaced with a different control filter (Filter 1.1). Filter 1 only processed tap water; there were no pond water samples run through it.

Filters 5 and 7 did not reach 1,000 liters of processed water. Both had an issue with the glue that attached the ceramic candle element to the plastic cap. It was found that the method in which the glue was applied to the ceramic element and plastic cap was inconsistent. When the glue had completely failed, the ceramic element completely detached from the plastic cap. At this point the filter was removed from the study, and thus explains the lower solids loadings and hydraulic loadings on these filters. An image of Filter 7 after the ceramic candle had detached from the plastic cap is shown in Figure 12.

Figure 12. Filter 7 after the glue failed. At this point Filter 7 was taken out of the experiment.

The solids loading calculation was based on the relationship between the turbidity and the total suspended solids for synthetic water as discussed in a later section. The solids loadings for the control filters are based on the average TSS measurement (0.17 mg/L) obtained for measurements performed on 10 tap water samples. Every time pond water was processed through the filters, the TSS was measured directly.

As a baseline, the first-hour flow rate was measured for each of the filters using only tap water before the experiment began. Table 10 shows that the filters flow rates for this first-hour flow rate with tap water vary even when the filters are processing the same influent. All of the filters process tap water above the manufacturer's claim of 4-5 L/hr (BWN, 2009). The highest first-hour flow rate was shown by Filter 7 at 11 L/hr and the lowest was 7.67 L/hr for Filter 2. The average first hour flow rate for all seven filters is 9.51 L (95% confidence interval of 0.92 L).

Table 10. First-hour flow rate using only tap water for each of the initial seven filters.

	Filter 1	Filter 2	Filter 3	Filter 4	Filter 5	Filter 6	Filter 7
First-Hour Q (L/hr)	8.50	7.67	8.27	10.33	10.42	10.42	11.00
N	3	3	3	3	3	3	3

4.2 Solids Loading

In order to test the effect of the solids loading on filter performance, there were two control filters, two set at a low turbidity, two set at a medium turbidity and two at a high turbidity. These categories determined the amount of silica sand added into the influent synthetic water. Silica sand was used because it was able to suspend well in water.

After this time the silica sand remained suspended and at a relatively constant turbidity, more information on this can be found in Appendix III. For high turbidity trials, the turbidity dropped from 67.7 NTU to 52.6 NTU between 30 minutes and 120 minutes. For medium turbidity water, the turbidity changed from 30.3 to 22.6 NTU and for low turbidity water it dropped from 5.27 to 3.21 NTU.

Figure 13 shows a 1 L sample of water from each of the influent sample categories: pond water, control (tap water), low turbidity, medium turbidity and high turbidity. The image shows the water when the filter would begin to start processing water, after allowing the sand to settle for 30 minutes.

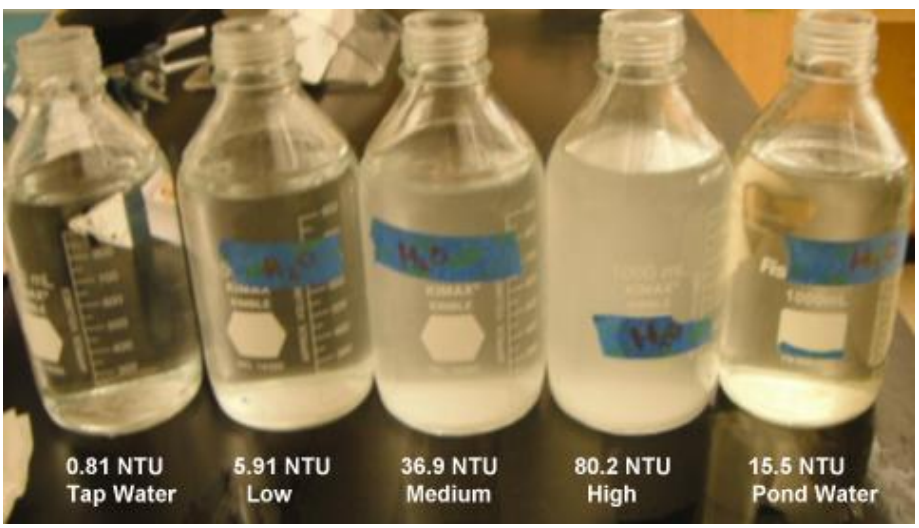


Figure 13. Influent samples after settling for 30 minutes. From left to right, the first is tap water (average 0.81 NTU), then low turbidity water (average 5.91 NTU), medium turbidity water (average 36.9 NTU), high turbidity water (average 80.2 NTU), and pond water (average 15.5 NTU).

At the time when the filter was turned on, the pond water had an average turbidity of 15.5 NTU, which was lower than both the medium and the high turbidity trials. The medium turbidity averaged 36.9 NTU and the high turbidity sample was 80.2 NTU. The low turbidity had an average of 5.91 NTU and tap water averaged 0.81 NTU at the start of the filtering process.

The turbidity was measured at the start of the filtering process and 2-3 times throughout one trial. The overall averages of influent turbidities, for each filter, at all times throughout the trial are given in Table 11. The sample size is just below 200 for each of the filters that processed 1,000 L.

Table 11. Average influent turbidity for synthetic waters for each of the filters. The influent turbidity is provided as an average ± the 95% confidence interval.

		Sample Size (N)	Avg. Influent Synthetic Turbidity (NTU)
Control	Filter 1	46	0.48±0.17
	Filter 1.1	178	0.67±0.08
Low Turbidity	Filter 2	186	4.63±0.30
	Filter 3	188	5.31±0.95
Med. Turbidity	Filter 4	139	26.2±2.2
	Filter 5	64	35.4±6.0
High Turbidity	Filter 6	187	61.2±2.9
	Filter 7	65	60.2±4.7

The filters processing low turbidity waters had an average influent turbidity of about 5 NTU, the medium turbidity filters had an average of about 30 NTU, and the high turbidity filters averaged about 60 NTU. The 95% confidence intervals are also very low, ranging from 0.08 NTU for the control to 6.0 NTU for Filter 5, indicating that the influent conditions were fairly consistent.

4.2.1 Flow Rate as a Function of Solids Loading

Table 11 shows the average influent turbidities for each of the filters over the course of the experiment. The control filters, Filter 1 and Filter 1.1, processed tap water almost exclusively. Filter 1 only processed tap water because it was broken before pond water could be tested. Filter 1.1 processed pond water to check for coliform removal on two instances; the second trial and the 80th (last) trial.

Flow rates were measured periodically over the course of the experiment. It was measured at least twice per trial (one trial corresponds to 17 L of processed water).

Table **12** provides the average flow rates determined over the course of an experiment for each filter. The flow rates ranged from almost 6 L/hr to over 10 L/hr processing synthetic water and were as low 2 L/hr. The only filter that was able to achieve a high flow rate for pond water was Filter 7. This is likely due to the fact that the glue had malfunctioned, allowing water to seep into the tube without passing through the ceramic element.

Overall, the filters in descending order were Filter 1, Filter 7, Filter 5, Filter 6, Filter 1.1, Filter 4 and then Filters 2 and 3. When compared with the first hour flow rates from Table 10, Filters 7, 5 and 6 are all in the top four again. The same filters that showed to be faster in a test of first hour flow rate with tap water, also seem to be fastest when processing synthetic and pond water. There appears to be no decrease in the flow rate with respect to the turbidity of the influent water.

Table 12. Average flow rate, Q (L/hr) of each filter. This is based on the all the measurements taken (at least 2 per trial) and then is separated to show the flow rate for just synthetic water or just pond water. N is the number of times that the flow rate was measured on the filter. The flow rate was measured 2-3 times per trial.

		Control		Low Turbidity		Med. Turbidity		High Turbidity	
		Filter 1*	Filter 1.1	Filter 2	Filter 3	Filter 4	Filter 5*	Filter 6	Filter 7*
All	Q (L/hr)	10.43	6.10	5.58	5.58	6.01	8.36	6.23	9.80
	N	44	195	184	218	167	84	216	81
Syn	Q (L/hr)	10.43	6.15	5.90	6.04	6.39	9.12	6.58	10.02
	N	44	190	162	193	146	71	194	71
Pond	Q (L/hr)		4.28	3.22	2.01	3.32	4.21	3.17	8.26
	N	0	5	22	25	21	13	22	10

*Filter 1, 5 and 7 were all taken out of the study before processing 1,000 L. Filters 5 and 7 had an issue with the glue attaching the ceramic element to the plastic cap.

The flow rates for filtering pond water were consistently slower than when the filter was processing synthetic water. This is true even for Filters 6 and 7 when the turbidity of synthetic water was about 40-80 NTU (over the course of one trial) and pond water turbidity averaged around 15.5 NTU. The reasons for this are discussed later in a later section.

4.2.2 Turbidity Removal as a Function of Solids Loading

As determined by the relationship described previously, the turbidity and the TSS were related by a linear relationship with an R2 value of 0.91. For this reason, the turbidity was used as a metric to estimate the amount of solids that the ceramic filter was able to remove. Table 13 describes the average influent and effluent turbidities as well as the average removal for each of the tested filters. Filters 2, 5 and 7 have percent removals below 65%. Filters 5 and 7 were removed from the study after complete failure. Because of the low removal of turbidity for Filter 2, it is likely that the glue was beginning to fail for this filter as well. The ceramic element of Filter 2 never completely detached from the plastic cap, however, so it was never removed from the study. Had testing continued, it is likely the Filter 2 ceramic element would have separated from the plastic cap. Of the other filters that showed no malfunctions over the life of the experiment (Filters 3, 4, and 6), they each showed high turbidity removals of 93.4%, 98.0% and 98.7%, respectively. This is similar to results from Berhanu Kiber Import & Export Enterprise (2010), which found an average turbidity removal of 96.3% at an average influent turbidity of 326 NTU (sample size of 5).

Table 13. The average influent and effluent turbidities are shown in the table below. These were averaged over all the measurements taken during 91 trials. The influent and effluent turbidities were measured simultaneously at least twice per trial.

All Trials					
		N	Avg. Influent Turbidity (NTU)	Avg. Effluent Turbidity (NTU)	Turbidity Percent Removal (%)
Low Turbidity	Filter 2	212	5.28	2.25	54.7% ± 7.91%
	Filter 3	214	5.67	0.33	93.4% ± 1.39%
Medium Turbidity	Filter 4	159	24.3	0.39	98.0% ± 1.39%
	Filter 5*	74	32.9	11.59	62.5% ± 9.11%
High Turbidity	Filter 6	213	55.8	0.40	98.7% ± 0.38%
	Filter 7*	78	56.2	23.58	54.2% ± 5.81%

Only considering the natural pond water trials, the turbidity removals were slightly lower than the overall average of turbidity removal as shown in Table 14. For Filters 3, 4 and 6 the turbidity removal of pond water were 93.4%, 94.5% and 94.2%, respectively as compared with 93.4%, 98.0% and 98.7% of all trials. Filter 3 achieves almost the exact same removal while Filters 4 and Filters 6 are slightly lower. It is likely that these are slightly lower because the turbidity of pond water was less than the average turbidity for the medium and high turbidity synthetic waters. Despite the influent turbidity, however, Filters 3, 4, and 6 achieved an average effluent turbidity below 0.50 NTU.

When just considering the synthetic water, the turbidity removals are slightly higher than the pond water trials as shown in Table 15. Filters 3, 4, and 6 achieved 93.4%, 98.5% and 99.3% turbidity removal for all the synthetic water trials.

Table 14. The average influent and effluent turbidities are shown in the table below for all of the pond water trials. The influent and effluent turbidities were measured simultaneously at least twice per trial.

Pond Water Trials					
		N	Avg. Influent Turbidity (NTU)	Avg. Effluent Turbidity (NTU)	Turbidity Percent Removal (%)
Low Turbidity	Filter 2	26	9.60	3.22	64.2% ± 13.13%
	Filter 3	26	8.29	0.55	93.4% ± 2.51%
Medium Turbidity	Filter 4	20	11.7	0.52	94.5% ± 1.48%
	Filter 5*	10	16.8	6.00	53.8% ± 28.40%
High Turbidity	Filter 6	26	16.4	0.57	94.2% ± 2.03%
	Filter 7*	13	36.6	17.9	43.7% ± 11.57%

The average effluent turbidity for Filters 3, 4 and 6 were also slightly higher, ranging from 0.55 NTU to 0.57 NTU. This is similar to the influent turbidity of tap water, which averaged to be 0.67 NTU over 178 measurements.

Table 15. The average influent and effluent turbidities are shown in the table below for only the synthetic water trials. The influent and effluent turbidities were measured simultaneously at least twice per trial.

Synthetic Water Trials					
		N	Avg. Influent Turbidity (NTU)	Avg. Effluent Turbidity (NTU)	Turbidity Percent Removal (%)
Low Turbidity	Filter 2	186	4.63	2.08	53.4%±8.82%
	Filter 3	188	5.31	0.30	93.4%±6.86%
Medium Turbidity	Filter 4	139	26.2	0.37	98.5%±0.36%
	Filter 5*	64	35.4	12.5	63.8%±9.61%
High Turbidity	Filter 6	187	61.2	0.38	99.3%±0.22%
	Filter 7*	65	60.2	24.7	56.3%±6.49%

The majority of the effluent samples from all the working filters were below the recommended WHO guidelines of 5 NTU (WHO Factsheet 2.33). This is shown in Table 16. All effluent samples for the control filter, Filter 1.1 were below 5 NTU. For the low turbidity filters, Filter 2 showed 190 of 212 effluent samples below 5 NTU, and Filter 3, 4 and 6 shows that all effluent samples were below 5 NTU (n =214, 168 and 214 respectively).

Table 16. Number of samples that conform to the World Health Organization's (WHO) guidelines for turbidity for each filter.

		Total Number of Samples	Number of Influent Samples >5 NTU	Number of Effluent Samples < 5 NTU
Control	Filter 1.1	182	4	182
Low Turbidity	Filter 2	212	89	190
	Filter 3	214	95	214
Medium Turbidity	Filter 4	168	166	168
	Filter 5	74	74	23
High Turbidity	Filter 6	214	214	214
	Filter 7	78	78	5

4.2.3 Coliform Removal as a Function of Solids Loading

The coliform removal was determined by using the IDEXX method which measured the total coliforms and the *E. coli* concentrations in CFU/100mL. The minimum detected value using this method is reported at <1 CFU/100mL. To be conservative in estimates of log and percentage removal, a value of 1 CFU/100mL was used in calculations when the sample was below the detection level. Because Filters 5 & 7 were failing due to manufacturing issue, they were removed from the testing of coliform removal. Filter 1.1 was the control and so it only tested pond water twice; once in the beginning and again at the end of the experiment. Figure 14 shows the log removal values for both total coliforms and *E. coli* for Filters 1.1, 2, 3, 4 and 6.

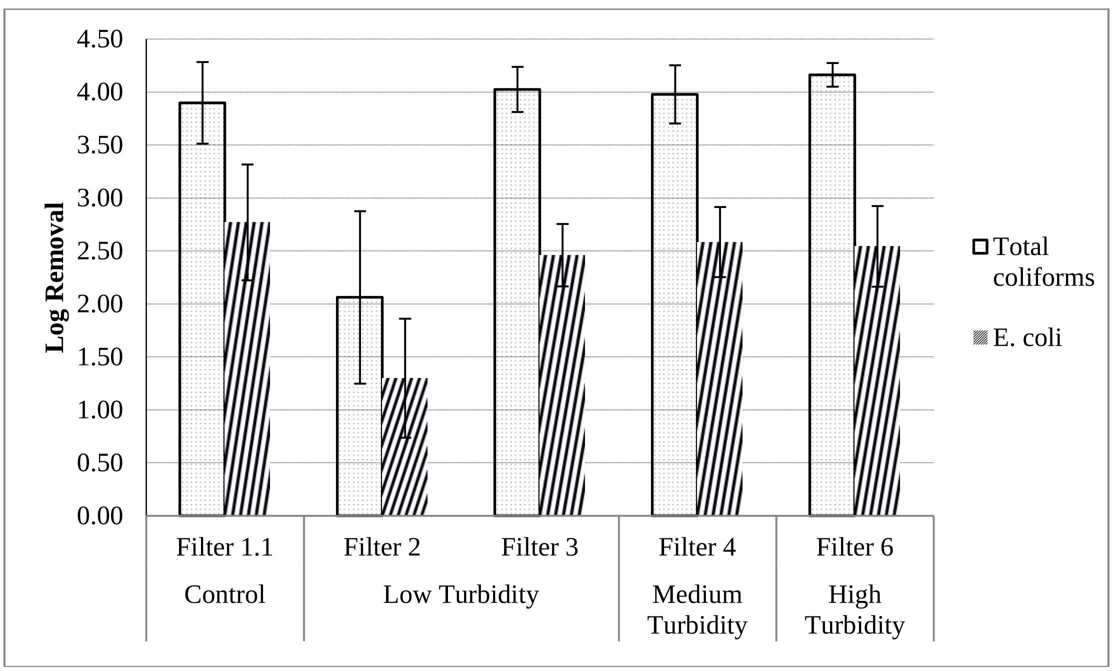


Figure 14. Log removal values for Filters 1.1, 2, 3, 4, and 6 for total coliforms and *E. coli.* Filter 5 & 7 were removed from the study so results are not shown. The total coliforms and *E. coli* log removals are depicted with the error bars representing the 95% confidence intervals.

The total coliform removal for Filters 1.1, 3, 4, and 6 were all approximately 4 log removals. This is displayed in Table 17. Filters 3, 4, and 6 all achieved the maximum amount of removal possible for eight out of nine trials. Filter 1.1 did not achieve the maximum removal for either trial but had low average effluent concentrations 1.33 CFU/100 mL for the first trial and 4.8 CFU/100 mL for the second trial. Filter 2 only achieved a log removal slightly above 2. The average influent concentration of total coliforms ranged from 14,600 to 16,400 CFU/100 mL.

Table 17. Log removal values for total coliforms and the associated average influent concentration. The IDEXX method of reporting coliforms determined that if no wells were positive, the most probable number of coliforms was <1 CFU/100 mL. To be conservative, a value of 1 CFU/100 mL was used for log removal calculations. Filters 3, 4, and 6 consistently had no positive wells in the effluent sample, thus the log removal value is reported as greater than the number listed.

Total Coliforms					
		Trials	Avg. Influent Concentration (CFU/100 mL)	Avg. Effluent Concentration (CFU/100 mL)	Avg. Removal
Control	Filter 1.1	2	14,700	2.4	>3.90±0.38
Low Turbidity	Filter 2	9	15,700	>1130	2.06±0.81
	Filter 3	9	16,100	1.6	>4.02±0.21
Medium Turbidity	Filter 4	6	14,600	2.2	>3.98±0.27
High Turbidity	Filter 6	9	16,400	1.1	>4.16±0.11

The *E. coli* removal for Filters 1.1, 3, 4, and 6 were all approximately 2.5 log removals as shown in Table 18. These filters all achieved the maximum amount of removal possible for all of the trials. Filter 2 only achieved a log removal slightly above 1.30. The average influent concentration of total coliforms ranged from as low as 308 CFU/100 mL to 866 CFU/100 mL. These are low influent concentrations of *E. coli* and thus explain the low log removal values.

Table 18 Log removal values for *E. coli* and the associated average influent concentration. The IDEXX method of reporting coliforms determined that if no wells were positive, the most probable number of coliforms was <1 CFU/100mL. To be conservative, a value of 1 CFU/100mL was used for log removal calculations. Filters 3, 4, and 6 consistently had no positive wells in the effluent sample, thus the log removal value is reported as greater than the number listed.

E. coli					
		Trials	Avg. Influent Concentration (CFU/100 mL)	Avg. Effluent Concentration (CFU/100 mL)	Avg. Removal *E. coli*
Control	Filter 1.1	2	866	1	>2.77±0.55
Low Turbidity	Filter 2	9	470	79	1.30±0.56
	Filter 3	9	448	1	>2.46±0.29
Medium Turbidity	Filter 4	6	589	1	>2.58±0.33
High Turbidity	Filter 6	9	854	1	>2.58±0.38

The effluent concentrations of *E. coli* are consistent with the WHO's classification of a low risk level. The risk levels established by the WHO are provided in Table 19. These are conservative estimates, as well, because a value of 1 CFU/100 mL was used to describe all samples that showed zero positive wells. It is possible that there was actually 0 CFU/100 mL in the sample, which would conform to the WHO guidelines for drinking water quality (WHO, 2011).

Table 19. Guidelines for risk levels developed by the World Health Organization (WHO, 2011).

Risk Level	*E. coli* Concentration (CFU/100 mL)
Conforms with WHO guidelines	0
Low	1-10
Intermediate	10-100
High	100 to 1000
Very High	>1000

Filter 2 was the only filter that was not in the low risk category. This filter averaged 79 CFU/100mL which would indicate an intermediate risk level.

To reflect that the distribution of samples that were in the WHO's "low risk" category for *E. coli*, the number of samples are tabulated as shown in Table 20. Almost all of the samples collected for Filters 1.1, 3, 4, and 6 showed no positive results for *E. coli*. Filter 1.1 showed no positive results for *E. coli* in 9 of 9 samples, Filter 3 in 20 of 20 samples, Filter 4 in 15 of 16 samples and Filter 6 in 20 of 20 samples. Filter 2 showed only 5 samples that had no positive results.

Table 20. Number of samples that are "low risk" according to World Health Organization (WHO) guidelines for *E. coli*

	Total # Samples	# of Influent Samples >1 CFU/100mL	# of Effluent Samples <1 CFU/100mL	# <10 CFU/100mL (WHO Low Risk or Conforms to Guidelines)
Filter 1.1	9	9	9	9
Filter 2	20	20	5	12
Filter 3	20	20	20	20
Filter 4	16	16	15	16
Filter 6	20	20	20	20

In Table 21, the sample distribution is shown for total coliforms. Because the influent concentration was much higher for total coliforms than *E. coli*, there are more samples with higher effluent concentrations of total coliforms. For Filter 1.1, 3, and 6, produced all effluent samples with <1 CFU/100 mL for *E. coli* but only 5 of 9, 13 of 20 and 16 of 20 are <1 CFU/100 mL for total coliforms. Despite this, Filter 1.1, Filter 3, and Filter 6 produced all of their effluent samples in the "low risk" category.

Table 21. Number of influent and effluent samples that are classified as "low risk" according to the World Health Organization (WHO) guidelines for total coliforms.

	Total # Samples	# of Influent Samples >1 CFU/100mL	# of Effluent Samples <1 CFU/100mL	# <10 CFU/100mL (WHO Low Risk or Conforms to Guidelines)
Filter 1.1	9	9	5	9
Filter 2	20	20	2	7
Filter 3	20	20	13	20
Filter 4	16	16	10	14
Filter 6	20	20	16	20

Because the synthetic water was partially made up of tap water, there was residual chlorine in the synthetic influent water. When processing pond water after water with residual chlorine, it is possible that the residual chlorine would partially disinfect the pond water. To minimize this effect, the filters only ran pond water a minimum of 12 hours after processing synthetic water, usually they sat out overnight.

4.3 Hydraulic Loading

The cumulative volume of water processed through each filter was recorded with each trial and the final hydraulic loading is tabulated in Table 22. The experiment was designed to process at least 1,000 L of water through each filter. Filter 1 was a control that was broken after 225 L and Filters 5 and 7 failed due to a manufacturing defect with the glue adhering the ceramic element to the plastic cap. The maximum volume filtered was processed by Filter 6 at 1,047 L of high turbidity water.

Table 22. The cumulative volume of water processed by each filter.

		Trials	Cumulative Volume (L)
Control	Filter 1	19	225
	Filter 1.1	80	1,014
Low Turb.	Filter 2	91	1,023
	Filter 3	91	1,035
Med. Turb.	Filter 4	65	740
	Filter 5*	31	350
High Turb.	Filter 6	91	1,047
	Filter 7*	31	346

4.3.1 Turbidity Removal as a Function of Hydraulic Loading

The turbidity removal varied for each filter. The low turbidity filters (Filters 2 and 3) had lower percentage turbidity removals because of the low influent concentration. The percent turbidity removal versus the cumulative volume filtered for these filters is shown in Figure 15. Filter 3 did well for the majority of trials throughout the entire 1,000 L tested. Filter 2, however, seems to have a more scattered distribution as the volume of water processed increased (see results as cumulative volume increases above 500 L). It is possible that this filter was beginning to show signs of failure due to malfunctioning glue (as in the case with Filters 5 and 7).

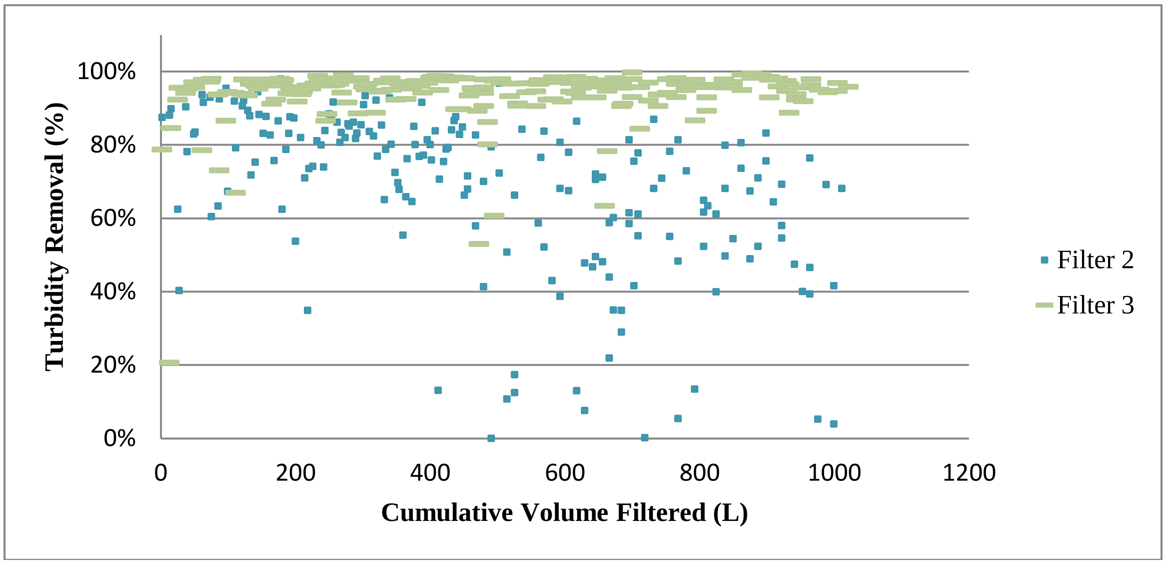


Figure 15. Turbidity removal as percent removal versus the cumulative volume filtered for low turbidity filters, Filters 2 and 3.

For the medium turbidity filters (Filters 4 and 5) a similar trend is shown in Figure 16. For these filters, the trend is much more apparent. Filter 4 is achieving near 100% removal for the majority of trials and Filter 5 slowly decreases turbidity removal with an increase in hydraulic loading.

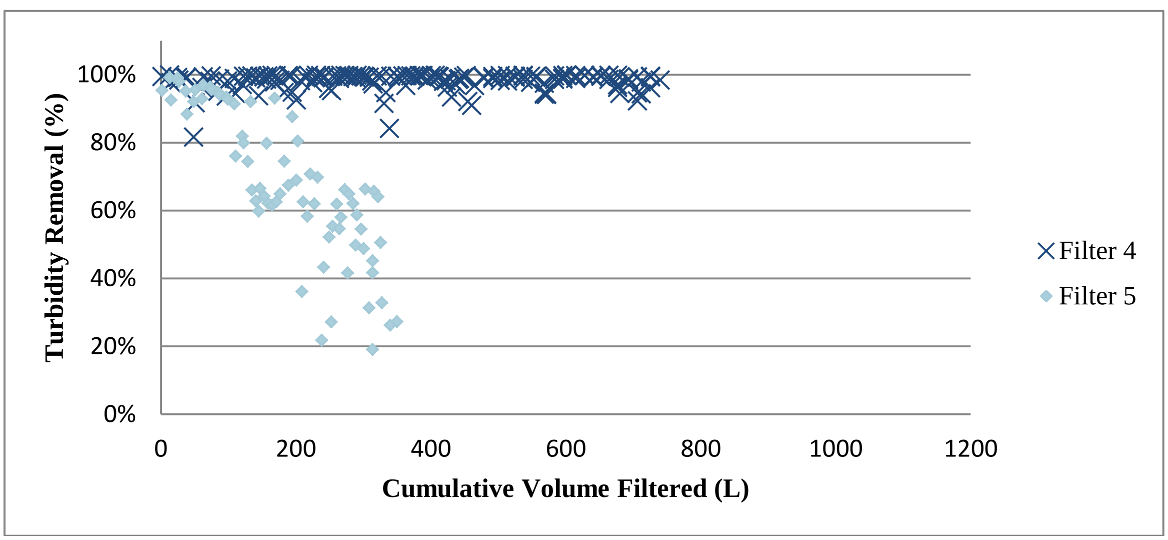


Figure 16. Turbidity removal as percent removal versus the cumulative volume filtered for medium turbidity filters, Filters 4 and 5.

Filters 6 and 7, the high turbidity filters, show a trend that resembles the medium turbidity filters. In Figure 17 it is obvious that Filter 6 is achieving almost 100% removal for nearly all tests. Filter 7, like Filter 5 shows a decrease in turbidity removal with an increase in hydraulic loading.

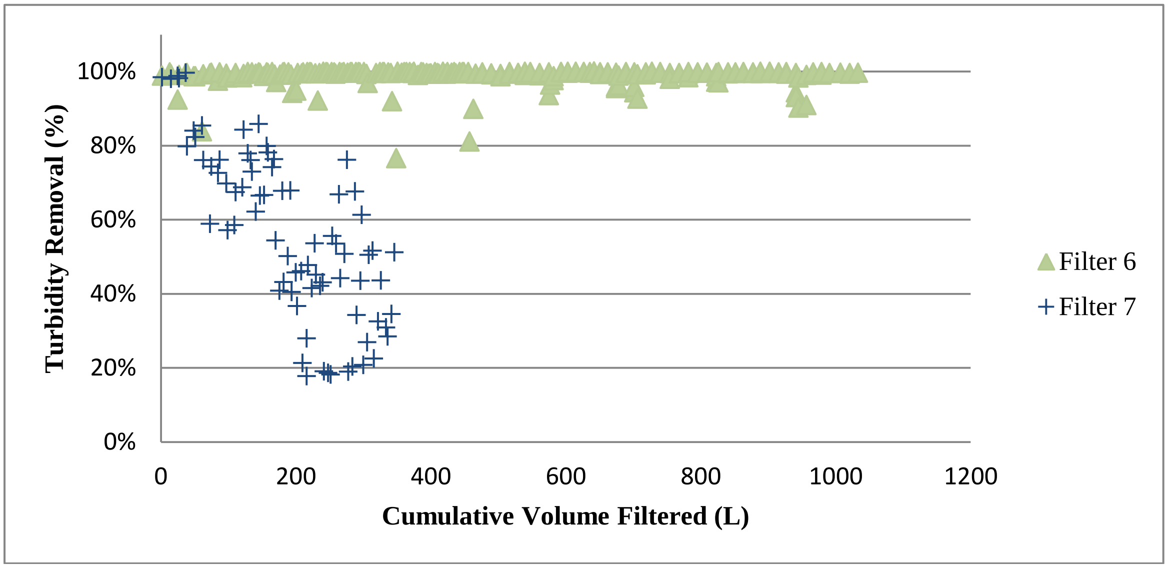


Figure 17. Turbidity removal as percent removal versus the cumulative volume filtered for high turbidity filters, Filters 6 and 7.

Filters 5 and 7 were both removed from the study because the glue had been poorly manufactured. Just before the glue completely failed, Filters 5 and 7 were only achieving 20-30% turbidity removal. Because this removal was so high, and the filters were treating water ranging from 20-80 NTU, the effluent water was noticeably turbid. The effluent turbidities for Filters 5 and 7 were 11.59 NTU, and 23.58 NTU respectively. It is suspected that Filter 2 may also have been showing initial signs of failure but this would require further testing to be sure.

4.4 Particle Size Distribution

The particle size distribution was analyzed by Particle Sizing Systems (New Port Richey, FL). The particles were sent on July 28, 2011 and tested on August 2, 2011. They were kept in a refrigerator to minimize any effects of organism growth in the pond water during this time. Figure 18 shows the percentage of particles at each specified diameter for both the influent and effluent sample of pond water processed by Filter 6. There are significantly more particles in and below the size ranges of 0.750 µm and 1.000 µm and in the effluent samples. There is also a higher percentage of particles below about 1.500 µm. The influent sample has a higher percentage of particles 2.000 µm or larger. The overall range of sizes reported range from 0.514 µm to 77.692 µm. Over 90% of all particles of either influent or effluent samples, however, were below about 1.500 µm. More data relating to the particle size distribution can be found in Appendix IV.

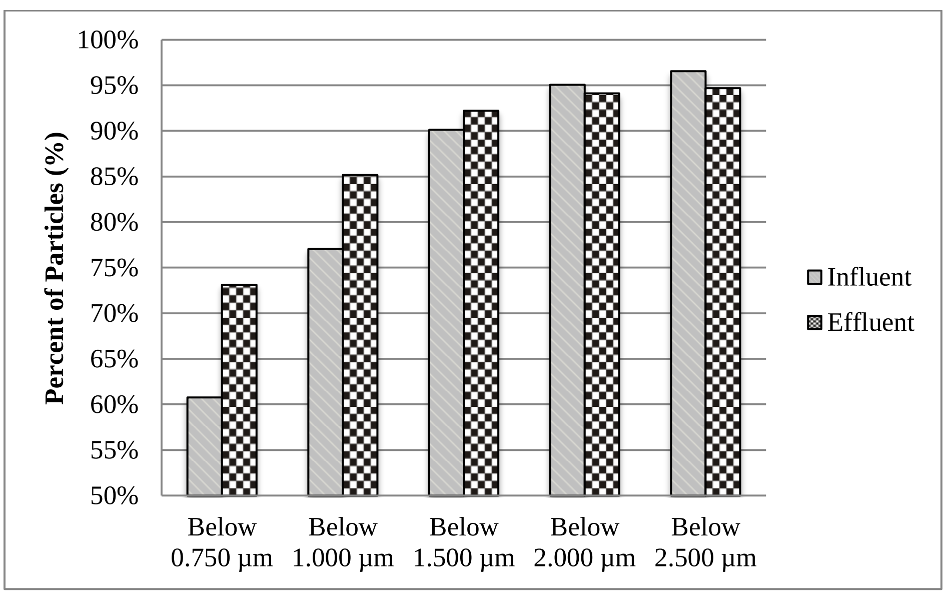


Figure 18. Filter 6 influent and effluent sample of pond water and the cumulative percent distribution.

The particle size distribution was analyzed for pond water and compared with synthetic water. The percent distribution for each of these influent samples is shown in Figure 19. This synthetic water was taken from Filter 5 and is associated with a medium turbidity of 24.3 NTU. The pond water here had a turbidity of 8.48 NTU. Though the pond water has a lower turbidity, it has a significantly higher concentration of particles below 1.000 µm than the synthetic water. Because of the higher percentage of smaller particles in pond water, this could explain the slower flow rate for pond water samples. The smaller particles could be responsible for clogging pores in the filter and decreasing the flow rate.

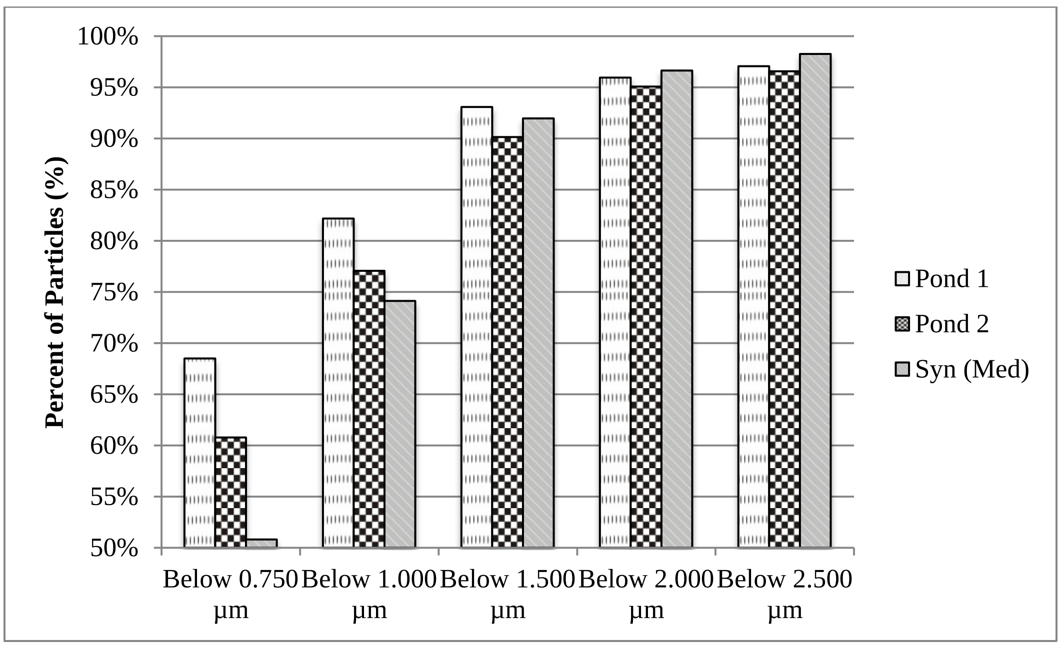


Figure 19. A comparison of the percent distribution for synthetic water and two pond water samples.

Filter 6 was able to remove particles of all sizes that were able to be measured by the Accusizer 780/AD Autodilutor at Particle Sizing Systems. In Figure 20, the percent removal for four particle sizes is shown. Filter 6 was able to remove over 95% of particles in all ranges shown.

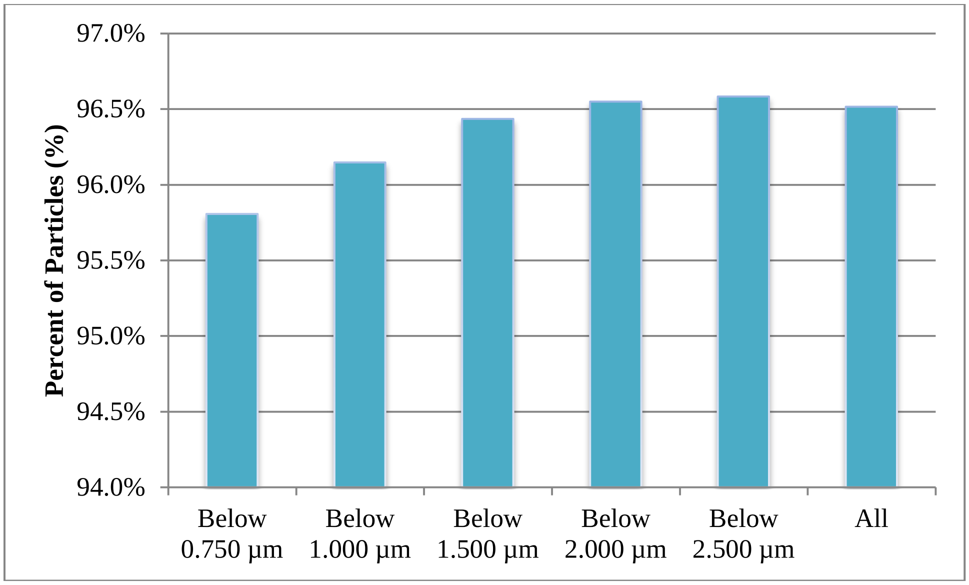


Figure 20. Percent reduction in particle size for pond water for each range of particle sizes and compared with the overall.

Because there are still particles less than 1 µm not being removed, the filter is not able to remove all bacterial and viral pathogens solely by size exclusion. From Table 4, the size of viruses is approximately 0.01-0.1 µm and the size of bacterial pathogens can range from 0.1-10 µm. The addition of silver is important for additional defense against bacterial and viral pathogens.

4.5 Synthetic and Pond Water pH Values

Table 23 shows that pond water was more basic than any of the tap water based synthetic water solutions. The pond water had a pH of 7.12 while the tap water solution for control, low turbidity, medium turbidity and high turbidity synthetic waters had pH values of 6.79, 6.29, 6.29, and 6.54, respectively. The pH can affect the attraction and repulsion of forces between particles and also affects interactions with bacteria. These pH values are all within one pH unit, however, so should have similar relationships of attraction and repulsion between particles. If the particles within the different types of samples are attracted and repelled similarly, they should also clog the filter in a similar way. These particles are also above the point of zero charge for silica, which ranges from 2-3.5 which indicates that the particles are unstable.

It is not clear how pH affects colloidal silver and bacteria, however. In a study performed by Fabrega et al. (2009) a pH range of 6-9 was tested with silver nanoparticles and Pseudomonas fluorescens, a gram-negative, rod-shaped bacterium (*E. coli* is also rod-shaped and Gram-negative). Fabrega et al. (2009) found that pH did not have a significant effect on growth of Pseudomonas fluorescens.

Table 23. Values of pH for pond water and each category of turbidity water after 30 minutes of settling.

Water Type	pH
Pond Water	7.12
Control (tap water)	6.79
High Turbidity (17L of tap water, 6.0 g of silica sand)	6.54
Medium Turbidity (17 L of tap water, 3.0 g of silica sand)	6.29
Low Turbidity (17 L of tap water, 0.5 g of silica sand)	6.29

The pH value of silver nanoparticles has been shown to have an increase in bactericidal effectiveness at lower pH values. This is because there is an electrostatic attraction between negatively charged bacterial cells and positively charged silver nanoparticles. There is one study performed by Sondi & Salopek-Sondi, 2004, however that found that negatively charged silver particles also are effective as bactericidal materials. It is unclear how the pH affects the stability of the silver nanoparticles and their interactions with potential pathogens.

4.6 Comment on User Acceptability and Limitations of Study

This study did not use this filter in the field and thus there is no way to describe the user acceptability of this technology. Basic Water Needs suggested frequent backwashing, and thus the author backwashed after each trial. Backwashing increases the lifetime of the filter by unclogging some of the pores and avoids excessive scrubbing. Ziff (2009) reported that few households remembered how to backwash after only three weeks. Frequently backwashing was not performed before resorting to scrubbing. This study only scrubbed the filters 7-10 times and was still achieving high flow rates. Emphasis on backwashing before scrubbing should be practiced to ensure the longevity of the filters. Ziff (2009) also suggested that removing the prefilter while backwashing seemed to resonate better with the user. It was apparent in the study conducted at USF that removing the prefilter highlighted the effectiveness of backwashing. This is illustrated in Figure 21. Thus, this would be a useful technique in explaining proper use of the filter to potential customers.

Figure 21. Backwashing the Tulip filter after using pond water. On the left is the filter before backwashing and on the right is immediately after backwashing.

Furthermore, the pond water and synthetic waters behaved differently in the Tulip filters. It is likely that surface water or water from a hand dug well will be more similar in composition to the water found in the USF Botanical Gardens. Additionally the Tulip filters are expected to last to process 7,000 L of water, and they were tested in the study up to only about 1,000 L. This was simulated by using various solids loadings, through using different synthetic water samples. Filters 4 and 6 processed the most solids throughout the experiment with 20 and 41 kg, respectively. The average amount of solids used during the pond water trials were 0.66 kg of solids over about 70 L of pond water. If all water was similar in composition to the pond water used in this study, Filters 4 and 6 would be at about ¾ of the lifetime of the filter and 1/3 of the lifetime. These filters were still able to remove coliforms and turbidity very effectively and there was no indication that these filters should not be able to process up to the expected 7,000 L.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions for Implementation of Tulip Filter

Overall, the filters performed very well in terms of water quality and are a useful technology for developing world settings to remove pathogens from drinking water. Of the filters that were not removed from the study due to glue malfunction (Filters 1, 1.1, 2, 3, 4 and 6), all but one (Filter 2) were achieving over 90% turbidity removal. It is important to note, though, that Filter 2 was suffering from the same quality control issue that required Filters 5 and 7 to be removed from the study. Furthermore, despite conservative estimates for coliforms in the filter effluent samples, Filters 1.1, 3, 4, and 6 all achieved almost 4 log removal of total coliforms (Filters 4 and 6 achieved over 4 log removals). Furthermore, the samples of the effluent water from the filters were all in the WHO's "low risk" category even with conservative estimates for the number coliform forming units. Despite the indication that Filter 2 was also beginning to fail, it was still producing effluent water that would place it in the "intermediate risk" category described by the WHO.

The Tulip filters did not, however, achieve expected flow rates (4-5 L/hr) for pond water samples (though they did achieve 4-5 L/hr for synthetic samples). This indicates that turbidity is not the sole variable in determining the flow rate of water through the filter.

The particle size distribution of pond water had a higher concentration of particles smaller than 0.5 µm, and thus could be responsible for clogging the pores of the ceramic. This could also be a result of the presence of natural organic matter (NOM) or other chemical constituents in pond water that are not present in the synthetic water.

The Tulip filter is a useful point-of-use technology for the developing world because it is relatively inexpensive (~5.30 USD), compact and requires minimal maintenance. A replacement filter would be required after about one year (assuming it lasts 7,000 L and one person uses 20 L daily). Furthermore, daily backwashing and occasional scrubbing of the filter would be required, but these are minor maintenance requirements. There is also a simple mechanism for determining when the filter has reached the end of its life.

Based on the results of the Ziff (2009) study and the study performed at USF, new users should be instructed on the benefits of frequent backwashing with demonstrations that remove the prefilter. Backwashing is not necessarily an intuitive concept to a typical user and is often avoided because the user either does not remember how to backwash or does not understand its importance. A demonstration with prefilter removal visually shows the benefits of backwashing and this will hopefully encourage the user to employ this cleaning technique that extends the filter's lifetime. Furthermore, it may be helpful to place pictures indicating how the backwash process works (such as Figure 21).

Additionally, the Tulip filter had the issue of a lack of quality control when attaching the ceramic element to the plastic cap. Two of the seven original filters had completely failed and needed to be removed from the study (Filters5 and 7), and it is suspected that a third was likely to fail in the near future (Filter 2). The performance of the filter depends highly on the quality of the glue attaching the ceramic element to the plastic cap. If the glue was not keeping the ceramic close enough to the plastic cap, water could bypass the ceramic element entirely and thus allowing pathogens through. It is critical to stress the importance of quality control in this type of technology that could place lives at risk. If this quality control issue has not been completely resolved, users should be informed that if their effluent water begins to look turbid that this could be a result of a faulty glue connection.

5.2 Recommendations for Future Research

More research needs to be done on coliform and *E. coli* removal over the entire filter lifetime which BWN recommends as 7,000 L. Additionally, the effectiveness of inactivating bacteria could be affected by different solids loadings over the course of filtering 7,000 L of water. This study found that for the first 1,000 L there was no verifiable effect of solids loading on the effluent water quality.

The particle size distribution found in this study shows that there were a significant number of particles in the effluent of the filter below 0.5 µm. This indicates that viruses, which are as small as 0.01 µm, could easily still be present in effluent water. Considering it is unknown if silver could act to deactivate viruses, a study on the presence of viruses in the effluent water could shed some interesting knowledge.

Another interesting result from this study was the difference in flow rates of synthetic water and pond water samples. The flow rate of the pond water through the filter was almost a factor of two less than synthetic water, despite being less turbid. This implies some other factor hindered the flow of particles through the ceramic. More research should be done to analyze particle size distribution and the fate and transport of different particle sizes through ceramic siphon filters. Additionally, the effect of NOM or other chemical constituents on modifying surface properties of the ceramic surface or clogging of the ceramic pores should be investigated.

REFERENCES

Ashbolt, N., Grabow, W.O.K., Snozzi, M. (2001). Chapter 13: Indicators of microbial water quality. Water Quality: Guidelines, Standards and Health. World Health Organization. Edited by Lorna Fewtress and Jamie Bartram. IWA Publishing, London, UK.

Ashbolt, N.J. (2004). Microbial contamination of drinking water and disease outcomes in developing regions. Toxicology 198. 229-238.

Basic Water Needs (2009). Products – Tulip siphon water filter. Retrieved from: http://www.basicwaterneeds.com/web/products.php?tid=1&flg=1

Berhanu Kiber Import & Export Enterprise. (2010) Efficacy Test of Tulip Water Filter for Fecal and Total Coliform Bacteria and Turbidity. Water Works Design and Supervision Enterprise

Bielefeldt, A.R., Kowalski, K., Schilling, C., Schreier, S., Kohler, A., Summers, S. (2010). Removal of virus to protozoan sized particles in point-of-use ceramic water filters. Water Research. 44. 1482-1488.

Black, R. E. (2001) Diarrheal diseases. Infectious Disease Epidemiology: Theory and Practice (ed. K. E. Nelson, C. Masters Williams & N Graham), Aspen Publisher, Inc., Gaithersburg, MD, USA, pp. 497-518.

Cairncross, S. & Feachem, R. G. (1993). Environmental health engineering in the tropics: an introductory text. New York: J. Wiley. Retrieved October 10, 2011, from Google books: http://books.google.com/books/about/Environmental_health_engineering_in_the.html?id=SQtSAAAAMAAJ

Clasen, T., Haller, L., Walker, D. Bartram, J., Cairncross, S. (2007) Cost-effectiveness of water quality interventions for preventing diarrheal disease in developing countries. Journal of Health and Water. 5 (4). 599-608.

Clasen, T., & Menon, S. (2007). Microbiological performance of common water treatment devices for household use in India. International Journal of Environmental Health Research, 17 (2), 83-93.

Clasen, T., Parra, G.G., Boisson, S., & Collin, S. (2005). Household-based ceramic water filters for the prevention of diarrhea: a randomized, controlled trial of a pilot program in Colombia. American Journal of Tropical Medicine Hygiene, 73(4), 790-795.

Clasen, T. F., Brown, J., Collin, S., Suntura, O., & Carincross, S. (2004). Reducing Diarrhea through the use of household-based ceramic water filters: a randomized, controlled trial in rural Bolivia. American Journal of Tropical Medicine Hygiene, 70(6), 651-657.

Eaton, A. D., Clesceri, L.S., Rice, E.W., Greenberg, A. E. (Eds). (2005) Standard Methods: For the examination of water and wastewater (Centennial Edition). Washington, DC American Public Health Association.

EMS Lab Report (2008). EMS Lab, T.N., India, 605101

Fabrega, J., Fawcett, S. R., Renshaw, J. C., and Lead, J. R. (2009). Silver nanoparticle impact on bacterial growth: effect of pH, concentration, and organic matter. Environmental Science & Technology 43, 7285-7290.

Fewtrell, L., Kauffman, R.B., Kay, D., Enanoria, W., Haller, L., Colford Jr., J.M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhea in less developed countries: a systematic review and meta-analysis. The Lancet Infectious Diseases, 5, 42-52.

Fry, L.M., Schweitzer, R.W. & Mihelcic, J.R. (2011) Water, Human Health, and Sustainable Development. Chapter in Water Quality and Sustainability Schnoor, J.L. (ed) Elsevier. Electronic publication expected December 2011.

Hunter, P.R. (2009) Household water treatment in developing countries: comparing different intervention types using meta-regression. Environmental Science & Technology. 43, 8991-8997.

K. van der Ven, personal communication, July-September, 2011

Mihelcic, J.R., E.A. Myre, L.M. Fry, L.D. Phillips, B.D. Barkdoll. (2009). Field Guide in Environmental Engineering for Development Workers: Water, Sanitation, Indoor Air, American Society of Civil Engineers (ASCE) Press, Reston, VA.

Oyanedel-Craver, V.A., & Smith, J.A. (2008). Sustainable Colloidal-Silver-Impregnated Ceramic Filter for Point-of-Use Water Treatment. Environmental Science & Technology. 42, 927-933.

P. O'Hagan, personal communication, July-September, 2011

Prüss-üstün, A. & Corvalán, C. (2006) Preventing Disease through Healthy Environments: toward an estimate of the environmental burden of disease. The World Health Organization, Geneva, Switzerland.

Prüss, A., Kay, D., Fewtrell, L., and Bartram, J. (May 2002). Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level. Retrieved from http://www.who.int/quantifying_ehimpacts/global/en/ArticleEHP052002.pdf

Sargam Test Report (2010). Sargam Laboratory PVT. LTD.

Silver, S. (2003) Bacterial silver resistance: molecular biology and uses and misuses of silver compounds. FEMS Microbiology Reviews. 27, 341-353.

Sobsey, M.D., Stauber, C.E., Casanova, L.M., Brown, J.M., Elliot, M.A. (2008). Point of use household drinking water filtration: a practical, effective solution for providing sustained access to safe drinking water in the developing world. Environmental Science & Technology. 42(12), 4261-4267.

Sobsey, M.D. (2002). Managing water in the home: accelerated health gains from improved water supply. Protection of the Human Environment Water, Sanitation and Health. World Health Organization.

Sondi, I. and Salopek-Sondi, B. (2004). Silver nanoparticles as antimicrobial agent: a case study on *E. coli* as a model for Gram-negative bacteria. Journal of Colloid and Interface Science 275, 177-182.

Souter, P. F., Cruickshank, G.D., Tankerville, M.Z., Keswick, B.H., Ellis, B.D., Langworth, D.E., Metz, K.A., Appleby, M.R., Hamilton, N., Jones, A. L., Perry, J.D. (2003). Evaluation of a new water treatment for point-of-use household application to remove microorganisms and arsenic from drinking water. Journal of Water and Health. 1(2), 73-84.

Straub, T.M., Chandler, D.P. (2003). Towards a unified system for detecting waterborne pathogens. Journal of Microbiological Methods. 53, 185-197.

United Nations. (2010) Millennium Development Goals Summit. Retrieved from http://www.un.org/en/mdg/summit2010/pdf/Closing%20press%20release%20FINAL-FINAL%20Rev3.pdf

Van Halem, D., van der Laan, H., Heijman, S.G.J., van Dijk, J.C., & Amy, G.L. (2009). Assessing sustainability of the silver-impregnated ceramic pot filter for low-cost household drinking water treatment.

Van Halem, D. (2006). Ceramic silver impregnated pot filters for household drinking water treatment in developing countries. (Master's Thesis). Delft University. Delft, The Netherlands.

Van Houten, M. (2009). Household treatment of turbid water in developing countries. Faculty Industrial Design Engineering at the Delft University of Technology.

White, D.J. (2002) The measurement of particle size distribution using the Single Particle Optical Sizing (SPOS) method. Cambridge University Engineering Department. Technical Report. Retrieved from http://www-civ.eng.cam.ac.uk/geotech_new/publications/TR/TR321.pdf

World Health Organization (2011) Guidelines for drinking-water quality. Fourth edition. Retrieved from: http://whqlibdoc.who.int/publications/2011/9789241548151_eng.pdf

World Health Organization (2010). World Health Statistics 2010. Retrieved from http://www.who.int/whosis/whostat/EN_WHS10_Full.pdf

World Health Organization (2009). Diarrheal Disease Factsheet. Retrieved from http://www.who.int/mediacentre/factsheets/fs330/en/index.html

World Health Organization. (2008). [World Health Statistics Database]. Retrieved from http://apps.who.int/ghodata/?vid=60970

World Health Organization. (2004).WHO Member States, by WHO subregion and Mortality Stratum. Retrieved from http://www.who.int/quantifying_ehimpacts/publications/preventingdiseaseannex1.pdf

World Health Organization. Fact sheet 2.33: Turbidity measurement. Retrieved from http://www.who.int/water_sanitation_health/hygiene/emergencies/fs2_33.pdf.

WHO & UNICEF (2010) Progress on sanitation and drinking-water. Joint Monitoring Programme for Water Supply and Sanitation.

Ziff, S. E. (2009). Siphon Filter Assessment for Northern Ghana. (Master's Thesis). Massachusetts Institute of Technology. Cambridge, MA.

APPENDICES

Appendix I. Instructions for Use of the Tulip Filter Provided by BWN

1 WATER FILTER

Instruction manual
Tulip water filter

How to make safe drinking water?

This water filter removes bacteria and parasites from contaminated water, removes bad taste, prevents water borne diseases, and delivers crystal clear safe drinking water.

1. Plastic connector for adjusting the desired hose length.
2. Plastic jar with ceramic filter element and washable pre-filter.
3. Upper container for contaminated water.

Place this container about 70 cm. above level of lower container.
The speed of filtration is faster when the container with contaminated water stands at a higher level.

4. Plastic bulb to start the filtering process of water and to clean the ceramic element.
5. Opening and closing tap.
6. Lower container with lid for safe storage of drinking water.

2 USING THE FILTER

STARTING THE FILTER

Using a new filter element.
Let the filter element stay in water during one night and do not use the first 15 liters of filtered water because it has a ceramic taste!

Open the tap and squeeze the bulb.
Wait until the bulb slowly has been filled with water and filtered water starts flowing out of the tap.
When the filter element is dry this has to be repeated a few times.

3 CLEANING THE FILTER

CLEANING backwash

After a while the ceramic element will become dirty, reducing the water flow. Now the filter has to be backwashed.
Close tap and press bulb firmly.
Wait till the bulb is again filled with water and open the tap.
When the flow is not enough after doing this, repeat this a few times.
Backwash the filter at **least one time per day**, resulting in a longer life of the ceramic element.
In case dirty water is used, remove the water filter from the top bucket while back washing.

3 CLEANING

CLEANING ceramic element

If backwashing does not increase the flow, clean the filter element with a cloth of toothbrush.
In case this cleaning does not increase the flow, the filter element has to be cleaned gently with the round scrub pad rinsing with clean water (do not use detergents or cleaning agents!). Remove only as little as possible of the ceramic material, as this will shorten the lifetime of the element.

Store scrub pad at a safe place in your kitchen.

CLEANING pre-filter

When the pre-filter becomes dirty, remove the pre-filter from the ceramic element and wash it in clean water.
In case dirty water is used, this cleaning should be done a few times each week.
In case the contaminated water is very clear the pre-filter is not needed.

4 REPLACING CERAMIC ELEMENT

When to replace filter element

The filter element has to be replaced when the plastic sensor fits around the thinnest part of the filter element. To test this, unscrew the wing nut and remove the plastic sensor from the cap to check diameter. If the sensor fits over the filter element, the diameter of the filter element has become too small to deliver safe drinking water..

How to replace filter element

Cut the hose near the nozzle with a knife. Now it is easy to connect the hose to a new replacement filter element by pushing.
In this way for each replacement filter element about 1 cm. of hose will be used.

5 HYGIENE

It is suggested the lower container has a tap and lid. If not and water is taken out with a cup make sure cup and hands are clean. Lower container should be cleaned frequently. Keep the lower container covered with a lid.

Filtering dirty water

When the contaminated water is dirty, let it stay overnight to allow dirt to sink to the bottom. Then pour the dirty water through a double folded piece of cotton into the top bucket.

If the dirt in the water does not sink to the bottom, the water should be pre-treated with a flocculant (alum or Moringa seed) as the filter element has to be cleaned too often, substantially reducing the treatment capacity of the filter element.

Manufactured by Basic Water Needs India Pvt. Ltd. Patent pending.
(www.basicwaterneeds.com) Nov. 2010

Appendix II. Standard Curve Between TSS and Turbidity

A standard curve was developed to determine the relationship between turbidity and total suspended solids of synthetic water.

The figure below shows the plots of the measured TSS samples and their corresponding turbidities. The lines represent the 95% confidence intervals of the regressions line.

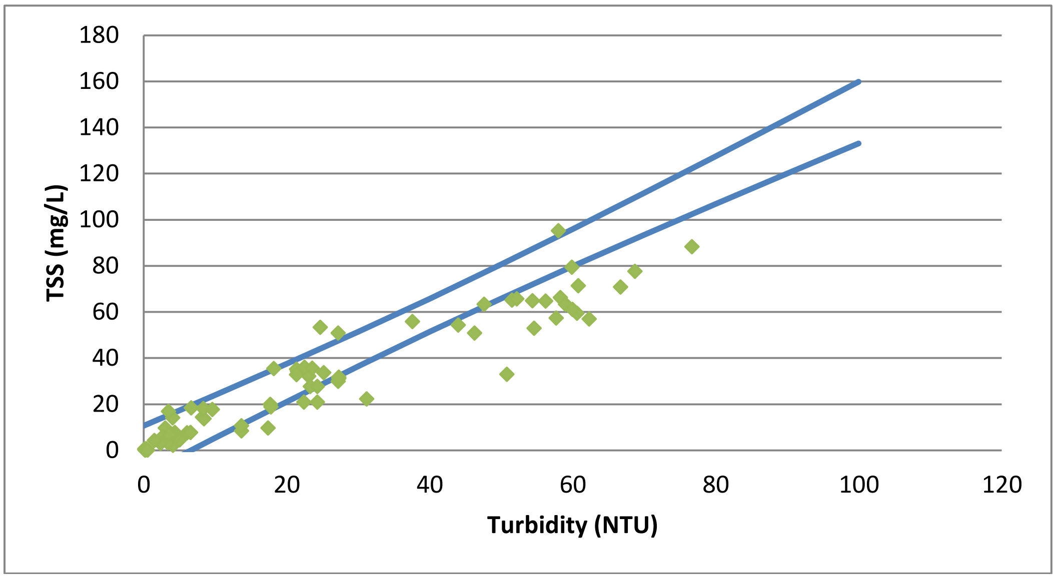


Figure II.1 95% confidence intervals of the regression line and all direct measurements

Verification of TSS and turbidity measurements for tap water mixed with silica sand (synthetic water). Each data point plots measured TSS against measured turbidity. The lines show the 95% confidence intervals for a developed regression line.

Two buckets at each turbidity level (low, medium, high) were tested periodically for NTU and corresponding TSS values. Five measurements were taken per buckets at times 0, 15, 30, 60 and 120 after mixing. The relationship between TSS and turbidity was developed based on the data listed below. From this, a regression line of TSS vs. turbidity was made and the slope was found to be 1.2 with an R2 value of 0.93.

Appendix II (Continued)

Table II.1 Data used to relate turbidity and TSS

	Time (min)	Turbidity (NTU)	TSS (mg/L)
Low Turbidity	0	5.88	10.1
	15	5.05	10.6
	30	5	8.6
	60	4.44	6.3
	120	3.28	4
	0	5.97	11.3
	15	5.62	10.8
	30	5.62	4.6
	60	4.27	3.8
	120	3.26	2.6
Medium Turbidity	0	49.5	82.7
	15	41.9	56
	30	27.7	45.7
	60	28	36.9
	120	24.7	27.9
	0	48.8	125.9
	15	38.2	58.9
	30	32.8	47.8
	60	28.9	35.1
	120	20.5	27.8
High Turbidity	0	140	239.8
	15	98.1	108.5
	30	67.2	89.5
	60	69.5	71.8
	120	51.6	53.2
	0	135	236.6
	15	90.2	104.6
	30	68.2	92.8
	60	65.1	78
	120	53.6	53.5

The 95% confidence intervals were found by using a t-distribution. The number of samples used to develop the equations was 30, thus a t-distribution was appropriate. First the slope of the line was found in excel and the y-intercept was set to zero. This was appropriate because a value of zero turbidity should indicate zero suspended solids. The standard error was then calculated according to the Equation below.

Appendix II (Continued)

Upper Confidence Interval

$$y = x_i + t * SE * \sqrt{\frac{1}{n} + \frac{(x_i - x)^2}{(x_i - x)^2}}$$

Lower Confidence Interval

$$y = x_i - t * SE * \sqrt{\frac{1}{n} + \frac{(x_i - x)^2}{(x_i - x)^2}}$$

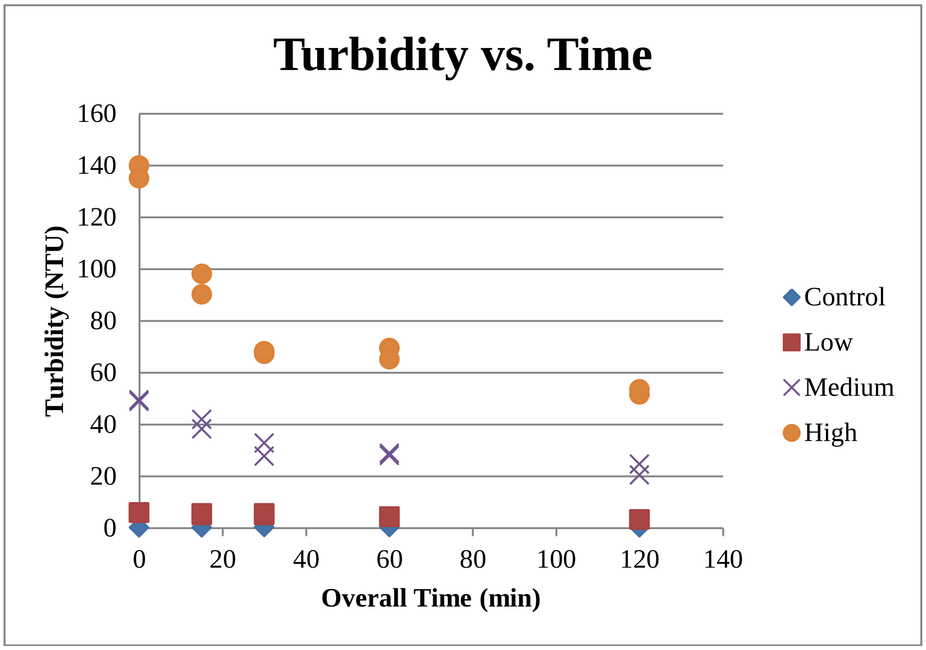
Table II.2 Statistical parameters for standard curve

Slope	1.4648
Intercept	0
Count	30
Standard Error	19.16896
Average x	40.92967
SSX	41880.82
t	2.04523

Table II.3 Regression line with 95% confidence intervals for standard curve

Regression			
x	CI	y+CI	y-CI
0	10.61675	10.61675	-10.6168
10	9.292095	23.94009	5.355905
20	8.204307	37.50031	21.09169
30	7.457767	51.40177	36.48623
40	7.160022	65.75202	51.43198
50	7.3657	80.6057	65.8743
60	8.03624	95.92424	79.85176
70	9.069111	111.6051	93.46689
80	10.35647	127.5405	106.8275
90	11.81541	143.6474	120.0166
100	13.38998	159.87	133.09

Appendix III. Turbidity vs. Time for Synthetic Water Samples



The figure above depicts measurements of turbidity vs. time for two sets of control, low turbidity water, medium turbidity water and high turbidity water. Low turbidity water is defined as 17 L of tap water with 0.5 g of silica sand, medium is 3.0 g of silica sand and high is 6.0 g of silica sand. The decision was made to allow the water to settle for 30 minutes before testing so that the turbidity would remain relatively constant over the course of the water filtering process.

Appendix IV. Raw Data
Table IV.I Turbidity and flow rate data.

Filter 1: Control Water - Data Entered															
								AVG	2.050109	0.478444	0.77				225
												# of Scrubs	0		
Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incremental Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
	0	1			#N/A	2	2	#N/A	0.1	0.45					2
1	0	1		1:13p/5-12	55	7	5	#N/A	#N/A	#N/A					7
	0	1			150	13	6	#N/A	0.98	0.36	Y	N	58.00		13
	0	1			#N/A	2	2	#N/A	0.34	0.52					15
2	0	1		11:20a/ 5-13	#N/A	7	5	7.2	#N/A	#N/A					20
	0	1			#N/A	12	5	#N/A	0.85	0.43	Y	N	58.03		25
	0	1			19	2	2	#N/A	0.48	0.34					27
3	0	1		3:17p/ 5/17	36	4	2	7.74	#N/A	#N/A					29
	0	1			93	12	8	#N/A	2.33	0.36	Y	Y	57.76		37
	1	1			15	2	2	#N/A	0.26	1.06					39
4	1	1		1:38p/5/18	25	4	2	8.46	#N/A	#N/A					41
	1	1			92	12	8	#N/A	1.36	0.19	Y	N	57.75		49
	0	1			14	2	2	#N/A	0.26	0.18					51
5	0	1		4p/5/19	30	4	2	7.68	#N/A	#N/A					53
	0	1			94	12	8	#N/A	3.37	0.53	Y	N	57.53		61

Appendix IV (Continued)
Table IV.1 (Continued)

6	1	1		1:02p/ 5/20	14	2	2	#N/A	0.31	0.26					63
	1	1			28	4	2	8.04	#N/A	#N/A					65
	1	1			90	12	8	#N/A	0.19	0.1	Y	Y	57.49		73
7	0	1		2:24p/ 5/24	13	2	2	#N/A	0.77	0.66					75
	0	1			28	4	2	7.32	#N/A	#N/A					77
	0	1			91	12	8	#N/A	0.3	0.53	Y	N	57.32		85
8	1	1		2:38p / 5/25	13	2	2	#N/A	0.28	0.7					87
	1	1			29	4	2	8.4	#N/A	#N/A					89
	1	1			86	12	8	#N/A	0.24	0.26	Y	N	57.30		97
9	0	1		2:40p/ 5/26	14	2	2	#N/A	0.29	0.19					99
	0	1			29	4	2	8.52	#N/A	#N/A					101
	0	1			89	12	8	#N/A	0.29	0.56	Y	Y	56.40		109
10	1	1		3:12p/ 5-27	14	2	2	#N/A	0.33	0.34					111
	1	1			26	4	2	141	#N/A	#N/A					113
	1	1			80	12	8	#N/A	0.92	0.14	Y	N	55.68		121
11	1	1		10:15am	13	2	2	10.87	0.11	0.14					123
	1	1			44	6	4	6.22	#N/A	#N/A					127
	1	1		10-Jun	60	8	2	6.34	0.17	0.09					129
	1	1			97	12	4	8.22	0.2	0.16	Y	N	56.32		133
12	1	1		2:45pm	12.5	2	2	4.39	0.4	0.08					135
	1	1			42	6	4	4.19	#N/A	#N/A					139
	1	1		13-Jun	57	8	2	5.46	0.28	0.14					141
	1	1			92	12	4	7.04	0.18	0.18	Y	N	#N/A		145
13	1	1		10:50am	15.5	2	2	4.94	0.2	0.25					147
	1	1			50.5	6	4	5.53	#N/A	#N/A					151
	1	1		14-Jun	70	8	2	5.44	0.24	0.16					153
	1	1			109	12	4	6.75	0.57	0.12	Y	N	57.14		157
14	1	1		11:00am	15	2	2	3.78	0.62	0.08					159
	1	1			48	6	4	4.65	#N/A	#N/A					163
	1	1		15-Jun	65	8	2	4.94	0.22	0.1					165
	1	1			105	12	4	5.4	0.33	0.11	Y	N	56.88		169

Appendix IV (Continued)
Table IV.1 (Continued)

15	1	1		12:00pm	14	2	2	4	0.22	0.16					171
	1	1			42	6	4	3.93	#N/A	#N/A					175
	1	1		16-Jun	57	8	2	4.75	0.17	0.08					177
	1	1			91	12	4	5.6	0.66	0.07	Y	N	55.82		181
16	1	1		9:45a	11	2	2	3.41	1.28	1.73					183
	1	1			38	6	4	4.15	#N/A	#N/A					187
	1	1		17-Jun	52	8	2	4.65	0.3	0.22					189
	1	1			81	12	4	5.06	0.23	0.14	Y	N	56.84		193
17	1	2		11:45AM	12.5	2	2	4.09	0.15	0.15					195
	1	2			43	6	4	4.59	#N/A	#N/A					199
	1	2		20-Jun	60	8	2	4.59	0.11	0.09					201
	1	2			#N/A	0	0	#N/A	#N/A	#N/A	y	n	55.82		201
18	1	1		11:45am	14	2	2	4.65	0.15	0.13					203
	1	1			46	6	4	5.13	#N/A	#N/A					207
	1	1		24-Jun	74	8	2	5.06	0.17	0.18					209
	1	1			110	12	4	6.07	0.2	0.2	y	n	55.74		213
19	1	1		1:45pm	12	2	2	3.86	0.16	0.23					215
	1	1			41	6	4	4.41	#N/A	#N/A					219
	1	1		24-Jun	52.5	8	2	4.54	0.42	0.08					221
	1	1			85	12	4	6.13	0.14	0.01					225
				Filter 1.1: Low Turbidity Water - Data Entered											
								AVG	5.165143	0.98975	0.81				1014.05
												# of Scrubs	12		

Appendix IV (Continued)
Table IV.1 (Continued)

Bucket	TSS (Y/N)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incremental Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/ N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
1		1		3:15	17.5	2	2	4.59	0.12	0.81					2
		1			38	6	4	4.41	#N/A	#N/A					6
		1		27-Jun	63	8	2	4.6	0.13	0.46					8
		1			96	12	4	6.37	0.16	0.36	Y	0	58.18		12
2		2		#N/A	14	2	2	4.97	14.2	1.08					14
		2			60	6	4	8.32	#N/A	#N/A					18
		2		28-Jun	97.5	8	2	13.09	12.1	1.16					20
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	57.90		20
3		1		10:00	20	2	2	6.97	1.46	1.77					22
		1			65	6	4	6.69	#N/A	#N/A					26
		1		30-Jun	91	8	2	7.44	0.21	0.29					28
		1			150	13	5	6.12	1.18	0.24	Y	0	57.68		33
4		1		#N/A	18	2	2	6.22	1.45	0.59					35
		1			58.5	6	4	6.28	#N/A	#N/A					39
		1		30-Jun	81	8	2	7.12	1.05	0.29					41
		1			136	12	4	7.12	1.09	0.61	Y	0	56.72		45
5		1		4:00pm	17	2	2	5.11	2.11	0.23					47
		1			52	6	4	5.57	#N/A	#N/A					51
		1		30-Jun	91	8	2	6.14	1.75	0.31					53
		1			113	12	4	5.44	1.65	0.29	Y	0	57.64		57
6		1		10;20am	18	2	2	5.46	0.24	0.19					59
		1			56	6	4	5.82	#N/A	#N/A					63
		1		1-Jul	74	8	2	6.19	0.18	0.18					65
		1			116.5	12	4	6.12	0.17	0.19	Y	0	56.94		69

Appendix IV (Continued)
Table IV.1 (Continued)

7		1		2:15	20.5	2	2	5.59	0.45	0.16					71
		1			59	6	4	6.31	#N/A	#N/A					75
		1		1-Jul	72	8	2	6.44	0.23	0.67					77
		1			124	12	4	5.29	0.26	0.16	Y	0	57.56		81
8		1		11am	23.5	2	2	7.69	0.35	0.2					83
		1			74	6	4	5.81	#N/A	#N/A					87
		1		5-Jul	95	8	2	5.97	0.3	0.18					89
		1			137	12	4	6.07	0.31	0.27	Y	0	57.10		93
9		1		5:00	21	2	2	6.16	0.35	0.21					95
		1			64	6	4	6.94	#N/A	#N/A					99
		1		7-Jul	88	8	2	7.44	0.25	0.11					101
		1			153	12	4	4.75	0.41	0.15	Y	0	56.80		105
10		1		11:30	21	2	2	1.97	0.18	0.15					107
		1			59	6	4	6.41	#N/A	#N/A					111
		1		8-Jul	84	8	2	6.4	0.23	0.12					113
		1			121	12	4	4.66	0.57	0.41	Y	0	58.08		117
11		1		12:00	16	2	2	14.4	0.86	0.51					119
		1			#N/A	6	4	4.56	#N/A	#N/A					123
		1		9-Jul	65	8	2	4.69	0.48	0.05					125
		1			92	12	4	5.16	0.57	0.09	Y	2	57.98		129
12		1		1:00	18	2	2	6.38	0.5	0.28					131
		1			56	6	4	4.34	#N/A	#N/A					135
		1		13-Jul	83	8	2	4.41	1.05	0.28					137
		1			121	12	4	4.93	0.61	0.21	Y	4	57.82		141
13		1		3:00	14	2	2	4.72	2.86	..24					143
		1			37	6	4	7.92	#N/A	#N/A					147
		1		13-Jul	60.5	8	2	5.12	2.77	0.28					149
		1			#N/A	14	6	#N/A	1.54	0.76	Y	0	57.62		155
14		1		9:00	17	2	2	5.37	0.31	0.09					157
		1			65	6.5	4.5	12.38	#N/A	#N/A					161.5
		1		15-Jul	102	8	1.5	18.69	0.22	0.19					163
		1			163	12	4	6.22	0.29	0.09	Y	0	57.44		167

Appendix IV (Continued)
Table IV.1 (Continued)

15		1		1:30	18	2	2	5.25	0.32	0.11					169
		1			57	6.5	4.5	8.5	#N/A	#N/A					173.5
		1		15-Jul	78	8	1.5	6.09	0.28	0.11					175
		1			118.5	12	4	6.63	0.26	0.09	Y	0	57.54		179
16		1		4:15	17	2	2	5.21	0.52	0.013					181
		1			55	6	4	5.93	#N/A	#N/A					185
		1		15-Jul	77.5	8	2	6.16	0.46	0.07					187
		1			123	12	4	7.4	0.22	0.2	Y	4	57.48		191
17		1		1:45	26	2.5	2.5	6.72	1.04	0.12					193.5
		1			78	6.75	4.25	7.37	#N/A	#N/A					197.75
		1		16-Jul	104	9	2.25	8.44	0.81	0.19					200
		1			168	12	3	14.66	0.33	0.29	Y	0	56		203
18		1		9:15	13	2	2	15.18	0.73	0.18					205
		1			46	7	5	5.46	#N/A	#N/A					210
		1		18-Jul	54	8	1	3.85	0.68	0.13					211
		1			92	12	4	5.38	0.54	0.12	Y	0	57.4		215
19		1		11:45 AM	16	2	2	3.98	0.53	0.2					217
		1			42	6	4	4.72	#N/A	#N/A					221
		1		18-Jul	58	8	2	5.16	1.33	0.07					223
		1			95	12	4	6.37	0.5	0.25	Y	2	57.32		227
20		1		11:30	13.5	2	2	4.57	1.19	0.18					229
		1			46	6	4	5.12	#N/A	#N/A					233
		1		18-Jul	#N/A	8	2	#N/A	#N/A	#N/A					235
		1			100	12	4	20.19	0.61	0.16	Y	0	57.28		239
21		1		3:20	13	2	2	3.94	0.61	0.23					241
		1			#N/A	7	5	4.97	#N/A	#N/A					246
		1		18-Jul	65	9.5	2.5	4.59	1.63	0.25					248.5
		1			88	12	2.5	5.16	0.49	0.14	Y	0	57.34		251
22		1		5:00	18	2	2	5.66	0.77	0.12					253
		1			59	6	4	6.88	#N/A	#N/A					257
		1		18-Jul	85	8	2	8.25	0.26	0.24					259
		1			141.5	12	4	5.31	0.52	0.26	Y	0	57.08		263

Appendix IV (Continued)
Table IV.1 (Continued)

23		1		11:30	17	2	2	4.97	0.91	0.07					265
		1			47	6	4	5.13	#N/A	#N/A					269
		1		19-Jul	70	8	2	6.81	0.54	0.16					271
		1			115	12	4	5.53	0.52	0.46	Y	0	57.34		275
24		1		1:45	22	2	2	5.4	1.59	0.42					277
		1			#N/A	6	4	#N/A	#N/A	#N/A					281
		1		19-Jul	82	8	2	6.81	0.5	0.34					283
		1			128	12	4	10.44	0.48	0.1	Y	0	57.35		287
25		1		11:10	20	2	2	6.35	0.22	0.17					289
		1			66	6	4	4.22	#N/A	#N/A					293
		1		20-Jul	81	8	2	4.87	0.83	0.16					295
		1			114	12.5	4.5	5.47	0.15	0.08	Y	0	56.65		299.5
26		1		1:15	32	3	3	7.71	0.43	0.05					302.5
		1			75	6	3	12.59	#N/A	#N/A					305.5
		1		20-Jul	#N/A	8	2	#N/A	#N/A	#N/A					307.5
		1			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	57.08		311.5
27		1		8:30	0	0	0	4.41	0.45	0.23					311.5
		1			#N/A	#N/A	0	#N/A	#N/A	#N/A					311.5
		1		22-Jul	60	#N/A	0	#N/A	#N/A	#N/A					311.5
		1			120	10.5	10.5	5.32	0.32	0.65	Y	0	57.28		322
28		1		10;55	0	0	0	4.06	0.46	0.69					322
		1			60	#N/A	0	4.97	0.29	0.07					322
		1		22-Jul	120	14	14	15.22	0.39	0.3	Y	0	57.36		336
29		1		1:00	0	0	0	3.81	0.46	0.25					336
		1			60	#N/A	0	#N/A	#N/A	#N/A					336
		1		22-Jul	120	14.6	14.6	13	0.28	4.99	Y	0	57.24		350.6
30		1		4:08	0	0	0	4.06	0.44	0.3					350.6
		1			60	#N/A	0	#N/A	#N/A	#N/A					350.6
		1		22-Jul	120	14	14	13	0.48	0.45	Y	0	57.26		364.6
31		1		9:00	0	0	0	4.4	0.32	0.15					364.6
		1			60	#N/A	0	#N/A	#N/A	#N/A					364.6
		1		25-Jul	120	9.5	9.5	8.91	0.42	0.13	Y	0	56.56		374.1

Appendix IV (Continued)
Table IV.1 (Continued)

32		1		11:15	0	0	0	3.68	0.42	0.39					374.1
		1			60	#N/A	0	#N/A	#N/A	#N/A					374.1
		1		25-Jul	120	14.2	14.2	5.18	0.61	0.09	Y	0	57.12		388.3
33		1		1:25	0	0	0	6.4	0.46	0.38					388.3
		1			60	#N/A	0	#N/A	#N/A	#N/A					388.3
		1		25-Jul	120	8.5	8.5	15.56	#N/A	#N/A	Y	0	57		396.8
S34		1		3:30	0	0	0	#N/A	1.24	0.93					396.8
		1			60	#N/A	0	#N/A	#N/A	#N/A					396.8
		1		25-Jul	120	14	14	#N/A	0.43	0.22	Y	0	57.3		410.8
35		1		5:50	0	0	0	6.06	0.61	0.32					410.8
		1			60	7	7		0.62	0.26					417.8
		1		25-Jul	120	9	9		0.44	3.64	Y	0	57.22		426.8
36		1			0	0	0	3.43	1.14	0.31					426.8
		1			60		0	#N/A	#N/A	#N/A					426.8
		1		26-Jul	120	14.6	14.6	9.97	0.56	0.16	Y	0	57.45		441.4
37		1			0	0	0	3.69	0.52	0.56					441.4
		1			60		0	#N/A	#N/A	#N/A					441.4
		1		26-Jul	120	14	14	35.53	0.55	0.07	Y	0	57.24		455.4
38		1		11:15	0	0	0	4.47	0.36	0.17					455.4
		1			60		0	#N/A	#N/A	#N/A					455.4
		1		27-Jul	120	6.5	6.5		0.41	0.09	Y	0			461.9
39		1		11:30	0	0	0	3.59	0.75	0.6					461.9
		1			60	#N/A	0	#N/A	#N/A	#N/A					461.9
		1		27-Jul	120	15	15	#N/A	0.51	0.12	Y	0	57.72		476.9
40		1		1:30	0	0	0	4.06	0.81	0.33					476.9
		1			60	#N/A	0	#N/A	#N/A	#N/A					476.9
		1		27-Jul	120	14	14	10.81	1.04	0.19	Y	0	57.52		490.9
41		1			0	0	0	3.53	0.83	0.23					490.9
		1			60	#N/A	0	#N/A	#N/A	#N/A					490.9
		1		27-Jul	120	14	14	#N/A	0.83	0.11	Y	0	57.42		504.9

Appendix IV (Continued)
Table IV.1 (Continued)

42		1		12:00	0	0	0	4.69	0.58	0.17					504.9
		1			60	#N/A	0	#N/A	#N/A	#N/A					504.9
		1		22-Jul	120	14.5	14.5	12.94	0.55	0.11	Y	0	57.59		519.4
43		1		10:25	0	0	0	5.22	0.84	0.19					519.4
		1			60	#N/A	0	#N/A	#N/A	#N/A					519.4
		1		29-Jul	120	12	12	7.34	0.84	0.2	Y	0			531.4
44		1		12:50pm	0	0	0	13.6	1.17	0.12					531.4
		1			60	#N/A	0	#N/A	#N/A	#N/A					531.4
		1		29-Jul	120	14.3	14.3	14.41	1.43	0.24	Y	0	57.45		545.7
45		1		3:00	0	0	0	6	1.18	0.21					545.7
		1			60	#N/A	0	#N/A	#N/A	#N/A					545.7
		1		29-Jul	120	9	9	9.65	0.66	0.13	Y	0	57.06		554.7
46		1		10:15	0	0	0	5.17	3.53	0.06					554.7
		1			60	#N/A	0	#N/A	#N/A	#N/A					554.7
		1		11-Aug	120	11.9	11.9	5.47	1.96	0.09	Y	0	57.02		566.6
47		1		12:25	0	0	0	4.47	2.44	0.15					566.6
		1			60	#N/A	0	#N/A	#N/A	#N/A					566.6
		1		1-Aug	120	12	12	8.41	1.98	0.18	Y	0	57.01		578.6
48		1		2:30	0	0	0	5.7	1.81	0.35					578.6
		1			60	#N/A	0	#N/A	#N/A	#N/A					578.6
		1		1-Aug	120	9	9	10.18	1.43	0.33	Y	0	57.12		587.6
49		1		9:30	0	0	0	4.16	1.2	0.18					587.6
		1			60	#N/A	0	#N/A	#N/A	#N/A					587.6
		1		2-Aug	120	14	14	20.24	1.16	0.36	Y	0	57.14		601.6
50		1		12:00	0	0	0	6.8	1.19	0.19					601.6
		1			60	#N/A	0	#N/A	#N/A	#N/A					601.6
		1		2-Aug	120	8.5	8.5	8.07	0.98	0.25	Y	0	58.52		610.1
51		1		12:00	0	0	0	6.32	0.75	0.7					610.1
		1			60	#N/A	0	#N/A	#N/A	#N/A					610.1
		1		8-Aug	120	11	11	8.47	0.54	0.22	Y	0	57.26		621.1

Appendix IV (Continued)
Table IV.1 (Continued)

52		1		3:00	0	0	0	5.94	0.54	0.45					621.1
		1			60	#N/A	0	#N/A	#N/A	#N/A					621.1
		1		8-Aug	120	10.25	10.25	10.28	0.93	0.13	Y	0	57.13		631.35
53		1			0	0	0	3.75	0.27	0.13					631.35
		1			60	#N/A	0	#N/A	#N/A	#N/A					631.35
		1		11-Aug	120	15	15	4.75	0.22	0.13	Y	0	#N/A		646.35
54		1			0	0	0	4.47	0.65	0.15					646.35
		1			60	#N/A	0	#N/A	#N/A	#N/A					646.35
		1		11-Aug	120	15	15	27.69	0.39	0.19	Y	0	#N/A		661.35
55		1			0	0	0	3.69	0.31	0.38					661.35
		1			60	#N/A	0	#N/A	#N/A	#N/A					661.35
		1		7-Sep	120	15	15	12.15	0.2	0.15	Y	0	#N/A		676.35
56		1			0	0	0	3.78	0.39	0.1					646.35
		1			60	#N/A	0	#N/A	#N/A	#N/A					646.35
		1		8-Sep	120	15	15	32.65	0.44	0.22	Y	0	#N/A		661.35
57		1		2:45	0	0	0	3.97	0.29	0.54					661.35
		1			60	#N/A	0	#N/A	#N/A	#N/A					661.35
		1		9-Sep	120	14.7	14.7	18	0.29	0.09	Y	0	#N/A		676.05
58		1		5:30	0	0	0	5.62	0.41	0.18					676.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					676.05
		1		9-Sep	120	15.25	15.25	#N/A	0.29	0.22	Y	0	#N/A		691.3
59		1		12:00	0	0	0	3.4	0.54	0.64					691.3
		1			60	#N/A	0	#N/A	#N/A	#N/A					691.3
		1		10-Sep	120	15	15	23.09	0.44	0.23	Y	0	#N/A		706.3
60		1		2:30	0	0	0	4.4	0.38	0.32					706.3
		1			60	#N/A	0	#N/A	#N/A	#N/A					706.3
		1		10-Sep	120	14.25	14.25	17.17	0.39	0.24	Y	0	#N/A		720.55
61		1		5:00	0	0	0	3.93	1.94	0.19					720.55
		1			60	#N/A	0	#N/A	#N/A	#N/A					720.55
		1		10-Sep	120	15	15	15.78	1.96	0.14	Y	0	#N/A		735.55

Appendix IV (Continued)
Table IV.1 (Continued)

62		1		7:30	0	0	0	3.53	1.89	0.23					735.55
		1			60	#N/A	0	#N/A	#N/A	#N/A					735.55
		1		10-Sep	120	15.25	15.25	18.69	0.89	0.15	Y	0	#N/A		750.8
63		1		12:45	0	0	0	3.57	0.2	0.22					750.8
		1			60	#N/A	0	#N/A	#N/A	#N/A					750.8
		1		11-Sep	120	15.25	15.25	15.71	0.85	0.09	Y	0	#N/A		766.05
64		1		10:00	0	0	0	3.54	0.39	0.18					766.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					766.05
		1		11-Sep	120	16	16	#N/A	0.48	0.16	Y	0	#N/A		782.05
65		1		2:00	0	0	0	3.68	0.66	0.1					782.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					782.05
		1		11-Sep	120	15	15	40	0.15	0.22	Y	0	#N/A		797.05
66		1		2:00	0	0	0	3.75	0.27	0.13					797.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					797.05
		1		12-Sep	120	15	15	4.72	0.22	0.13	Y	0	#N/A		812.05
67		1		11:00	0	0	0	4.47	0.65	0.15					812.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					812.05
		1		12-Sep	120	15	15	27.69	0.39	0.19	Y	0	#N/A		827.05
68		1		3:00	0	0	0	3.69	0.31	0.38					827.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					827.05
		1		12-Sep	120	15	15	12.15	0.2	0.15	Y	0	#N/A		842.05
69		1		5:30	0	0	0	3.78	0.39	0.1					842.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					842.05
		1		12-Sep	120	15	15	32.65	0.44	0.22	Y	0	#N/A		857.05
70		1		3:00	0	0	0	4.13	0.33	0.09					857.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					857.05
		1		13-Sep	120	15	15	16.78	0.33	0.1	Y	0	#N/A		872.05
71		1		5:30	0	0	0	6.12	0.4	0.19					872.05
		1			60	#N/A	0	#N/A	#N/A	#N/A					872.05
		1		13-Sep	120	15	15	6.57	0.37	0.16	Y	0	#N/A		887.05

Appendix IV (Continued)
Table IV.1 (Continued)

		1		10:00	0	0	0	3.53	0.3	0.12					887.05
72		1			60	#N/A	0	#N/A	#N/A	#N/A					887.05
		1		14-Sep	120	16	16	5.37	0.17	0.65	Y	0	#N/A		903.05
		1		3:00	0	0	0	3.28	0.55	0.14					903.05
73		1			60	#N/A	0	#N/A	#N/A	#N/A					903.05
		1		15-Sep	120	16	16	19.94	0.24	0.16	Y	0	#N/A		919.05
		1		1:30	0	0	0	5.16	0.3	0.09					919.05
74		1			60	#N/A	0	#N/A	#N/A	#N/A					919.05
		1		16-Sep	120	15	15	40	0.25	0.3	Y	0	#N/A		934.05
		1		4:30	0	0	0	3.75	0.38	0.21					934.05
75		1			60	#N/A	0	#N/A	#N/A	#N/A					934.05
		1		16-Sep	120	16	16	#N/A	0.34	0.26	Y	0	#N/A		950.05
		1		3:00	0	0	0	3.5	0.44	0.22					950.05
76		1			60	#N/A	0	#N/A	#N/A	#N/A					950.05
		1		17-Sep	120	14	14	15.16	0.16	0.17	Y	0	#N/A		964.05
		1		12:00	0	0	0	3.25	0.53	0.22					964.05
77		1			60	#N/A	0	#N/A	#N/A	#N/A					964.05
		1		20-Sep	120	14	14	21	1.11	0.21	Y	0	#N/A		978.05
		1		10:00	0	0	0	3.62	0.18	0.25					978.05
78		1			60	#N/A	0	#N/A	#N/A	#N/A					978.05
		1		21-Sep	120	16	16	#N/A	#N/A	#N/A	Y	0	#N/A		994.05
		1		3:00	0	0	0	3.88	0.24	0.13					994.05
79		1			60	#N/A	0	#N/A	#N/A	#N/A					994.05
		1		21-Sep	120	16	16	#N/A	0.29	0.12	Y	0	#N/A		1010.05
		2		5:00	0	0	0	5.69	4.78	0.3					1010.05
80		2			60	#N/A	0	#N/A	7.54	0.54					1010.05
		2		25-Sep	120	4	4	49	5.3	0.25	Y	0	#N/A		1014.05
				Filter 2: Low Turbidity Water - Data Entered											
								AVG	11.12032	1.031689	0.91				1023.3

Appendix IV (Continued)
Table IV.1 (Continued)

												# of Scrubs	7		
Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incrementa Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
		1			#N/A	2	2	#N/A	9.87	1.23					2
1		1		1:10	#N/A	7	5	#N/A	#N/A	#N/A					7
		1			#N/A	13	6	#N/A	3.12	0.37	Y	0	#N/A		13
		1			#N/A	2	2	#N/A	5.81	0.59					15
2		1		#N/A	#N/A	7	5	6	#N/A	#N/A					20
		1			#N/A	12	5	#N/A	3.94	1.48	Y	0	#N/A		25
		1			19	2	2	#N/A	4.69	2.8					27
3		1		3:17p/5-17	36	4	2	6.42	#N/A	#N/A					29
		1			123	12	8	#N/A	3.22	0.31	Y	1	58.41		37
		1			24	2	2	#N/A	5.49	1.2					39
4		1		1:38p/5-18	38	4	2	6.12	#N/A	#N/A					41
		1			122	12	8	#N/A	4.88	0.83	Y	0	57.12		49
		1			17	2	2	#N/A	5.58	0.92					51
5		1		4:00p/5-19	37	4	2	6.06	#N/A	#N/A					53
		1			120	12	8	#N/A	3.8	0.24	Y	0	58.37		61
		1			22	2	2	#N/A	5.11	0.43					63
6		1		1:02p	38	4	2	6.36	#N/A	#N/A					65
		1			122	12	8	#N/A	3.44	0.24	Y	1	57.93		73
		2			15	2	2	#N/A	4.48	1.77					75
7		2		2:28p	37	4	2	6.66	#N/A	#N/A					77
		2			121	12	8	#N/A	3.27	1.2	Y	0	58.22		85

Appendix IV (Continued)
Table IV.1 (Continued)

8		1		2:38p	17	2	2	#N/A	5.08	0.38					87
		1			35	4	2	6.48	#N/A	#N/A					89
		1			113	12	8	#N/A	3.74	0.17	Y	0	58.01		97
9		1		2:40p	17	2	2	#N/A	5.52	1.8					99
		1			35	4	2	6.3	#N/A	#N/A					101
		1			112	12	8	#N/A	3.12	0.25	Y	1	57.62		109
10		1		3:12p	15	2	2	#N/A	5.09	1.06					111
		1			35	4	2	6.72	#N/A	#N/A					113
		1			110	12	8	#N/A	4.36	0.41	Y	0	57.07		121
11		1		10:15am	12.5	2	2	5.4	4.84	0.38					123
		1			45.5	6	4	6.53	#N/A	#N/A					127
		1		10-Jun	65	8	2	7.15	3.6	0.38					129
		1			100	11	3	#N/A	2.98	0.36	Y	0	57.06		132
12		1		2:45pm	16	2	2	5.5	6.07	1.71					134
		1			51	6	4	5.31	#N/A	#N/A					138
		1		13-Jun	69	8	2	5.56	3.56	0.88					140
		1			112	12	4	10.81	18	0.99	Y	0	#N/A		144
13		1		10:50am	16	2	2	5.31	5.65	0.66					146
		1			62	6	4	6.1	#N/A	#N/A					150
		1		14-Jun	80	8	2	6.97	4.09	0.69					152
		1			#N/A	10.25	2.25	#N/A	#N/A	#N/A	Y	0	57.26		154.25
14		1		11:00am	17	2	2	5.19	3.44	0.42					156.25
		1			59	6	4	6.07	#N/A	#N/A					160.25
		1		15-Jun	76	8	2	5.47	3.75	0.65					162.25
		1			124	12	4	#N/A	3.52	0.11	Y	0	57.02		166.25
15		1		12:00pm	16	2	2	4.72	3.67	0.89					168.25
		1			45	6	4	5.6	#N/A	#N/A					172.25
		1		16-Jun	78	8	2	3.84	3.04	0.41					174.25
		1			120	11.5	3.5	7.12	2.97	0.06	Y	0	57.22		177.75

Appendix IV (Continued)
Table IV.1 (Continued)

16		1		9:45a	19	2	2	5.56	5.78	2.17					179.75
		1			58	6	4	5.88	#N/A	#N/A					183.75
		1		17-Jun	78	8	2	6.31	3.86	0.82					185.75
		1			132	12	4	12	3.02	0.51	Y	1	56.98		189.75
17		2		11:45AM	18.5	2	2	6.59	10.5	1.29					191.75
		2			125	6	4	54.25	#N/A	#N/A					195.75
		2		20-Jun	280	8	2	#N/A	8.21	1.04					197.75
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	1	56.92		197.75
18		2		10:00am	14	2	2	8.06	9.81	4.54					199.75
		2			165	6	4	50.53	#N/A	#N/A					203.75
		2		21-Jun	255	8	2	#N/A	17.4	1.01					205.75
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	57.38		205.75
19		1		12:20	22	2	2	11.7	4.67	0.84					207.75
		1			70	6	4	7.22	#N/A	#N/A					211.75
		1		24-Jun	97	8	2	4.69	3.24	0.94					213.75
		1			162	12	4	12	2.61	1.7	y	0	57.04		217.75
20		1		3:00pm	17.5	2	2	5.62	4.27	1.13					219.75
		1			48	6	4	6.19	#N/A	#N/A					223.75
		1		27-Jun	77	8	2	7.47	3.52	0.91					225.75
		1			122	12	4	5.44	#N/A	#N/A	y	0	57.02		229.75
21		1		11:00am	18.5	2	2	5.44	4.3	0.81					231.75
		1			56	6	4	5.97	#N/A	#N/A					235.75
		1		27-Jun	75	8	2	6.12	3.4	0.68					237.75
		1			130	12	4	18	2.92	0.76	y	0	57.60		241.75
22		1		10:30am	18	2	2	5.53	5.67	0.91					243.75
		1			55	6	4	5.9	#N/A	#N/A					247.75
		1		30-Jun	72	8	2	7	3.89	0.45					249.75
		1			120	12	4	8.87	8.1	1	y	0	57.62		253.75
23		1		4:00pm	16	2	2	5.16	5.91	0.49					255.75
		1			53	6	4	6.17	#N/A	#N/A					259.75
		1		30-Jun	74	8	2	6.39	3.69	0.51					261.75
		1			120	12	4	9.86	3.16	0.61	y	0	57.58		265.75

Appendix IV (Continued)
Table IV.1 (Continued)

24		1		10:30am	16	2	2	4.96	5.01	0.83					267.75
		1			53	6	4	5.6	#N/A	#N/A					271.75
		1		1-Jul	73	8	2	6.13	3.89	0.7					273.75
		1			136	12	4	>13	2.59	0.37	y	0	57.48		277.75
25	1	1		2:45pm	15	2	2	4.78	4.32	0.64					279.75
	1	1			49	6	4	5.22	#N/A	#N/A					283.75
	1	1		1-Jul	67	8	2	5.5	3.48	0.48					285.75
	1	1			#N/A	11.5	3.5	>13	2.74	0.5	y	0	57.5		289.25
26	0	1		11:00am	14.5	2	2	5.25	5.18	0.87					291.25
	0	1			49	6	4	5.66	#N/A	#N/A					295.25
	0	1		5-Jul	68	8	2	>13	4.89	0.71					297.25
	0	1			126.5	12	4	14.12	3.23	0.29	y	0	57.42		301.25
27	1	2		2:00pm	30	2	2	14.12	12.2	0.8					303.25
	1	2			345	6.5	4.5	#N/A	#N/A	#N/A					307.75
	1	2		7-Jul	#N/A	#N/A	0	#N/A	#N/A	#N/A					307.75
	1	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	y	0	57.6		307.75
28	0	1		#N/A	25	2	2	8.19	5.87	0.96					309.75
	0	1			84	6	4	9.32	#N/A	#N/A					313.75
	0	1		#N/A	123	8	2	11.56	9.39	1.65					315.75
	0	1			237	12	4	31.13	4.5	0.35	y	0	57.36		319.75
29	0	1		2:00 PM	18	2	2	5.93	4.34	1					321.75
	0	1			63	6	4	6.69	#N/A	#N/A					325.75
	0	1		13-Jul	82	8	2	7.22	3.64	0.53					327.75
	0	1			148	12	4	>13	2.75	0.96	y	0	56.92		331.75
30	1	2		10:00	23	2	2	13.79	9.82	2.08					333.75
	1	2			145	6	4	56.42	#N/A	#N/A					337.75
	1	2		14-Jul	#N/A	8	2	142	16.02	1.15					339.75
	1	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	y	0	57.2		339.75
31	1	1		9:00	21	2	2	6.82	5.3	1.05					341.75
	1	1			85	6	4	6.78	#N/A	#N/A					345.75
	1	1		15-Jul	115	8	2	7.13	4.37	1.2					347.75
	1	1			205	12	4	>13	2.54	0.77	###	0	#N/A		351.75

Appendix IV (Continued)
Table IV.1 (Continued)

32	0	1		1:30	13	2	2	5.09	4.11	1.32					353.75
	0	1			57	7	5	5.44	#N/A	#N/A					358.75
	0	1		15-Jul	75	8	1	6.75	5.07	2.26					359.75
	0	1			126	12	4	#N/A	2.99	1.02	Y	0	57.26		363.75
33	0	1		2:00	17	2	2	5.06	4.59	1.09					365.75
	0	1			54	6	4	5.72	#N/A	#N/A					369.75
	0	1		16-Jul	87	9	3	7.15	3.84	1.36					372.75
	0	1			123	12	3	56	6.09	0.91	Y	0	57.34		375.75
34	0	1		9:30	16	2	2	5.29	4.88	0.97					377.75
	0	1			62	6.5	4.5	5.62	#N/A	#N/A					382.25
	0	1		18-Jul	81	8	1.5	6.37	3.98	0.92					383.75
	0	1			134	12	4	17.44	3.44	0.29	Y	0	57.02		387.75
35	0	1		12:50	14	2	2	7	5.08	1.16					389.75
	0	1			47	6	4	5.44	#N/A	#N/A					393.75
	0	1		18-Jul	68	8	2	7.78	3.82	0.71					395.75
	0	1			108	12	4	8.09	3.82	0.76	Y	0	57.4		399.75
36	1	1		12:50	15	2	2	6.19	4.61	1.11					401.75
	1	1			55	6	4	6.47	#N/A	#N/A					405.75
	1	1		18-Jul	76	8	2	5.71	3.52	0.57					407.75
	1	1			22	12	4	#N/A	2.82	2.45	Y	0	57.04		411.75
37	0	1		5:45	15	2	2	5.25	4.57	1.34					413.75
	0	1			52.5	6	4	5.96	#N/A	#N/A					417.75
	0	1		18-Jul	72	8	2	6.19	3.38	0.83					419.75
	0	1			117	12	4	18.75	3.27	0.69	Y	0	57.36		423.75

Appendix IV (Continued)
Table IV.1 (Continued)

38	0	1		1:45	18	3	3	5.31	4.63	0.96					426.75
	0	1			43	6	3	5.4	#N/A	#N/A					429.75
	0	1		19-Jul	62	8	2	5.03	5.16	0.82					431.75
	0	1			111	12	4	10.53	4.49	0.6	Y	2	57.28		435.75
39	0	1		11:30	17	2	2	5	5.21	0.64					437.75
	0	1			56	6	4	9.41	#N/A	#N/A					441.75
	0	1		20-Jul	76	8	2	5.72	3.67	0.63					443.75
	0	1			121	12	4	18.88	2.64	0.4	Y	0	57.82		447.75
40	1	2		2:30	23	3	3	5.69	8.37	2.82					450.75
	1	2			88	7	4	20.78	#N/A	#N/A					454.75
	1	2		20-Jul	#N/A	7.75	0.75	#N/A	7.3	2.08					455.5
	1	2			#N/A	0	0	#N/A	#N/A	#N/A	Y	0	57.75		455.5
41	0	1		9:30	0	0	0	5.12	4.99	1.6					455.5
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					455.5
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					455.5
	0	1			120	11.75	11.75	16.5	3.47	0.6	Y	0	57.3		467.25
42	1	1		12:20	0	0	0	4.09	5.51	2.32					467.25
	1	1			#N/A	0	0	#N/A	#N/A	#N/A					467.25
	1	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					467.25
	1	1			120	12	12	#N/A	4.47	2.62	Y	0	56.78		479.25
43	0	1		3:30	0	0	0	4.47	5.95	1.78					479.25
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					479.25
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					479.25
	0	1			120	11.5	11.5	#N/A	3.4	3.4	Y	0	57.28		490.75
44	0	1		9:30	0	0	0	4.5	4.72	0.97					490.75
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					490.75
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					490.75
	0	1			120	11.8	11.8	23.81	2.96	0.82	Y	0	57.48		502.55
45	0	1		12:45	0	0	0	4.38	4.8	0.15					502.55
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					502.55
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					502.55
	0	1			120	11.2	11.2	#N/A	2.88	2.57	Y	0	57.62		513.75

Appendix IV (Continued)
Table IV.1 (Continued)

46	0	1		3:35	0	0	0	4.28	6.07	2.99					513.75
	0	1			60	0	0	#N/A	#N/A	#N/A					513.75
	0	1		25-Jul	120	11.75	11.75	#N/A	3.23	2.67	Y	0	57.6		525.5
47	1	1		10:20	0	0	0	5.5	4.48	3.92					525.5
	1	1			60	0	0	#N/A	2.76	0.93					525.5
	1	1		26-Jul	120	10.75	10.75	9.62	3.56	0.56	Y	0	56.74		536.25
48	0	1			0	0	0	4.12	6.22	6.88					536.25
	0	1			60	0	0	#N/A	#N/A	#N/A					536.25
	0	1		27-Jul	120	12	12	#N/A	3.15	12.5	Y	0	56.92		548.25
49	0	1		4:009	0	0	0	3.5	6.11	8.16					548.25
	0	1			60	0	0	#N/A	#N/A	#N/A					548.25
	0	1		27-Jul	135	12	12	#N/A	3.17	3.99	Y	0	57.32		560.25
50	1	2		9:00	0	0	0	5.19	9.01	3.72					560.25
	1	2			60	4	4	24.4	7.68	1.8					564.25
	1	2		27-Jul	120	5	5	44.66	7.65	1.24	Y	0	56.88		569.25
51	0	1		12:10	0	0	0	4.34	5.6	2.68					569.25
	0	1			60	0	0	#N/A	#N/A	#N/A					569.25
	0	1		27-Jul	120	11.75	11.75	#N/A	3.56	3.61	Y	0	57.02		581
52	0	1		3:40	0	0	0	4.4	6.23	3.55					581
	0	1			60	0	0	#N/A	#N/A	#N/A					581
	0	1		27-Jul	120	12	12	62.22	4.17	1.33	Y	0	56.88		593
53	1	1		11:00	0	0	0	4.31	6.09	3.73					593
	1	1			20	0	0	#N/A	6.05	1.17					593
	1	1		28-Jul	120	12.5	12.5	84	4.91	1.08	Y	0	57.1		605.5
54	0	1		10:55	0	0	0	4.31	5.7	1.85					605.5
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					605.5
	0	1		29-Jul	120	11.8	11.8	12.28	3.98	0.54	Y	0	57.04		617.3
55	0	1		11.:50	0	0	0	9.36	7.24	6.3					617.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					617.3
	0	1		29-Jul	120	12	12	#N/A	3.45	1.8	Y	0	57.04		629.3
56	0	1		10:25	0	0	0	4.34	3.43	3.17					629.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					629.3
	0	1		1-Aug	120	12	12	#N/A	4.29	8.73	Y	0	57.52		641.3

Appendix IV (Continued)
Table IV.1 (Continued)

57	0	1		1:30	0	0	0	5	8.42	4.48					641.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					641.3
	0	1		1-Aug	120	4	4	60	5.27	2.66	Y	0	57.24		645.3
58	1	1		10:25	0	0	0	4.43	6.65	1.86					645.3
	1	1			60	#N/A	0	5.64	4.65	1.37					645.3
	1	1		2-Aug	120	10.75	10.75	23.67	3.82	1.1	Y	0	57.8		656.05
59	0	1		1:30	0	0	0	3.65	4.96	2.57					656.05
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					656.05
	0	1		2-Aug	120	10	10	26.72	3.74	2.92	Y	0	57.06		666.05
60	1	2		12:40	0	0	0	4.38	14	7.84					666.05
	1	2			60	#N/A	0	#N/A	8.9	3.67					666.05
	1	2		5-Aug	120	6	6	15.25	8.77	3.49	Y	0	57.33		672.05
61	0	1			0	0	0	4.84	6.68	4.34					672.05
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					672.05
	0	1		8-Aug	120	12	12	12.97	3.24	2.3	Y	0	57.32		684.05
62	0	1			0	0	0	4.38	5.44	3.54					684.05
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					684.05
	0	1		8-Aug	120	11.5	11.5	#N/A	3.21	1.33	Y	0	56.81		695.55
63	1	2			0	0	0	8	8.03	3.09					695.55
	1	2			60	#N/A	0	#N/A	8.85	1.65					695.55
	1	2		11-Aug	120	7	7	22.94	5.93	1.45	Y	0	56.88		702.55
64	0	1		2:00	0	0	0	5.1	3.05	1.78					702.55
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					702.55
	0	1		1-Sep	120	6	6	14.59	2.12	0.95	Y	0	56.72		708.55
65	1	1		6:00	0	0	0	#N/A	6.03	1.34					708.55
	1	1			60	#N/A	0	#N/A	4.38	1.7					708.55
	1	1		7-Sep	120	10	10	#N/A	3.66	7.94	Y	0	56.85		718.55
66	0	1		4:30	0	0	0	4.51	6.23	6.22					718.55
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					718.55
	0	1		8-Sep	120	13.25	13.25	28	3.07	0.4	Y	0	56.81		731.8
67	0	1		2:00	0	0	0	4.18	5.83	1.86					731.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					731.8
	0	1		9-Sep	120	12	12	13.97	3.16	0.92	Y	0	57.38		743.8

Appendix IV (Continued)
Table IV.1 (Continued)

68	0	1		5:00	0	0	0	5.14	4.32	6.77					743.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					743.8
	0	1		9-Sep	120	12	12	#N/A	3.22	0.7	Y	0	57.3		755.8
69	0	1		12:30	0	0	0	3.56	5.7	2.56					755.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					755.8
	0	1		10-Sep	120	12.5	12.5	#N/A	3.11	2.94	Y	0	57.18		768.3
70	1	1		3:00	0	0	0	4.06	5.54	2.86					768.3
	1	1			60	#N/A	0	#N/A	3.76	0.7					768.3
	1	1		10-Sep	120	12	12	#N/A	3.1	0.84	Y	0	56.94		780.3
71	0	1		5:30	0	0	0	3.96	4.39	10.5					780.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					780.3
	0	1		10-Sep	120	12.5	12.5	#N/A	2.96	15	Y	0	56.84		792.8
72	0	1		11:00	0	0	0	4.09	7.52	6.51					792.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					792.8
	0	1		11-Sep	120	13.5	13.5	#N/A	3.55	1.36	Y	0	57.54		806.3
73	1	2		2:00	0	0	0	16.97	14.3	5.02					806.3
	1	2			60	#N/A	0	#N/A	9.36	4.46					806.3
	1	2		11-Sep	120	6	6	40	9.47	3.46	Y	0	#N/A		812.3
74	0	1		11:00	0	0	0	5.32	5.93	11					812.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					812.3
	0	1		12-Sep	120	12.5	12.5	8.23	2.9	1.74	Y	0	#N/A		824.8
75	0	1		5:30	0	0	0	4.47	4.45	1.73					824.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					824.8
	0	1		12-Sep	120	13	13	9.69	3.73	1.19	Y	0	#N/A		837.8
76	1	1		3:00	0	0	0	4.41	5.69	2.86					837.8
	1	1			60	#N/A	0	#N/A	3.58	0.72					837.8
	1	1		13-Sep	120	12	12	14.97	3.84	1.75	Y	0	#N/A		849.8
77	0	1		5:30	0	0	0	4.57	6.05	10.1					849.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					849.8
	0	1		13-Sep	120	12	12	6.15	3.45	0.67	Y	0	#N/A		861.8
78	0	1		3:00	0	0	0	4.75	6.11	1.61					861.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					861.8
	0	1		13-Sep	120	13	13	#N/A	20.9	6.8	Y	0	#N/A		874.8

Appendix IV (Continued)
Table IV.1 (Continued)

79	0	1		5:30	0	0	0	4	5.07	2.59					874.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					874.8
	0	1		14-Sep	120	12	12	#N/A	6.25	2.98	Y	0	#N/A		886.8
80	0	1		10:00	0	0	0	4.88	5.14	1.49					886.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					886.8
	0	1		14-Sep	120	12	12	#N/A	3.69	0.9	Y	0	#N/A		898.8
81	1	1		3:00	0	0	0	4.71	4.8	5.59					898.8
	1	1			60	#N/A	0	#N/A	6.72	1.13					898.8
	1	1		14-Sep	120	11	11	12.15	3.16	8.57	Y	0	#N/A		909.8
82	0	1		3:00	0	0	0	4.91	6.47	2.3					909.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					909.8
	0	1		15-Sep	120	12	12	#N/A	3.59	1.63	Y	0	#N/A		921.8
83	1	2		1:30	0	0	0	4.49	10.7	4.49					921.8
	1	2			60	#N/A	0	#N/A	11.6	3.56					921.8
	1	2		16-Sep	120	7	7	18.37	7.94	15	Y	0	#N/A		928.8
84	0	1		4:30	0	0	0	5.65	4.76	7.16					928.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					928.8
	0	1		16-Sep	120	12	12	#N/A	3.5	1.84	Y	0	#N/A		940.8
85	0	1		10:00	0	0	0	4.97	5.04	8.21					940.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					940.8
	0	1		17-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		952.8
86	0	1		12:30	0	0	0	4.25	7.96	4.77					952.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					952.8
	0	1		17-Sep	120	11	11	#N/A	6.48	3.46	Y	0	#N/A		963.8
87	0	1		3:00	0	0	0	4.41	5.95	3.61					963.8
	0	1			60	#N/A	0	#N/A	4.07	0.96					963.8
	0	1		17-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		975.8
88	0	1		12:00	0	0	0	5.25	6.29	5.96					975.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					975.8
	0	1		20-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		987.8
89	0	1		10:00	0	0	0	5.02	5.81	1.79					987.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					987.8
	0	1		21-Sep	120	11.5	11.5	#N/A	3.53	3.39	Y	0	#N/A		999.3

Appendix IV (Continued)
Table IV.1 (Continued)

90	0	1		3:00	0	0	0	4.07	7.14	4.17					999.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					999.3
	0	1		21-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		1011.3
91	0	1		3:30	0	0	0	4.75	6.47	2.06					1011.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1011.3
	0	1		22-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		1023.3
Parameters				Filter 3: Low Turbidity Water - Data Entered											
								AVG	24.56954	1.845619	0.92				1111.55
												# of Scrubs	6		
Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incrementa Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
1		1		#N/A	#N/A	2	2	#N/A	9.95	2.12					2
		1			#N/A	7	5	#N/A	#N/A	#N/A					7
		1			#N/A	13	6	#N/A	3.49	2.77	Y	0	#N/A		13
2		1		#N/A	#N/A	2	2	#N/A	6.33	0.98					15
		1			#N/A	7	5	6.6	#N/A	#N/A					20
		1			#N/A	12	5	#N/A	22.8	1.76	Y	0	#N/A		25
3		1		3:17p/5-17	19	2	2	#N/A	6	0.27					27
		1			36	4	2	7.32	#N/A	#N/A					29
		1			105	12	8	#N/A	4.43	0.26	Y	1	57.81		37

Appendix IV (Continued)
Table IV.1 (Continued)

4		1		1:38p/5-18	15	2	2	#N/A	5.99	0.29					39
		1			25	4	2	7.26	#N/A	#N/A					41
		1			106	12	8	#N/A	4.98	0.15	Y	0	57.90		49
5		1		4:00p/5-19	20	2	2	#N/A	5.03	0.22					51
		1			35	4	2	7.56	#N/A	#N/A					53
		1			103	12	8	#N/A	4.24	0.91	Y	0	57.77		61
6		1		1:02p	16	2	2	#N/A	7.5	0.17					63
		1			33	4	2	7.62	#N/A	#N/A					65
		1			99	12	8	#N/A	3.23	0.09	Y	1	56.98		73
7		2		2:28p	14	2	2	#N/A	4.42	0.09					75
		2			32	4	2	7.38	#N/A	#N/A					77
		2			101	12	8	#N/A	4.61	0.29	Y	0	57.03		85
8		1		2:38p	15	2	2	#N/A	5.3	1.43					87
		1			33	4	2	7.02	#N/A	#N/A					89
		1			105	12	8	#N/A	5.05	0.68	Y	0	56.82		97
9		1		2:40p	17	2	2	#N/A	3.04	0.17					99
		1			33	4	2	7.08	#N/A	#N/A					101
		1			105	12	8	#N/A	12	0.7	Y	1	56.72		109
10		1		3:12p	14	2	2	#N/A	5.78	1.91					111
		1			30	4	2	7.8	#N/A	#N/A					113
		1			99	12	8	#N/A	4.08	0.25	Y	0	56.42		121
11		1		10:15am	12.5	2	2	5.15	4.97	0.11					123
		1			42.5	6	4	6.62	#N/A	#N/A					127
		1		10-Jun	57	8	2	6.28	3.64	0.24					129
		1			92	12	4	7	6.71	0.23	Y	0	56.34		133
12		1		2:45pm	14	2	2	5.09	5.74	0.16					135
		1			48	6	4	5.09	#N/A	#N/A					139
		1		13-Jun	70	8	2	5.66	3.8	0.15					141
		1			108	12	4	5.53	3.39	0.16	Y	0	#N/A		145

Appendix IV (Continued)
Table IV.1 (Continued)

13		1		10:50am	28	2	2	6.41	5.95	0.13					147
		1			92	6	4	9.25	#N/A	#N/A					151
		1		14-Jun	126	8	2	9.47	#N/A	#N/A					153
		1			205	12	4	10.53	2.76	0.09	Y	0	56.36		157
14		1		11:00am	20	2	2	10.15	4.44	0.1					159
		1			66	6	4	6.75	#N/A	#N/A					163
		1		15-Jun	82	8	2	6.78	3.38	0.3					165
		1			134	12	4	8.06	3.84	0.15	Y	0	56.38		169
15		1		12:00pm	14	2	2	3.59	4.43	0.34					171
		1			46	6	4	4.5	#N/A	#N/A					175
		1		16-Jun	65	8	2	5.03	3.48	0.07					177
		1			103	12	4	6.63	2.81	0.08	Y	0	56.57		181
16		1		9:45a	22	2	2	7.19	5.06	0.12					183
		1			71	6	4	7.44	#N/A	#N/A					187
		1		17-Jun	95	8	2	7.87	4.56	0.27					189
		1			152	12	4	9.44	2.78	0.12	Y	0	56.40		193
17		2		11:45AM	16	2	2	6.22	10.5	0.48					195
		2			98	6	4	31.37	#N/A	#N/A					199
		2		20-Jun	190	8	2	180	8.44	0.52					201
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	1	56.58		201
18		2		10:00am	27	2	2	14.82	9.96	0.82					203
		2			229	6	4	47.88	#N/A	#N/A					207
		2		21-Jun	332	8	2	57.4	6.56	0.41					209
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.39		209
19		1		12:20	24	2	2	7.69	4.08	0.22					211
		1			84	6	4	10.47	#N/A	#N/A					215
		1		24-Jun	118	8	2	11.44	2.34	0.09					217
		1			212	12	4	13.94	2.29	0.09	#N/A	#N/A	#N/A		221
20		1		3:00pm	21.5	2	2	6.94	5.17	0.24					223
		1			73	6	4	8.38	#N/A	#N/A					227
		1		27-Jun	#N/A	8	2	10.16	3.56	0.12					229
		1			93	12	4	10.18	9.05	0.11	Y	0	56.48		233

Appendix IV (Continued)
Table IV.1 (Continued)

21		1		11:00am	23	2	2	7.28	4.31	0.1					235
		1			75	6	4	8.65	#N/A	#N/A					239
		1		27-Jun	105	8	2	9.63	3.12	0.06					241
		1			184	12	4	13.94	2.08	0.28	Y	0	56.06		245
22		1		10:30am	24.5	2	2	7.35	4.89	0.57					247
		1			#N/A	6	4	#N/A	#N/A	#N/A					251
		1		30-Jun	93	8	2	9.47	3.6	0.14					253
		1			187	12	4	11.84	3.72	0.1	Y	0	56.2		257
23		1		4:00pm	23	2	2	7.57	5.2	0.19					259
		1			79	6	4	8.6	#N/A	#N/A					263
		1		30-Jun	108	8	2	9.47	3.33	0.11					265
		1			180	12	4	23.83	3.13	0.18	Y	0	56.64		269
24		1		10:30am	14.5	2	2	5	5.41	0.06					271
		1			49.5	6	4	5.44	#N/A	#N/A					275
		1		1-Jul	69.5	8	2	5.75	4.01	0.34					277
		1			109	12	4	6.21	3.17	0.08	Y	0	56.62		281
25	1	1		2:45pm	16.5	2	2	4.94	4.24	0.1					283
	1	1			53	6	4	5.31	#N/A	#N/A					287
	1	1		1-Jul	71	8	2	5.97	3.23	0.07					289
	1	1			118	12	4	8.53	2.96	0.34	Y	0	56.19		293
26	0	1		11:00am	18	2	2	5.41	4.34	0.08					295
	0	1			57	6	4	5.79	#N/A	#N/A					299
	0	1		5-Jul	75.5	8	2	6.28	3.34	0.14					301
	0	1			121.5	12	4	8.88	3.46	0.17	Y	0	56.26		305
27	1	2		2:00pm	50	2	2	39.88	9.64	0.33					307
	1	2			#N/A	6	4	#N/A	#N/A	#N/A					311
	1	2		7-Jul	#N/A	8	2	#N/A	#N/A	#N/A					313
	1	2			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	56		317
28	0	1		#N/A	88	2	2	28.41	3.91	0.44					319
	0	1			402	6	4	13.34	#N/A	#N/A					323
	0	1		#N/A	460	8	2	9.6	1.81	0.1					325
	0	1			488	12	4	12.53	3.82	0.2	Y	0	56.44		329

Appendix IV (Continued)
Table IV.1 (Continued)

29	0	1		2:00 PM	20	2	2	6.53	4.23	0.11					331
	0	1			66	6	4	7.44	#N/A	#N/A					335
	0	1		13-Jul	92	8	2	8.1	3.01	0.09					337
	0	1			145.5	12	4	8.78	3.1	0.06	Y	0	56.72		341
30	1	2		10:00	23	2	2	15.25	8.24	0.41					343
	1	2			311	6	4	75.62	#N/A	#N/A					347
	1	2		14-Jul	#N/A	8	2	142	5.99	0.46					349
	1	2			#N/A	#N/A	4	#N/A	#N/A	#N/A	Y	0	56.68		353
31	1	1		9:00	25	2	2	6.19	5.27	0.174					355
	1	1			65	6	4	12.16	#N/A	#N/A					359
	1	1		15-Jul	108	8	2	10.31	4.77	0.17					361
	1	1			176	12	4	13.06	3.07	0.23	Y	0	55.7		365
32	0	1		1:30	13	2	2	5:37	4.79	0.14					367
	0	1			57	6.5	4.5	5.93	#N/A	#N/A					371.5
	0	1		15-Jul	75	8	1.5	6	4.12	0.19					373
	0	1			121.5	12	4	9.81	2.84	0.1	Y	0	56		377
33	0	1		4:40	17	2	2	5	4.93	0.13					379
	0	1			57	6	4	6.47	#N/A	#N/A					383
	0	1		15-Jul	88	8.75	2.75	6.97	3.3	0.13					385.75
	0	1			133	12	3.25	8.88	5.19	0.3	Y	0	56.62		389
34	0	1		2:00	32	2.5	2.5	5.63	4.5	0.12					391.5
	0	1			#N/A	6	3.5	#N/A	#N/A	#N/A					395
	0	1		16-Jul	94	8	2	6.85	3.23	0.1					397
	0	1			144	12	4	10.44	6.15	0.11	Y	0	56.7		401
35	0	1		9:30	14	2	2	4.44	6.04	0.09					403
	0	1			49	6	4	7.19	#N/A	#N/A					407
	0	1		18-Jul	69	8	2	7.12	4.76	0.06					409
	0	1			119	12	4	7.94	3.54	0.18	Y	0	56.53		413
36	1	1		12:50	15	2	2	4.94	6.04	0.1					415
	1	1			55	6	4	5.91	#N/A	#N/A					419
	1	1		18-Jul	73.5	8	2	6.28	3.84	0.05					421
	1	1			143	13	5	12.81	4.47	0.1	Y	0	56.54		426

Appendix IV (Continued)
Table IV.1 (Continued)

37	0	1		5:45	14	2	2	4.75	5.64	0.14					428
	0	1			50	6	4	5.4	#N/A	#N/A					432
	0	1		18-Jul	68	8	2	5.78	4.26	0.07					434
	0	1			111	12	4	8.63	3.5	0.36	Y	0	56.44		438
38	0	1		1:45	22	2	2	7.5	5.09	0.09					440
	0	1			67	6	4	6	#N/A	#N/A					444
	0	1		19-Jul	92	8	2	5.97	3.5	0.36					446
	0	1			133	12	4	8.69	3.02	0.06	Y	2	56.38		450
39	0	1		11:30	16	2	2	5.31	4.22	0.08					452
	0	1			49	6	4	6.85	#N/A	#N/A					456
	0	1		20-Jul	70	8	2	6.16	3.35	0.22					458
	0	1			104	12	4	7.12	2.86	0.13	Y	0	56.32		462
40	1	2		2:30	23	2	2	10.41	10	0.59					464
	1	2			138	6	4	33.5	#N/A	#N/A					468
	1	2		20-Jul	#N/A	8	2	48.8	4.29	0.46					470
	1	2			#N/A	10.5	2.5	#N/A	#N/A	#N/A	Y	0	56.4		472.5
41	0	1		9:30	0	0	8	72.5	4.04	1.9					480.5
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					480.5
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					480.5
	0	1			120	7	7	14.47	3.22	0.07	Y	0	56.36		487.5
42	1	1		12:20	0	0	0	5.63	5.14	0.3					487.5
	1	1			#N/A	0	0	#N/A	#N/A	#N/A					487.5
	1	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					487.5
	1	1			120	0	0	17.57	2.87	0.27	Y	0	56.18		487.5
43	0	1		3:30	0	0	0	9.51	5.51	0.24					487.5
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					487.5
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					487.5
	0	1			120	6	6	13.15	3.05	0.42	Y	0	56.62		493.5
44	0	1		9:30	0	0	0	6.4	4.36	0.87					493.5
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					493.5
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					493.5
	0	1			120	9.8	9.8	9.65	3.16	0.08	Y	0	56.34		503.3

Appendix IV (Continued)
Table IV.1 (Continued)

45	0	1		12:45	0	0	0	5.5	5.99	2.36					503.3
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					503.3
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					503.3
	0	1			120	10.25	10.25	8.88	3.35	0.07	Y	0	56.45		513.55
46	0	1		3:35	0	0	0	4.16	5.46	0.17					513.55
	0	1			60	0	0	#N/A	#N/A	#N/A					513.55
	0	1		25-Jul	120	12.75	12.75	11.87	3.26	0.11	Y	0	56.62		526.3
47	1	1		10:20	0	0	0	4.31	4.02	0.27					526.3
	1	1			60	0	0	#N/A	1.51	1.57					526.3
	1	1		26-Jul	120	12	12	13.25	3.2	0.28	Y	0	56.03		538.3
48	0	1		11:00	0	0	0	4.41	4.15	0.39					538.3
	0	1			60	0	0	#N/A	#N/A	#N/A					538.3
	0	1		27-Jul	120	13	13	8.84	2.75	0.09	Y	0	56.48		551.3
49	0	1		4:00	0	0	0	4.5	4.23	0.24					551.3
	0	1			60	0	0	#N/A	#N/A	#N/A					551.3
	0	1		27-Jul	120	13.75	13.75	12.45	3.06	0.29	Y	0	56.32		565.05
50	1	2		9:00	0	0	0	5.69	9.59	0.52					565.05
	1	2			60	2	2	34.4	8.3	0.25					567.05
	1	2		27-Jul	120	3	3	52	8.41	0.2	Y	0	56.52		570.05
51	0	1		12:10	0	0	0	3.97	4.98	0.17					570.05
	0	1			60	0	0	#N/A	#N/A	#N/A					570.05
	0	1		27-Jul	120	12.5	12.5	58	3.23	0.25	Y	0	56.48		582.55
52	0	1		3:40	0	0	0	10.54	5.97	0.17					582.55
	0	1			60	0	0	#N/A	#N/A	#N/A					582.55
	0	1		27-Jul	120	8.5	8.5	10.97	4.17	0.12	Y	0	56.43		591.05
53	1	1		11:30	0	0	0	4.13	5.91	0.45					591.05
	1	1			60	0	0	#N/A	5.05	0.08					591.05
	1	1		28-Jul	120	13	13	14.22	3.39	0.28	Y	0	56.33		604.05
54	0	1		10:55	0	0	0	5	5.48	0.09					604.05
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					604.05
	0	1		29-Jul	120	12.2	12.2	10.16	3.46	0.11	Y	0	56.49		616.25

Appendix IV (Continued)
Table IV.1 (Continued)

	0	1		11.:50	0	0	0	7.15	8.09	0.45					616.25
55	0	1			60	#N/A	0	#N/A	#N/A	#N/A					616.25
	0	1		29-Jul	120	8.2	8.2	9.69	3.4	0.05	Y	0	56.38		624.45
	0	1		10:25	0	0	0	6.73	7.15	0.42					624.45
56	0	1			60	#N/A	0	#N/A	#N/A	#N/A					624.45
	0	1		1-Aug	120	8.25	8.25	9.53	4.25	0.19	Y	0	56.38		632.7
	0	1		1:30	0	0	0	4.25	9.06	0.64					632.7
57	0	1			60	#N/A	0	#N/A	#N/A	#N/A					632.7
	0	1		1-Aug	120	10.1	10.1	9.57	4.47	0.09	Y	0	56.46		642.8
	1	1		10:25	0	0	0	4.49	7.48	0.31					642.8
58	1	1			60	#N/A	0	5.85	4.47	0.14					642.8
	1	1		2-Aug	120	12	12	11.07	4.02	0.1	Y	0	56.54		654.8
	0	1		1:30	0	0	0	3.67	5.81	0.41					654.8
59	0	1			60	0	0	#N/A	#N/A	#N/A					654.8
	0	1		2-Aug	120	12.5	12.5	9.72	4.12	0.13	Y	0	56.59		667.3
	1	2		12:40	0	0	0	7.37	10.7	0.44					667.3
60	1	2			60	#N/A	0	#N/A	9.84	3.61					667.3
	1	2		5-Aug	120	4	4	26.34	9.17	0.48	Y	0	56.14		671.3
	0	1		#N/A	0	0	0	4.94	5.94	1.29					671.3
61	0	1			60	#N/A	0	#N/A	#N/A	#N/A					671.3
	0	1		8-Aug	120	11	11	7.43	3.79	0.07	Y	0	56.48		682.3
	0	1		#N/A	0	0	0	5.68	6.61	0.17					682.3
62	0	1			60	#N/A	0	#N/A	#N/A	#N/A					682.3
	0	1		8-Aug	120	10	10	7.75	3.61	0.34	Y	0	56.63		692.3
	1	2		#N/A	0	0	0	22.28	7.96	0.23					692.3
63	1	2			60	#N/A	0	#N/A	7.32	0.67					692.3
	1	2		11-Aug	120	2.75	2.75	68.06	7.02	0.62	Y	0	56.43		695.05
	0	1		2:00	0	0	0	7.9	4.66	0.21					695.05
64	0	1			60	#N/A	2.75	#N/A	#N/A	#N/A					697.8
	0	1		1-Sep	120	13	13	27	2.01	0.14	Y	0	56.75		710.8

Appendix IV (Continued)
Table IV.1 (Continued)

	1	1		6:00	0	0	0	#N/A	88.52	0.23					710.8
65	1	1			60	#N/A	0	#N/A	6.65	0.14					710.8
	1	1		7-Sep	120	11.5	11.5	12.19	5.24	0.82	Y	0	56.3		722.3
	0	1		4:30	0	0	0	4.5	5.32	0.23					722.3
66	0	1			60	#N/A	11.5	#N/A	#N/A	#N/A					733.8
	0	1		8-Sep	120	13	13	5.59	3.25	0.26	Y	0	55.92		746.8
	0	1		2:00	0	0	0	4.23	6.81	0.21					746.8
67	0	1			60	#N/A	13	#N/A	#N/A	#N/A					759.8
	0	1		9-Sep	120	14	14	15.92	2.87	0.18	Y	0	56.25		773.8
	0	1		5:00	0	0	0	4.16	3.93	0.37					773.8
68	0	1			60	#N/A	0	#N/A	#N/A	#N/A					773.8
	0	1		9-Sep	120	14	14	12.43	2.73	0.16	Y	0	55.92		787.8
	0	1		12:30	0	0	0	4.32	5.55	0.12					787.8
69	0	1			60	#N/A	0	#N/A	#N/A	#N/A					787.8
	0	1		10-Sep	120	13.25	13.25	9.04	2.95	0.1	Y	0	56.35		801.05
	1	1		3:00	0	0	0	3.81	5.99	0.11					801.05
70	1	1			60	#N/A	0	#N/A	4	0.28					801.05
	1	1		10-Sep	120	14	14	10.71	3.91	0.2	Y	0	56.22		815.05
	0	1		5:30	0	0	0	4.93	6.12	0.22					815.05
71	0	1			60	#N/A	0	#N/A	#N/A	#N/A					815.05
	0	1		10-Sep	120	14	14	8.96	3.05	0.07	Y	0	56.1		829.05
	0	1		11:00	0	0	0	3.89	6.13	0.82					829.05
72	0	1			60	#N/A	0	#N/A	#N/A	#N/A					829.05
	0	1		11-Sep	120	14	14	8.49	2.99	0.11	Y	0	56.43		843.05
	1	2		2:00	0	0	0	45	9.05	0.37					843.05
73	1	2			60	#N/A	0	#N/A	7.22	0.31					843.05
	1	2		11-Sep	120	3	3	22	7.16	0.51	Y	0	#N/A		846.05
	0	1		11:00	0	0	0	4.44	4.76	0.51					846.05
74	0	1			60	#N/A	3	#N/A	#N/A	#N/A					849.05
	0	1		12-Sep	120	13.5	13.5	11.12	3.47	0.15	Y	0	#N/A		862.55

Appendix IV (Continued)
Table IV.1 (Continued)

	0	1		1:30	0	0	0	4.75	5.81	0.22					862.55
75	0	1			60	#N/A	13.5	#N/A	#N/A	#N/A					876.05
	0	1		12-Sep	120	12	12	6.09	3.43	0.15	Y	0	#N/A		888.05
	1	1		3:00	0	0	0	4	5.52	0.22					888.05
76	1	1			60	#N/A	12	#N/A	5.33	0.12					900.05
	1	1		12-Sep	120	13	13	5.91	3.47	0.14	Y	0	#N/A		913.05
	0	1		5:30	0	0	0	4.9	5.11	0.15					913.05
77	0	1			60	#N/A	0	#N/A	#N/A	#N/A					913.05
	0	1		12-Sep	120	14	14	13.44	11.7	0.11	Y	0	#N/A		927.05
	0	1		3:00	0	0	0	4.53	7.51	0.38					927.05
78	0	1			60	#N/A	0	#N/A	#N/A	#N/A					927.05
	0	1		13-Sep	120	14.5	14.5	13.97	26	0.14	Y	0	#N/A		941.55
	1	1		5:30	0	0	0	5.37	6.34	0.11					941.55
79	1	1			60	#N/A	0	#N/A	#N/A	#N/A					941.55
	1	1		13-Sep	120	14	14	13.44	11.7	0.11	Y	0	#N/A		955.55
	0	1		10:00	0	0	0	6.53	6.06	0.08					955.55
80	0	1			60	#N/A	0	#N/A	#N/A	#N/A					955.55
	0	1		14-Sep	120	12	12	9.72	3.38	0.24	Y	0	#N/A		967.55
	1	1		3:00	0	0	0	4.69	6.19	0.14					967.55
81	1	1			60	#N/A	0	#N/A	7.44	0.11					967.55
	1	1		14-Sep	120	13	13	6.59	4.36	0.18	Y	0	#N/A		980.55
	0	1		3:00	0	0	0	4.78	6.76	0.13					980.55
82	0	1			60	#N/A	0	#N/A	#N/A	#N/A					980.55
	0	1		15-Sep	120	13	13	13.56	4.3	0.23	Y	0	#N/A		993.55
	1	2		1:30	0	0	0	10.06	11.3	0.3					993.55
83	1	2			60	#N/A	13	#N/A	10.8	0.56					1006.55
	1	2		16-Sep	120	3.5	3.5	36	9.05	0.32	Y	0	#N/A		1010.05
	0	1		4:30	0	0	0	4.65	5.57	0.63					1010.05
84	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1010.05
	0	1		16-Sep	120	10.5	10.5	6.37	3.1	0.24	Y	0	#N/A		1020.55

Appendix IV (Continued)

Table IV.1 (Continued)

	0	1		10:00	0	0	0	6.61	5.81	0.36					1020.55
85	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1020.55
	0	1		17-Sep	120	10.5	10.5	8.56	2.97	0.13	Y	0	#N/A		1031.05
	0	1		12:30	0	0	0	4.85	7.77	0.63					1031.05
86	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1031.05
	0	1		17-Sep	120	11.5	11.5	7.84	4.46	0.17	Y	0	#N/A		1042.55
	1	1		3:00	0	0	0	4.6	7.04	0.15					1042.55
87	1	1			60	#N/A	0	#N/A	3.55	0.14					1042.55
	1	1		17-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		1054.55
	0	1		12:00	0	0	0	6.05	6.25	0.31					1054.55
88	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1054.55
	0	1		20-Sep	120	13	13	#N/A	#N/A	#N/A	Y	0	#N/A		1067.55
	0	1		10:00	0	0	0	5.66	5.6	0.32					1067.55
89	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1067.55
	0	1		21-Sep	120	14.5	14.5	#N/A	5.4	0.29	Y	0	#N/A		1082.05
	0	1		3:00	0	0	0	5.03	6.04	0.19					1082.05
90	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1082.05
	0	1		21-Sep	120	16	16	#N/A	#N/A	#N/A	Y	0	#N/A		1098.05
	0	1		3:30	0	0	0	6.16	5.7	0.24					1098.05
91	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1098.05
	0	1		22-Sep	120	13.5	13.5	#N/A	#N/A	#N/A	Y	0	#N/A		1111.55

Appendix IV (Continued)
Table IV.1 (Continued)

				Filter 4: Medium Turbidity Water - Data Entered											
								AVG	42.67572	5.307156	0.88				1016.8
												# of Scrubs	8		
Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incrementa Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
1		1		#N/A	#N/A	2	2	#N/A	32.2	0.21					2
		1			#N/A	7	5	#N/A	#N/A	#N/A					7
		1			#N/A	13	6	#N/A	131	0.19	Y	0	#N/A		13
2		1		#N/A	#N/A	2	2	#N/A	31.2	0.75					15
		1			#N/A	7	5	8.7	#N/A	#N/A					20
		1			#N/A	12	5	#N/A	55.8	0.51	Y	0	#N/A		25
3		1		3:17p/5-17	19	2	2	#N/A	33.7	0.56					27
		1			22	4	2	9.6	#N/A	#N/A					29
		1			77	12	8	#N/A	25.2	0.29	Y	1	58.29		37
4		1		1:38p/5-18	15	2	2	#N/A	31.3	0.28					39
		1			25	4	2	9.96	#N/A	#N/A					41
		1			73	12	8	#N/A	32.4	6	Y	0	58.50		49
5		1		4:00p/5-19	17	2	2	#N/A	34.4	2.87					51
		1			25	4	2	10.14	#N/A	#N/A					53
		1			75	12	8	#N/A	27	1.05	Y	0	57.92		61

Appendix IV (Continued)
Table IV.1 (Continued)

6		1		1:02p	10	2	2	#N/A	41.1	0.32					63
		1			24	4	2	9.96	#N/A	#N/A					65
		1			73	12	8	#N/A	18.2	0.37	Y	1	58.19		73
7		2		2:28p	13	2	2	#N/A	30.6	0.15					75
		2			26	4	2	9.96	#N/A	#N/A					77
		2			79	12	8	#N/A	20	1	Y	0	57.98		85
8		1		2:38p	12	2	2	#N/A	34.5	0.47					87
		1			24	4	2	9	#N/A	#N/A					89
		1			74	12	8	#N/A	19.8	1.27	Y	0	57.59		97
9		1		2:40p	11	2	2	#N/A	29.6	0.58					99
		1			24	4	2	9.3	#N/A	#N/A					101
		1			76	12	8	#N/A	23	0.29	Y	1	56.97		109
10		1		3:12p	13	2	2	#N/A	30.9	1.75					111
		1			21	4	2	10.26	#N/A	#N/A					113
		1			72	12	8	#N/A	22	0.66	Y	0	57.57		121
11		1		11:00a	9	2	2	4.19	30.5	0.18					123
		1			33	6	4	4.63	#N/A	#N/A					127
		1		13-Jun	47	8	2	5.16	24.7	0.13					129
		1			76	12	4	7.63	18.5	#N/A	Y	0	#N/A		133
12		1		9:00a	12	2	2	3.28	28.4	0.13					135
		1			33	6	4	3.47	#N/A	#N/A					139
		1		14-Jun	44	8	2	3.19	19.6	0.21					141
		1			72	12	4	5.84	21.5	1.35	Y	0	57.02		145
13		1		2:00p	15	2	2	3.78	32.2	0.19					147
		1			33	6	4	3.25	#N/A	#N/A					151
		1		14-Jun	45	8	2	4.16	21.5	0.17					153
		1			78	12	4	7.03	18.9	0.27	Y	0	56.98		157
14		1		2:30p	13	2	2	4.94	26.7	0.13					159
		1			48	6	4	5.44	#N/A	#N/A					163
		1		15-Jun	64	8	2	5.75	23.1	0.07					165
		1			108.5	12	4	7.44	17.2	0.38	Y	0	57.02		169

Appendix IV (Continued)
Table IV.1 (Continued)

15		1		3:00p	12	2	2	3.94	30.4	0.12					171
		1			39	6	4	4.69	#N/A	#N/A					175
		1		16-Jun	53.5	8	2	4.5	21.4	0.39					177
		1			88	12	4	6.58	#N/A	#N/A	Y	0	57.04		181
16		1		3:15pm	11	2	2	3.47	2.06	0.11					183
		1			35	6	4	3.88	#N/A	#N/A					187
		1		17-Jun	46.5	8	2	4.03	25.2	0.1					189
		1			80	12	4	6.69	37.4	0.19	Y	0	57.20		193
17		2		11:45am	18	2	2	8.56	11	0.58					195
		2			200	6	4	12.24	#N/A	#N/A					199
		2		21-Jun	280	8	2	18.84	8.37	0.63					201
		2			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	56.98		205
18		2		12:00pm	17	2	2	4.44	16.4	0.31					207
		2			45	6	4	5.75	#N/A	#N/A					211
		2		22-Jun	62.5	8	2	5.19	24.3	0.17					213
		2			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	57.14		217
19		1		10:15am	22	2	2	7.22	31.7	0.09					219
		1			77	6	4	8.68	#N/A	#N/A					223
		1		27-Jun	108	8	2	8.65	17.7	0.43					225
		1			171	12	4	11.35	15.9	0.16	Y	0	57.26		229
20		1		5:00pm	26	2	2	6.65	30.8	0.08					231
		1			76	6	4	6.91	#N/A	#N/A					235
		1		28-Jun	102	8	2	6.87	22.4	0.09					237
		1			154	12	4	10.59	17.8	0.185	Y	0	56.04		241
21		1		11:30am	18	2	2	3.49	35.7	0.27					243
		1			45	6	4	4.72	#N/A	#N/A					247
		1		29-Jun	67	8	2	4.71	17.9	0.74					249
		1			101	12	4	6.28	19.7	0.95	Y	0	57.10		253
22		1		11:00am	12	2	2	3.27	30.1	0.18					255
		1			36	6	4	#N/A	#N/A	#N/A					259
		1		30-Jun	49	8	2	4.17	24.2	0.11					261
		1			82.5	12	4	8.67	18.5	0.22	Y	0	57.1		265

Appendix IV (Continued)
Table IV.1 (Continued)

23		1		10:45am	11.5	2	2	3.5	33.4	0.08					267
		1			38.5	6	4	4.12	#N/A	#N/A					271
		1		1-Jul	71.5	8	2	4.5	24.1	0.1					273
		1			87.5	12	4	7.29	18.4	0.12	Y	0	55.94		277
24		1		3:00pm	15.5	2	2	5.28	32.3	0.13					279
		1			66	6	4	6.25	#N/A	#N/A					283
		1		1-Jul	75.5	8	2	6.81	23.1	0.14					285
		1			124	12	4	8.97	20.2	0.19	Y	0	57.16		289
25	1	1		11:10am	12	2	2	3.71	34.6	0.09					291
	1	1			39	6	4	4	#N/A	#N/A					295
	1	1		5-Jul	54.5	8	2	4.28	26.2	0.11					297
	1	1			86	12	4	7.16	22.5	0.16	Y	0	56.9		301
26	0	1		3:10pm	16	2	2	5.37	30.7	0.24					303
	0	1			59	6	4	6.72	#N/A	#N/A					307
	0	1		5-Jul	81	8	2	11.69	23.3	0.2					309
	0	1			134	12	4	9.6	21.8	0.42	Y	0	57.06		313
27	1	2		11:45am	50	2	2	32.8	9.44	0.27					315
	1	2			585	6	4	121	#N/A	#N/A					319
	1	2		7-Jul	#N/A	#N/A	0	121.4	#N/A	#N/A					319
	1	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.72		319
28	0	1		#N/A	40	2	2	11.85	28.7	0.14					321
	0	1			98	6	4	17.08	#N/A	#N/A					325
	0	1		#N/A	139	8	2	9.9	31.6	0.18					327
	0	1			205	12	4	18.37	15	1.28	Y	0	56.45		331
29	0	2		10:30am	39	3	3	27	8.5	0.46					334
	0	2			#N/A	6	3	#N/A	#N/A	#N/A					337
	0	2		14-Jul	#N/A	8	2	128	5.83	0.93					339
	0	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	57.25		339
30	1	1		9:30	22	2	2	8.59	29.5	0.16					341
	1	1			81	6	4	9.85	#N/A	#N/A					345
	1	1		15-Jul	#N/A	8	2	#N/A	#N/A	#N/A					347
	1	1			210	12	4	19.66	21.6	0.12	Y	0	57.4		351

Appendix IV (Continued)
Table IV.1 (Continued)

31	1	1		#N/A	17	2	2	4.79	28.5	0.32					353
	1	1			62	6	4	8.12	#N/A	#N/A					357
	1	1		15-Jul	96.5	8	2	14.71	20.6	0.1					359
	1	1			137	12	4	16.13	15.7	0.51	Y	0	56.65		363
32	0	1		2:15	14	2	2	3.62	30	0.1					365
	0	1			#N/A	#N/A	0	#N/A	#N/A	#N/A					365
	0	1		16-Jul	65	8	6	4.1	27.5	0.12					371
	0	1			100	12	4	7.13	23.6	0.16	Y	0	57.24		375
33	0	1		9:30	15	2	2	7.16	35.5	0.2					377
	0	1			67	6	4	7.78	#N/A	#N/A					381
	0	1		18-Jul	98	8	2	8.78	20	0.07					383
	0	1			159	12	4	7.19	47.7	0.18	Y	0	57.24		387
34	0	1		12:45	16	2	2	4.4	43.9	0.15					389
	0	1			55	6	4	4.22	#N/A	#N/A					393
	0	1		18-Jul	69	8	2	4.44	23.8	0.4					395
	0	1			102	12	4	6.57	21	0.22	Y	0	57.02		399
35	0	1		3:25	16	2	2	5.31	31.3	0.11					401
	0	1			63	7	5	6.53	#N/A	#N/A					406
	0	1		18-Jul	77	8	1	7.28	22.2	0.07					407
	0	1			145	12	4	10.22	17.1	0.09	Y	0	57.8		411
36	1	1		9:00	19	2	2	3.06	33.4	0.25					413
	1	1			50	6.75	4.75	3.82	3.82	#N/A					417.75
	1	1		19-Jul	58	8	1.25	3.94	3.94	0.08					419
	1	1			89	12	4	6.44	6.44	0.12	Y	0	56.94		423
37	0	1		11:30	15	2	2	3.22	3.22	0.12					425
	0	1			48	6	4	5.1	5.1	0.07					429
	0	1		19-Jul	#N/A	#N/A	0	#N/A	#N/A	#N/A					429
	0	1			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	57.24		429
38	0	1		1:15	10	2	2	3.31	3.31	0.22					431
	0	1			#N/A	6	4	#N/A	#N/A	#N/A					435
	0	1		19-Jul	49	8	2	3.97	3.97	0.12					437
	0	1			78	12	4	6.18	6.18	0.09	Y	2	56.8		441

Appendix IV (Continued)
Table IV.1 (Continued)

39	0	1		11:30	15	2	2	4.78	33.2	0.42					443
	0	1			#N/A	6	4	#N/A	#N/A	#N/A					447
	0	1		20-Jul	74	8	2	5.5	23.9	0.19					449
	0	1			106	12	4	7.99	21.5	0.08	Y	0	56.72		453
40	1	2		2:30	27	2	2	14.66	8.6	0.69					455
	1	2			#N/A	6	4	#N/A	#N/A	#N/A					459
	1	2		20-Jul	201	8	2	50.25	6.35	0.58					461
	1	2			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	56.75		465
41	0	1		9:30	0	0	8	3.63	28.7	0.95					473
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					473
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					473
	0	1			120	14	14	16	21.2	0.23	Y	0	57.04		487
42	1	1		12:30	0	0	0	3.53	32.9	0.29					487
	1	1			#N/A	0	0	#N/A	#N/A	#N/A					487
	1	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					487
	1	1			120	13	13	20.76	17.2	0.11	Y	0	56.55		500
43	0	1		3:45	0	0	0	4.6	33.3	0.41					500
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					500
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					500
	0	1			120	11	11	9.03	17.4	0.07	Y	0	57.3		511
44	0	1		9:45	0	0	0	7.37	32.2	0.57					511
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					511
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					511
	0	1			120	11	11	20.84	21.7	0.09	Y	0	56.88		522
45	0	1		1:05	0	0	0	4.59	36	0.7					522
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					522
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					522
	0	1			120	11.2	11.2	8.87	17.1	0.09	Y	0	57.33		533.2
46	0	1		3:55	0	0	0	4.16	31	0.26					533.2
	0	1			60	0	0	#N/A	#N/A	#N/A					533.2
	0	1		1-Jul	120	12.2	12.2	9.5	19	0.09	Y	0	56.22		545.4

Appendix IV (Continued)
Table IV.1 (Continued)

47	1	1		6:30	0	0	0	4.38	32.5	0.48					545.4
	1	1			60	0	0	#N/A	27.2	0.07					545.4
	1	1		26-Jul	120	10.8	10.8	10.63	16.9	0.09	Y	0	57.12		556.2
48	0	1			0	0	0	5.84	31.8	0.74					556.2
	0	1			60	0	0	#N/A	#N/A	#N/A					556.2
	0	1		26-Jul	120	8.2	8.2	8.34	24.4	0.17	Y	0	57		564.4
49	0	1		4:30	0	0	0	2.95	40.2	0.37					564.4
	0	1			60	0	0	#N/A	#N/A	#N/A					564.4
	0	1		26-Jul	120	12	12	10.53	16.9	0.45	Y	0	57.32		576.4
50	1	2		9:45	0	0	0	3.44	13.6	0.8					576.4
	1	2			60	0	0	34.6	11.1	0.62					576.4
	1	2		27-Jul	120	3.5	3.5	#N/A	10	0.57	Y	0	56.78		579.9
51	0	1		12:30	0	0	0	4.03	37.5	2.21					579.9
	0	1			60	0	0	#N/A	#N/A	#N/A					579.9
	0	1		27-Jul	120	12	12	10.62	17.9	0.27	Y	0	57.29		591.9
52	0	1		3:45	0	0	0	4.04	37.8	0.17					591.9
	0	1			60	0	0	#N/A	#N/A	#N/A					591.9
	0	1		27-Jul	120	12	12	9.41	17.2	0.24	Y	0	56.8		603.9
53	1	1		11:00	0	0	0	5.28	34.2	0.37					603.9
	1	1			60	0	0	#N/A	31.2	0.11					603.9
	1	1		28-Jul	120	6	6	3.82	23.3	0.05	Y	0	56.95		609.9
54	0	1		10:55	0	0	0	4.12	34.1	0.13					609.9
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					609.9
	0	1		29-Jul	120	13	13	10.37	21.1	0.07	Y	0	57.04		622.9
55	0	1		11.:50	0	0	0	3.54	37.6	0.46					622.9
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					622.9
	0	1		29-Jul	120	13.2	13.2	17.88	19.1	0.06	Y	0	56.73		636.1
56	0	1		10:25	0	0	0	4.37	38.5	0.16					636.1
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					636.1
	0	1		1-Aug	120	13	13	15.07	19.4	0.18	Y	0	56.02		649.1
57	0	1		1:30	0	0	0	4.29	46	0.29					649.1
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					649.1
	0	1		1-Aug	120	11.2	11.2	8.27	25.7	0.08	Y	0	56.82		660.3

Appendix IV (Continued)
Table IV.1 (Continued)

58	1	1		10:25	0	0	0	3.86	36.6	0.19					660.3
	1	1			60	#N/A	0	5.6	21.4	0.12					660.3
	1	1		2-Aug	120	12	12	18.28	18.4	0.05	Y	0	56.48		672.3
59	0	1		1:30	0	0	0	4	34.4	0.53					672.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					672.3
	0	1		2-Aug	120	13	13	14.3	19.5	0.06	Y	0	56.24		685.3
60	1	2		12:40	0	0	0	9.78	9.79	0.3					685.3
	1	2			60	#N/A	0	#N/A	8.75	0.34					685.3
	1	2		5-Aug	120	3	3	48.32	7.3	0.41	Y	0	56.64		688.3
61	0	1			0	0	0	4.43	35.9	0.3					688.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					688.3
	0	1		8-Aug	120	13	13	10.25	22.8	0.39	Y	0	57.1		701.3
62	0	1		2:30	0	0	0	4.28	38.9	0.52					701.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					701.3
	0	1		8-Aug	120	13.5	13.5	15.5	17.7	0.13	Y	0	57.18		714.8
63	1	2			0	0	0	7.75	8.65	0.47					714.8
	1	2			60	#N/A	0	9.07	9.07	0.71					714.8
	1	2		11-Aug	120	5.25	5.25	22.08	6.25	0.36	Y	0	56.75		720.05
64	0	1		2:30	0	0	0	3.53	38.9	0.88					720.05
	0	1			60	#N/A	5.25	#N/A	#N/A	#N/A					725.3
	0	1		1-Sep	120	14	14	23.8	15.6	0.11	Y	0	56.56		739.3
65	0	1		4:00	0	0	0	3.82	35.6	1.41					739.3
	0	1			60	#N/A	0	#N/A	18.2	0.1					739.3
	0	1		8-Sep	120	14	14	32	16	0.27	Y	0	56.55		753.3
66	0	1		1:00	0	0	0	#N/A	38.7	0.16					753.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					753.3
	0	1		16-Oct	120	13.5	13.5	#N/A	16.2	0.74	Y	0	#N/A		766.8
67	0	1		3:00	0	0	0	#N/A	35.9	0.11					766.8
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					766.8
	0	1		16-Oct	120	13.5	13.5	#N/A	#N/A	#N/A	Y	3	#N/A		780.3
68	0	1		5:15	0	0	0	3.28	35.8	0.28					780.3
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					780.3
	0	1		16-Oct	120	13.5	13.5	#N/A	18.2	0.22	Y	0	#N/A		793.8

Appendix IV (Continued)
Table IV.1 (Continued)

	0	1		7:30	0	0	0	3.58	34.8	0.35					793.8
69	0	1			60	#N/A	0	#N/A	#N/A	#N/A					793.8
	0	1		16-Oct	120	14.5	14.5	#N/A	18.4	0.17	Y	0	#N/A		808.3
	0	1		8:00	0	0	0	3.22	33.8	0.16					808.3
70	0	1			60	#N/A	0	#N/A	#N/A	#N/A					808.3
	0	1		17-Oct	120	14.5	14.5	#N/A	17.2	#N/A	Y	0	#N/A		822.8
	0	1		10:30	0	0	0	3.54	43.9	0.34					822.8
71	0	1			60	#N/A	0	#N/A	#N/A	#N/A					822.8
	0	1		17-Oct	120	14.5	14.5	#N/A	72.8	0.64	Y	0	#N/A		837.3
	0	1		1:30	0	0	0	3.62	41.8	0.38					837.3
72	0	1			60	#N/A	0	#N/A	#N/A	#N/A					837.3
	0	1		17-Oct	120	14.5	14.5	#N/A	15.6	0.3	Y	0	#N/A		851.8
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					851.8
73	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					851.8
	0	1		#N/A	#N/A	6	6	#N/A	#N/A	#N/A	Y	0	#N/A		857.8
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					857.8
74	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					857.8
	0	1		#N/A	#N/A	14	14	#N/A	#N/A	#N/A	Y	0	#N/A		871.8
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					871.8
75	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					871.8
	0	1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	0	#N/A		886.3
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					886.3
76	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					886.3
	0	1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	0	#N/A		900.8
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					900.8
77	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					900.8
	0	1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	0	#N/A		915.3
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					915.3
78	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					915.3
	0	1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	0	#N/A		929.8
	0	1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					929.8
79	0	1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					929.8
	0	1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	0	#N/A		944.3

Appendix IV (Continued)
Table IV.1 (Continued)

80		1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					944.3
		1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					944.3
		1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	1	#N/A		958.8
81		1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					958.8
		1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					958.8
		1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	2	#N/A		973.3
82		1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					973.3
		1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					973.3
		1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	3	#N/A		987.8
83		1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					987.8
		1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					987.8
		1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	4	#N/A		1002.3
84		1		#N/A	#N/A	0	0	#N/A	#N/A	#N/A					1002.3
		1		#N/A	#N/A	#N/A	0	#N/A	#N/A	#N/A					1002.3
		1		#N/A	#N/A	14.5	14.5	#N/A	#N/A	#N/A	Y	5	#N/A		1016.8
				Filter 5: Medium Turbidity Water - Data Entered											
								AVG	51.0031	7.546224	0.85				349.75
												# of Scrubs	4		
Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incrementa Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)

Appendix IV (Continued)
Table IV.1 (Continued)

		1			#N/A	2	2	#N/A	29.92	1.42					2
1		1		#N/A	#N/A	7	5	#N/A	#N/A	#N/A					7
		1			#N/A	13	6	#N/A	42.8	0.4	Y	0	#N/A		13
		1			#N/A	2	2	#N/A	38	2.86					15
2		1		#N/A	#N/A	7	5	7.2	#N/A	#N/A					20
		1			#N/A	12	5	#N/A	83.4	0.86	Y	0	#N/A		25
		1			14	2	2	#N/A	74.3	1.57					27
3		1		3:17p/5-17	25	4	2	7.8	#N/A	#N/A					29
		1			94	12	8	#N/A	22.6	1.1	Y	1	57.64		37
		1			15	2	2	#N/A	36.6	4.26					39
4		1		1:38p/5-18	25	4	2	8.52	#N/A	#N/A					41
		1			109	12	8	#N/A	30.6	2.46	Y	0	58.32		49
		1			14	2	2	#N/A	35.6	1.62					51
5		1		4:00p/5-19	26	4	2	8.34	#N/A	#N/A					53
		1			93	12	8	#N/A	24.7	1.77	Y	0	57.89		61
		1			13	2	2	#N/A	38.6	1.25					63
6		1		1:02p	33	4	2	8.04	#N/A	#N/A					65
		1			105	12	8	#N/A	26	0.97	Y	1	57.40		73
		2			12	2	2	#N/A	25.7	1.13					75
7		2		2:28p	27	4	2	8.34	#N/A	#N/A					77
		2			89	12	8	#N/A	19.4	1.01	Y	0	57.26		85
		1			12	2	2	#N/A	30.8	1.83					87
8		1		2:38p	25	4	2	8.7	#N/A	#N/A					89
		1			84	12	8	#N/A	24	1.61	Y	0	27.21		97
		1			11	2	2	#N/A	27.9	2.02					99
9		1		2:40p	26	4	2	8.7	#N/A	#N/A					101
		1			89	12	8	#N/A	26.8	2.32	Y	1	57.13		109
		1			13	2	2	#N/A	30.7	7.37					111
10		1		3:12p	24	4	2	9.84	#N/A	#N/A					113
		1			77	12	8	#N/A	33.6	6.1	Y	0	56.30		121

Appendix IV (Continued)
Table IV.1 (Continued)

11		1		11:00a	9	2	2	4.06	30.1	6.08					123
		1			34	6	4	4.25	#N/A	#N/A					127
		1		13-Jun	46	8	2	4.1	22.5	5.77					129
		1			#N/A	12	4	12	65.7	5.29	Y	0	#N/A		133
12		1		9:00a	10	2	2	2.56	32.6	11.1					135
		1			31	6	4	3.75	#N/A	#N/A					139
		1		14-Jun	42	8	2	3.25	23.8	8.86					141
		1			75	12	4	4.84	20.6	8.3	Y	0	56.45		145
13		1		2:00p	11	2	2	2.87	30.1	10.1					147
		1			32	6	4	3.32	#N/A	#N/A					151
		1		14-Jun	42	8	2	3.47	23.6	8.45					153
		1			82	12	4	12	19.5	3.95	Y	0	56.44		157
14		1		2:30p	11	2	2	3.1	30.1	11.4					159
		1			32	6	4	3.37	#N/A	#N/A					163
		1		15-Jun	43	8	2	3.59	27.3	10.5					165
		1			67	12	4	4.22	125	8.7	Y	0	56.36		169
15		1		3:00p	10.5	2	2	3.28	33.6	12.6					171
		1			31.5	6	4	3.38	#N/A	#N/A					175
		1		16-Jun	43.5	8	2	3.58	27.2	9.56					177
		1			#N/A	12	4	12	#N/A	#N/A	Y	0	55.42		181
16		1		3:15pm	11	2	2	3.41	79.4	20.3					183
		1			3	6	4	3.54	#N/A	#N/A					187
		1		17-Jun	43.5	8	2	3.5	62.3	20.3					189
		1			#N/A	12	4	100	#N/A	#N/A	Y	1	56.30		193
17		2		11:45am	18	2	2	8.84	14.5	1.81					195
		2			60	6	4	16.63	#N/A	#N/A					199
		2		21-Jun	295	8	2	18.84	13.7	4.26					201
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.98		201
18		2		1:00pm	15.5	2	2	5.35	33.2	6.5					203
		2			52	6	4	5.65	#N/A	#N/A					207
		2		22-Jun	72	8	2	5.97	23.3	14.9					209
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.4		209

Appendix IV (Continued)
Table IV.1 (Continued)

19		1		10:15am	11	2	2	3.22	34.1	12.8					211
		1			33.5	6	4	3.37	#N/A	#N/A					215
		1		27-Jun	46	8	2	3.72	27.3	11.4					217
		1			91	10.5	2.5	#N/A	#N/A	#N/A	Y	0	56.06		219.5
20		1		5:00pm	16	2	2	3.25	28.1	8.23					221.5
		1			40	6	4	3.63	#N/A	#N/A					225.5
		1		28-Jun	63	8	2	3.87	24.3	9.25					227.5
		1			91	11	3	#N/A	51.5	153	Y	0	56.48		230.5
21		1		11:30am	11	2	2	3.31	33.7	10.2					232.5
		1			42	6	4	3.44	#N/A	#N/A					236.5
		1		29-Jun	51	8	2	3.54	13.8	10.8					238.5
		1			66	11	3	#N/A	164	93.1	Y	0	56.1		241.5
22		1		11:00am	#N/A	2	2	#N/A	#N/A	#N/A					243.5
		1			30	6	4	3.16	#N/A	#N/A					247.5
		1		30-Jun	41	8	2	3.13	28.2	13.5					249.5
		1			#N/A	11.25	3.25	13	19.9	14.5	Y	0	55.12		252.75
23		1		10:45am	10	2	2	2.7	32.2	14.4					254.75
		1			15.5	6	4	3.09	#N/A	#N/A					258.75
		1		1-Jul	32	8	2	8.6	31.7	12.1					260.75
		1			66	12	4	14.84	22.9	10.4	Y	0	56.33		264.75
24		1		3:00pm	10.5	2	2	2.94	30.2	12.7					266.75
		1			32.5	6	4	3.16	#N/A	#N/A					270.75
		1		1-Jul	43	8	2	3.25	28.8	9.77					272.75
		1			100	12	4	3.75	18.3	10.7	Y	0	55.7		276.75
25	1	1		11:10am	10.5	2	2	2.84	27.1	9.53					278.75
	1	1			30	6	4	3.25	#N/A	#N/A					282.75
	1	1		5-Jul	42	8	2	3.34	26.3	10					284.75
	1	1			67	12	4	3.69	21.7	10.9	Y	0	56.43		288.75
26	0	1		3:10pm	9.5	2	2	3.03	34.8	14.4					290.75
	0	1			32	6	4	3.5	#N/A	#N/A					294.75
	0	1		5-Jul	44.5	8	2	3.69	24.4	11.1					296.75
	0	1			72	12	4	4.66	19.9	10.2	Y	0	55.7		300.75

Appendix IV (Continued)
Table IV.1 (Continued)

27	1	2		11:45am	16	2	2	9.19	12.2	4.12					302.75
	1	2			106	6	4	49.41	#N/A	#N/A					306.75
	1	2		7-Jul	174	8	2	61.43	7.2	4.95					308.75
	1	2			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	56.2		312.75
28	0	1		#N/A	16	2	1	3.28	25	14.6					313.75
	0	1			43	6		3.63	#N/A	#N/A					313.75
	0	1		#N/A	53	8		4.06	25.9	14.2					313.75
	0	1			94	12		4.41	37.8	30.6	Y	0	56.48		313.75
29	0	1		2:20 PM	10	2	2	3.25	34.9	12					315.75
	0	1			27	6	4	3.63	#N/A	#N/A					319.75
	0	1		13-Jul	46.5	8	2	4.03	27.5	9.91					321.75
	0	1			75	12	4	5.53	20.2	10	Y	0	#N/A		325.75
30	1	2		12pm	45	2	2	4.62	9.46	6.36					327.75
	1	2			127	6	4	8.34	#N/A	#N/A					331.75
	1	2		14-Jul	254	8	2	10.31	9.64	15					333.75
	1	2			#N/A	12	4	#N/A	#N/A	#N/A	Y	0	56.42		337.75
31	1	1		3:00	9	2	2	2.41	24.8	18.3					339.75
	1	1			28.5	6	4	2.62	#N/A	#N/A					343.75
	1	1		14-Jul	42	8	2	#N/A	#N/A	#N/A					345.75
	1	1			73	12	4	139.45	16.9	12.3	Y	0	56.62		349.75
				Filter 6: High Turbidity Water - Data Entered											
								AVG	55.71636	6.566314	0.88				351
												# of Scrubs	7		

Appendix IV (Continued)
Table IV.1 (Continued)

Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incrementa Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
		1			#N/A	2	2	#N/A	74.2	0.85					2
1		1		#N/A	#N/A	7	5	#N/A	#N/A	#N/A					7
		1			#N/A	13	6	#N/A	76.2	0.22	Y	0	#N/A		13
		1			#N/A	2	2	#N/A	56.3	0.47					15
2		1		#N/A	#N/A	7	5	8.1	#N/A	#N/A					20
		1			#N/A	12	5	#N/A	20.2	1.54	Y	0	#N/A		25
		1			19	2	2	#N/A	74.8	0.7					27
3		1		3:17p/5-17	25	4	2	8.82	#N/A	#N/A					29
		1			84	12	8	#N/A	52.9	0.3	Y	1	57.48		37
		1			12	2	2	#N/A	82.8	0.35					39
4		1		1:38p/5-18	25	4	2	7.8	#N/A	#N/A					41
		1			86	12	8	#N/A	51.6	0.69	Y	0	58.22		49
		1			12	2	2	#N/A	76.4	1.02					51
5		1		4:00p/5-19	23	4	2	9.36	#N/A	#N/A					53
		1			79	12	8	#N/A	52.1	8.44	Y	0	57.42		61
		1			10	2	2	#N/A	73.9	0.6					63
6		1		1:02p	23	4	2	7.92	#N/A	#N/A					65
		1			81	12	8	#N/A	46.2	0.26	Y	1	57.00		73
		2			11	2	2	#N/A	54.6	0.18					75
7		2		2:28p	24	4	2	9.42	#N/A	#N/A					77
		2			78	12	8	#N/A	36.1	0.92	Y	0	56.98		85

Appendix IV (Continued)
Table IV.1 (Continued)

8		1		2:38p	11	2	2	#N/A	66.5	0.2					87
		1			24	4	2	9.54	#N/A	#N/A					89
		1			77	12	8	#N/A	45.4	0.27	Y	0	56.88		97
9		1		2:40p	11	2	2	#N/A	61.7	1.01					99
		1			21	4	2	9.54	#N/A	#N/A					101
		1			86	12	8	#N/A	44.5	0.56	Y	1	57.51		109
10		1		3:12p	13	2	2	#N/A	65	0.31					111
		1			26	4	2	9.84	#N/A	#N/A					113
		1			76	12	8	#N/A	50.6	0.78	Y	0	56.03		121
11		1		11:00a	10	2	2	4.62	83.8	0.56					113
		1			36	6	4	4.54	#N/A	#N/A					117
		1		13-Jun	48	8	2	4.41	51.5	0.11					119
		1			85.5	12	4	10	#N/A	#N/A	Y	0	#N/A		123
12		1		9:00a	12	2	2	4.19	72.5	0.23					125
		1			45	6	4	4.85	#N/A	#N/A					129
		1		14-Jun	56	8	2	4.51	48.2	0.28					131
		1			12	12	4	6.78	49.1	0.12	Y	0	#N/A		135
13		1		2:00p	11	2	2	3.28	73.5	0.35					137
		1			36	6	4	4.31	#N/A	#N/A					141
		1		14-Jun	49	8	2	4.12	58.3	0.71					143
		1			82	12	4	6.28	47.3	0.14	Y	0	56.54		147
14		1		2:30p	10	2	2	3.78	74.6	0.35					149
		1			36.5	6	4	4.19	#N/A	#N/A					153
		1		15-Jun	51	8	2	4.53	57.7	0.13					155
		1			83	12	4	6.56	21.7	0.19	Y	0	57.22		159
15		1		3:00p	14	2	2	4.4	66.1	1.92					161
		1			43.5	6	4	5.18	#N/A	#N/A					165
		1		16-Jun	65	8	2	5.93	54.4	0.49					167
		1			103	12	4	6.75	42.1	0.12	Y	0	56.11		171
16		1		3:15pm	13	2	2	4	76.6	0.15					173
		1			41	6	4	4.5	#N/A	#N/A					177
		1		17-Jun	56.5	8	2	4.56	60.6	0.17					179
		1			92.5	12	4	6.31	89.2	0.81	Y	1	56.92		183

Appendix IV (Continued)
Table IV.1 (Continued)

17		2		4:15pm	16	2	2	6.47	13	0.75					185
		2			195	6	4	12.54	#N/A	#N/A					189
		2		21-Jun	360	8	2	16.36	9.6	0.5					191
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	1	55.68		191
18		2		12:30pm	16	2	2	4.93	74.2	0.35					193
		2			56	6	4	6.28	#N/A	#N/A					197
		2		22-Jun	79	8	2	6.66	37.6	0.21					199
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.92		199
19		1		10:15am	13	2	2	4.09	72.2	0.17					201
		1			44	6	4	5.07	#N/A	#N/A					205
		1		27-Jun	62	8	2	5.12	54.6	0.11					207
		1			103	12	4	8.82	42	0.09	Y	0	55.76		211
20		1		5:00pm	19	2	2	4.68	68.3	0.19					213
		1			#N/A	6	4	#N/A	#N/A	#N/A					217
		1		28-Jun	75	8	2	5.25	58	0.32					219
		1			122	12	4	12.97	48.7	3.82	Y	1	55.42		223
21		1		11:30am	11	2	2	3.59	83.8	0.39					225
		1			38	6	4	4.41	#N/A	#N/A					229
		1		29-Jun	57	8	2	5.06	67.8	0.08					231
		1			92.5	12	4	6.84	59.9	0.09	Y	0	56.05		235
22		1		3:30pm	11	2	2	3.76	69.1	0.2					237
		1			39	6	4	4.65	#N/A	0.601002					241
		1		30-Jun	54	8	2	4.84	56.6	0.09					243
		1			92	12	4	6.02	52.4	0.16	Y	0	55.6		247
23		1		10:55am	14.5	2	2	4.19	69.8	0.44					249
		1			41	6	4	6	#N/A	0.687023					253
		1		1-Jul	63	8	2	5.85	40.8	0.07					255
		1			99	12	4	5.72	41.4	0.14	Y	0	55.64		259
24		1		3:00pm	11.5	2	2	4	79.8	0.15					261
		1			42	6	4	4.62	#N/A	0.869565					265
		1		1-Jul	60	8	2	5.29	63.7	0.21					267
		1			97	12	4	6.59	48.2	0.09	Y	0	55.72		271

Appendix IV (Continued)
Table IV.1 (Continued)

25	1	1		11:30am	14.5	2	2	4.47	69.1	0.15					273
	1	1			47	6	4	5.12	#N/A	#N/A					277
	1	1		5-Jul	66	8	2	5.47	49.9	0.1					279
	1	1			104.5	12	4	7.4	42.1	0.09	Y	0	55.8		283
26	0	1		3:30om	12.5	2	2	3.66	78	0.22					285
	0	1			41	6	4	4.34	#N/A	0.07					289
	0	1		5-Jul	56	8	2	4.66	54.4	0.12					291
	0	1			95.5	12	4	6.06	45.8	0.31	Y	0	57.14		295
27	1	2		11:45am	22	2	2	#N/A	9.96	0.31					297
	1	2			53	5.25	4	#N/A	#N/A	#N/A					301
	1	2		7-Jul	#N/A	#N/A	2	#N/A	#N/A	#N/A					303
	1	2			#N/A	#N/A	4	#N/A	#N/A	#N/A	Y	1	57.34		307
28	0	1		#N/A	17	2	2	3.53	62.5	0.26					309
	0	1			34	6	4	4.34	#N/A	#N/A					313
	0	1		#N/A	42	8	2	4.78	52	0.08					315
	0	1			80	12	4	4.88	63.9	0.12	Y	0	57.34		319
29	0	1		2:20pm	14	2	2	4.38	80.2	0.13					321
	0	1			44.5	6	4	4.94	#N/A	#N/A					325
	0	1		13-Jul	62	8	2	5.09	54.3	0.14					327
	0	1			99	12	4	6.06	46.3	0.19	Y	0	55.7		331
30	1	2		#N/A	86	2	2	31.04	8.34	0.67					333
	1	2			#N/A	6	4	#N/A	#N/A	#N/A					337
	1	2		#N/A	420	8.5	2	78	5.63	1.32					339
	1	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.4		339
31	1	1		9:00	13	2	2	4.59	72.4	0.1					341
	1	1			45	6	4	5.28	#N/A	#N/A					345
	1	1		15-Jul	61	8	2	6	58.7	0.19					347
	1	1			109	12	4	7.56	40.7	0.08	Y	0	56.14		351
32	0	1		1:00	23	3	3	4.65	75.5	0.16					354
	0	1			48	6	3	4.79	#N/A	#N/A					357
	0	1		15-Jul	61	8	2	5.28	55	0.12					359
	0	1			105	12	4	7	41	0.19	Y	0	55.96		363

Appendix IV (Continued)
Table IV.1 (Continued)

33	0	1		2:00	15	2	2	4.44	64.7	0.08					365
	0	1			50	6	4	5.43	#N/A	#N/A					369
	0	1		16-Jul	66	8	2	5.91	53.7	0.53					371
	0	1			123	13	5	6.33	147	0.29	Y	0	56.18		376
34	0	1		9:30	24	3	3	5.63	67.1	0.21					379
	0	1			62	6.5	3.5	6.65	#N/A	#N/A					382.5
	0	1		18-Jul	80	8	1.5	6.75	49.9	0.23					384
	0	1			131	12	4	937	33.5	0.22	Y	0	56.02		388
35	0	1		12:45	14	2	2	3.84	79.9	0.4					390
	0	1			55	6	4	4.09	#N/A	#N/A					394
	0	1		18-Jul	72	8.25	2.25	5.28	51	0.12					396.25
	0	1			111	12	3.75	8.09	42.5	0.21	Y	0	57.08		400
36	1	1		9:00	16	2	2	4.09	82.7	0.5					396.25
	1	1			44	6	4	4.92	#N/A	#N/A					400
	1	1		18-Jul	60	8	2	5.21	53.9	0.08					402
	1	1			121	13	5	13.91	38.9	0.25	Y	0	56.1		400.25
37	0	1		9:00	14	2	2	4	74.5	0.14					402.25
	0	1			50	6.5	4.5	5.31	#N/A	#N/A					406.75
	0	1		19-Jul	65	8	1.5	5.38	73.9	0.25					408.25
	0	1			110	12	4	6.88	52.1	0.09	Y	0	56.24		412.25
38	0	1		1:40	11	2	2	3.72	24.2	0.13					414.25
	0	1			51	6	4	8.04	#N/A	#N/A					418.25
	0	1		19-Jul	69	8	2	7.4	55.4	0.09					420.25
	0	1			123	12	4	8.6	41.3	0.07	Y	2	56.72		424.25
39	0	1		11:30	13	2	2	4.31	65.8	0.12					426.25
	0	1			45	6	4	7.41	#N/A	#N/A					430.25
	0	1		20-Jul	72	8	2	5.28	47.6	0.21					432.25
	0	1			110	8.5	0.5	6.57	45.9	0.08	Y	0	56.41		432.75
40	1	2		2:30	22	2	2	10.19	8.7	1.65					434.75
	1	2			201	6	4	73.86	#N/A	#N/A					438.75
	1	2		20-Jul	420	8	2	#N/A	7.08	0.72					440.75
	1	2			#N/A	11.25	3.25	#N/A	#N/A	#N/A	Y	0	56.55		444

Appendix IV (Continued)
Table IV.1 (Continued)

41	0	1		9:30	0	0	8	5.47	66.6	0.44					452
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					452
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					452
	0	1			120	10	10	10.34	44.2	0.11	Y	0	55.37		462
42	1	1		12:30	0	0	0	3.78	77.3	0.43					462
	1	1			#N/A	0	0	#N/A	#N/A	#N/A					462
	1	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					462
	1	1			120	13	13	7.06	35.7	0.27	Y	0	55.47		475
43	0	1		3:45	0	0	0	3.66	67.2	0.36					475
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					475
	0	1		22-Jul	#N/A	0	0	#N/A	#N/A	#N/A					475
	0	1			120	14	14	#N/A	17.6	0.12	Y	0	56.54		489
44	0	1		9:45	0	0	0	3.78	69.4	0.91					489
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					489
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					489
	0	1			120	13	13	8.62	39	0.08	Y	0	55.32		502
45	0	1		1:05	0	0	0	3.97	75.1	0.48					502
	0	1			#N/A	0	0	#N/A	#N/A	#N/A					502
	0	1		25-Jul	#N/A	0	0	#N/A	#N/A	#N/A					502
	0	1			120	13	13	7.81	43	0.19	Y	0	55.58		515
46	0	1		3:55	0	0	0	5.38	77.3	0.37					502
	0	1			60	0	0	#N/A	#N/A	#N/A					502
	0	1		1-Jul	120	9.75	9.75	9.56	51.8	0.06	Y	0	55.68		511.75
47	1	1		6:30	0	0	0	6.41	45.6	0.46					511.75
	1	1			60	#N/A	0	#N/A	59	0.14					511.75
	1	1		26-Jul	120	8	8	9.47	40.7	0.09	Y	0	55.72		519.75
48	0	1		#N/A	0	0	0	4.1	65.3	0.18					519.75
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					519.75
	0	1		26-Jul	120	13.8	13.8	11.28	42.4	0.46	Y	0	57.62		533.55
49	0	1		4:30	0	0	0	3.35	74.8	0.32					533.55
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					533.55
	0	1		26-Jul	120	14	14	10.53	39.1	0.11	Y	0	57.37		547.55

Appendix IV (Continued)
Table IV.1 (Continued)

	1	2		9:45	0	0	0	5	10.6	0.68					547.55
50	1	2			60	2	2	49.44	8.48	0.3					549.55
	1	2		27-Jul	120	5.2	5.2	43.62	9.04	0.21	Y	0	55.41		554.75
	0	1		12:30	0	0	0	5.82	78.1	1.04					554.75
51	0	1			60	#N/A	0	#N/A	#N/A	#N/A					554.75
	0	1		27-Jul	120	10.5	10.5	9.53	36.4	0.08	Y	0	55.72		565.25
	0	1		3:45	0	0	0	5.41	93.2	0.18					565.25
52	0	1			60	#N/A	0	#N/A	#N/A	#N/A					565.25
	0	1		27-Jul	120	10	10	9.53	42.3	0.12	Y	0	55.48		575.25
	1	1		11:00	0	0	0	5.18	83.6	0.28					575.25
53	1	1			60	#N/A	0	#N/A	76.7	0.09					575.25
	1	1		28-Jul	120	12	12	7.88	39.4	0.06	Y	0	56.1		587.25
	0	1		10:55	0	0	0	4.56	76.7	0.11					587.25
54	0	1			60	#N/A	0	#N/A	#N/A	#N/A					587.25
	0	1		29-Jul	120	12.1	12.1	8.28	45.2	0.08	Y	0	55.4		599.35
	0	1		11.:50	0	0	0	3.88	91.8	0.18					599.35
55	0	1			60	#N/A	0	#N/A	#N/A	#N/A					599.35
	0	1		29-Jul	120	9	9	12.65	45.5	0.08	Y	0	55.42		608.35
	0	1		10:25	0	0	0	8.09	75	0.26					608.35
56	0	1			60	#N/A	0	#N/A	#N/A	#N/A					608.35
	0	1		1-Aug	120	6	6	15.37	47.1	0.13	Y	0	55.4		614.35
	0	1		1:30	0	0	0	4.1	94.4	0.02					614.35
57	0	1			60	#N/A	0	#N/A	#N/A	#N/A					614.35
	0	1		1-Aug	120	9.2	9.2	12.17	50.4	0.16	Y	0	55.86		623.55
	1	1		10:25	0	0	0	4.33	68.3	0.17					623.55
58	1	1			60	#N/A	0	5.43	44	0.33					623.55
	1	1		2-Aug	120	11.1	11.1	7.12	35.3	0.11	Y	0	55.62		634.65
	0	1		1:30	0	0	0	4.02	78.9	0.3					634.65
59	0	1			60	#N/A	0	#N/A	#N/A	#N/A					634.65
	0	1		2-Aug	120	12.5	12.5	10.3	39.6	0.15	Y	0	55.31		647.15
	1	2		12:40	0	0	0	8.88	11	0.5					647.15
60	1	2			60	#N/A	0	#N/A	9.99	0.41					647.15
	1	2		5-Aug	120	3.5	3.5	50.47	9.05	0.34	Y	0	55.28		650.65

Appendix IV (Continued)
Table IV.1 (Continued)

61	0	1		#N/A	0	0	0	5.57	79.1	0.88					650.65
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					650.65
	0	1		8-Aug	120	11	11	8.09	43.9	0.08	Y	0	56.38		661.65
62	0	1		#N/A	0	0	0	3.94	85	0.29					661.65
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					661.65
	0	1		8-Aug	120	12.5	12.5	8.34	72	0.17	Y	0	56.49		674.15
63	1	2		#N/A	0	0	0	12.81	8.46	0.48					674.15
	1	2			60	#N/A	0	#N/A	7.86	0.33					674.15
	1	2		11-Aug	120	4.5	4.5	28.05	7.16	0.53	Y	0	55.92		678.65
64	0	1		2:30	0	0	0	3.66	62.8	0.51					678.65
	0	1			60	#N/A	4.5	#N/A	#N/A	#N/A					683.15
	0	1		1-Sep	120	12.5	12.5	7.35	25.5	0.13	Y	0	55.52		695.65
65	1	1		4:00	0	0	0	6.06	75.2	0.62					695.65
	1	1			60	#N/A	0	#N/A	56.2	0.16					695.65
	1	1		8-Sep	120	9	9	7.45	44.7	0.12	Y	0	55.75		704.65
66	0	1		2:30	0	0	0	5.48	82.7	0.11					704.65
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					704.65
	0	1		9-Sep	120	12.5	12.5	7.6	44.2	0.09	Y	0	56.84		717.15
67	0	1		5:30	0	0	0	3.63	97.1	0.38					717.15
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					717.15
	0	1		9-Sep	120	14	14	22.33	37.9	0.16	Y	0	55.3		731.15
68	0	1		12:00	0	0	0	4.06	88.5	1.74					731.15
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					731.15
	0	1		10-Sep	120	13.75	13.75	10.35	35.1	0.18	Y	0	56.72		744.9
69	0	1		2:30	0	0	0	4.16	84.2	0.38					744.9
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					744.9
	0	1		10-Sep	120	14	14	6.53	30.2	0.17	Y	0	55.29		758.9
70	1	1		5:00	0	0	0	4.12	97.3	1.55					758.9
	1	1			60	#N/A	0	#N/A	66.7	0.12					758.9
	1	1		10-Sep	120	13.5	13.5	9.47	38.9	0.11	Y	0	56.62		772.4
71	0	1		7:30	0	0	0	3.56	87.9	0.31					772.4
	0	1			60	#N/A	0	#N/A	#N/A	#N/A					772.4
	0	1		10-Sep	120	14	14	7.34	33.8	0.13	Y	0	55.68		786.4

Appendix IV (Continued)
Table IV.1 (Continued)

	0	1		11:45	0	0	0	3.5	85.5	0.34					786.4
72	0	1			60	#N/A	0	#N/A	#N/A	#N/A					786.4
	0	1		11-Sep	120	13.5	13.5	7.84	35	0.17	Y	0	56.69		799.9
	1	2		2:00	0	0	0	14.37	16.9	0.47					799.9
73	1	2			60	#N/A	0	#N/A	21.1	0.27					799.9
	1	2		11-Sep	120	3.5	3.5	52	12.3	0.36	Y	0	#N/A		803.4
	0	1		11:00	0	0	0	4.09	80.6	0.16					803.4
74	0	1			60	#N/A	3.5	#N/A	#N/A	#N/A					806.9
	0	1		12-Sep	120	14	14	100	44.5	0.25	Y	0	#N/A		820.9
	0	1		1:30	0	0	0	4.28	83.7	0.25					820.9
75	0	1			60	#N/A	14	#N/A	#N/A	#N/A					834.9
	0	1		12-Sep	120	11	11	7.56	53.9	0.25	Y	0	#N/A		845.9
	1	1		3:00	0	0	0	4.56	91.8	0.27					845.9
76	1	1			60	#N/A	11	#N/A	55.8	0.19					856.9
	1	1		12-Sep	120	12	12	8.28	44.7	0.12	Y	0	#N/A		868.9
	0	1		5:30	0	0	0	5.15	78.8	0.13					868.9
77	0	1			60	#N/A	0	#N/A	#N/A	#N/A					868.9
	0	1		12-Sep	120	14	14	11.15	71.6	0.18	Y	0	#N/A		882.9
	0	1		8:00	0	0	0	6.12	87.8	0.42					882.9
78	0	1			60	#N/A	14	#N/A	#N/A	#N/A					896.9
	0	1		13-Sep	120	11	11	9.88	43.7	0.2	Y	0	#N/A		907.9
	0	1		3:00	0	0	0	5.15	74.1	0.11					907.9
79	0	1			60	#N/A	11	#N/A	#N/A	#N/A					918.9
	0	1		13-Sep	120	14	14	11.15	71.6	0.18	Y	0	#N/A		932.9
	0	1		10:00	0	0	0	4.5	71.6	0.09					932.9
80	0	1			60	#N/A	0	#N/A	#N/A	#N/A					932.9
	0	1		14-Sep	120	13	13	7.15	41.1	0.19	Y	0	#N/A		945.9
	1	1		3:00	0	0	0	5.09	79.6	0.23					945.9
81	1	1			60	#N/A	0	#N/A	67.1	#N/A					945.9
	1	1		14-Sep	120	11.5	11.5	7.19	165	0.25	Y	0	#N/A		957.4
	0	1		3:00	0	0	0	4.66	79.1	0.5					957.4
82	0	1			60	#N/A	0	#N/A	#N/A	#N/A					957.4
	0	1		15-Sep	120	14	14	8.56	44.2	0.21	Y	0	#N/A		971.4

Appendix IV (Continued)
Table IV.1 (Continued)

	1	2		1:30	0	0	0	5.69	9.45	0.53					971.4
83	1	2			60	#N/A	0	#N/A	13	0.9					971.4
	1	2		16-Sep	120	4	4	31	8.36	0.82	Y	0	#N/A		971.4
	0	1		4:30	0	0	0	4.78	80	1.33					971.4
84	0	1			60	#N/A	0	#N/A	#N/A	#N/A					971.4
	0	1		16-Sep	120	12	12	6.19	43.8	3.99	Y	0	#N/A		983.4
	0	1		10:00	0	0	0	5.57	73.3	0.7					983.4
85	0	1			60	#N/A	0	#N/A	#N/A	#N/A					983.4
	0	1		17-Sep	120	10	10	6.5	44.8	0.25	Y	0	#N/A		993.4
	0	1		12:30	0	0	0	4.19	72.8	0.23					993.4
86	0	1			60	#N/A	0	#N/A	#N/A	#N/A					993.4
	0	1		17-Sep	120	12	12	6.84	45.8	0.39	Y	0	#N/A		1005.4
	1	1		3:00	0	0	0	4.47	82.4	0.14					1005.4
87	1	1			60	#N/A	0	#N/A	50.8	0.18					1005.4
	1	1		17-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		1017.4
	0	1		12:00	0	0	0	4.28	77.1	0.35					1017.4
88	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1017.4
	0	1		20-Sep	120	16	16	#N/A	#N/A	#N/A	Y	0	#N/A		1033.4
	0	1		10:00	0	0	0	4.69	88.3	0.32					1033.4
89	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1033.4
	0	1		21-Sep	120	14	14	#N/A	39	0.25	Y	0	#N/A		1047.4
	0	1		3:00	0	0	0	5.46	82.6	0.35					1047.4
90	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1047.4
	0	1		21-Sep	120	12	12	#N/A	#N/A	#N/A	Y	0	#N/A		1059.4
	0	1		3:30	0	0	0	4.47	73.7	0.29					1059.4
91	0	1			60	#N/A	0	#N/A	#N/A	#N/A					1059.4
	0	1		22-Sep	120	14	14	#N/A	#N/A	#N/A	Y	0	#N/A		1073.4
				Filter 7: High Turbidity Water - Data Entered											
								AVG	56.24115	23.57769	0.58				346

Appendix IV (Continued)
Table IV.1 (Continued)

												# of Scrubs	4		
Bucket	TSS (1 - yes, 0 - no)	1 - Syn, 2 - PW		Filter Start Time/Date (HH:MM)/ (MM-DD)	Filter Time (min)	Volume Filtered (L)	Incrementa Volume (L)	Time to 10mL (s)	Influent Turbidity (NTU)	Effluent Turbidity (NTU)	BW (Y/N)	Scrub (Y = 1 / N=0)	Dia. after Scrub (mm)		Cumul. Vol Filtered (L)
		1			#N/A	2	2	#N/A	83.4	1.28					2
1		1		#N/A	#N/A	7	5	#N/A	#N/A	#N/A					7
		1			#N/A	13	6	#N/A	#N/A	#N/A	Y	0	#N/A		13
		1			#N/A	2	2	#N/A	79	1.61					15
2		1		#N/A	#N/A	7	5	7.2	#N/A	#N/A					20
		1			#N/A	12	5	#N/A	125	1.49	Y	0	#N/A		25
		1			17	2	2	#N/A	84.2	1.52					27
3		1		3:17p/5-17	25	4	2	8.4	#N/A	#N/A					29
		1			91	12	8	#N/A	51.8	0.2	Y	1	57.00		37
		1			12	2	2	#N/A	71.7	14.5					39
4		1		1:38p/5-18	25	4	2	8.28	#N/A	#N/A					41
		1			86	12	8	#N/A	65.5	10.5	Y	0	57.64		49
		1			10	2	2	#N/A	85.8	15.2					51
5		1		4:00p/5-19	22	4	2	10.26	#N/A	#N/A					53
		1			73	12	8	#N/A	68.9	10.1	Y	0	57.51		61
		1			10	2	2	#N/A	77.2	18.5					63
6		1		1:02p	21	4	2	10.02	#N/A	#N/A					65
		1			74	12	8	#N/A	50.1	20.6	Y	1	56.51		73
		2			10	2	2	#N/A	60.7	15.6					75
7		2		2:28p	19	4	2	9.96	#N/A	#N/A					77
		2			79	12	8	#N/A	47.5	13	Y	0	56.61		85

Appendix IV (Continued)
Table IV.1 (Continued)

8		1		2:38p	12	2	2	#N/A	81.7	19.5					87
		1			22	4	2	9.18	#N/A	#N/A					89
		1			80	12	8	#N/A	49.3	14.9	Y	0	56.81		97
9		1		2:40p	10	2	2	#N/A	58.6	25.1					99
		1			20	4	2	11.76	#N/A	#N/A					101
		1			71	12	8	#N/A	44.8	18.6	Y	1	56.00		109
10		1		3:12p	11	2	2	#N/A	71.5	23.3					111
		1			21	4	2	10.98	#N/A	#N/A					113
		1			20	12	8	#N/A	53.3	16.7	Y	0	56.96		121
11		1		1:45	8.5	2	2	3.53	43.2	6.8					123
		1			31.5	6	4	4.19	#N/A	#N/A					127
		1		10-Jun	43.5	8	2	4.68	58.7	13					129
		1			106	12	4	20.22	41.6	9.98	Y	0	56.22		133
12		1		3:20	10	2	2	3.56	75.7	20.5					135
		1			33	6	4	3.46	#N/A	#N/A					139
		1		13-Jun	45	8	2	3.66	47.6	18					141
		1			91	12	4	#N/A	44.3	6.28	Y	0	#N/A		145
13		1		3:30	9.5	2	2	3.28	70	23.5					147
		1			31	6	4	3.85	#N/A	#N/A					151
		1		14-Jun	43	8	2	3	59.9	20					153
		1			77	12	4	16.05	44.7	9	Y	0	56.22		157
14		1		9:30	20	2	2	3.65	73.2	16					159
		1			45	6	4	3.5	#N/A	#N/A					163
		1		16-Jun	62	8	2	3.5	60	15.5					165
		1			90	11	3	12	36.6	8.66	Y	0	56.18		168
15		1		5:30	10	2	2	3.29	78.2	35.7					170
		1			33	6	4	3.75	#N/A	#N/A					174
		1		16-Jun	45	8	2	3.91	52.2	30.9					176
		1			#N/A	12	4	#N/A	50.2	16.2	Y	0	56.14		180
16		1		10:30am	7.5	2	2	2.71	76.8	43.7					182
		1			29	6	4	2.6	#N/A	#N/A					186
		1		17-Jun	38	8	2	2.71	60.8	30.3					188
		1			#N/A	12	4	12	42.6	13.7	Y	1	56.02		192

Appendix IV (Continued)
Table IV.1 (Continued)

17		2		12:30pm	13	2	2	6.44	10	5.95					194
		2			165	6	4	16.75	#N/A	#N/A					198
		2		22-Jun	180	8	2	#N/A	13.7	7.44					200
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.02		200
18		2		12:30pm	15	2	2	4.19	16.9	10.7					202
		2			45	6	4	4.44	#N/A	#N/A					206
		2		22-Jun	70	8	2	5.46	17.8	9.6					208
		2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.10		208
19		1		10:15am	10	2	2	2.66	56	44.1					210
		1			28	6	4	2.84	#N/A	#N/A					214
		1		27-Jun	36	8	2	2.84	68.7	49.5					216
		1			57	#N/A	0	3.34	55.7	45.8	Y	0	55.90		216
20		1		5:00pm	9.5	2	2	3	70	36.6					218
		1			32	6	4	3.37	#N/A	#N/A					222
		1		28-Jun	45.5	8	2	3.62	46.3	27.1					224
		1			72	12	4	7.53	53.9	25	Y	0	56.06		228
21		1		11:30am	15	2	2	2.94	82.6	45.3					230
		1			27	6	4	3.15	#N/A	#N/A					234
		1		29-Jun	45	8	2	3.84	71.2	41.2					236
		1			70	12	4	11.78	73.4	41.8	Y	0	56.10		240
22		1		1:00pm	8	2	2	2.47	67.4	54.6					242
		1			25	6	4	2.5	#N/A	#N/A					246
		1		29-Jun	33	8	2	2.66	51.7	42.1					248
		1			52	12	4	3.69	54.5	44.6	Y	0	55.94		252
23		1		10:55	10	2	2	2.91	73	32.4					254
		1			31	6	4	2.99	#N/A	#N/A					258
		1		1-Jul	41	8	2	3.52	61.7	28.7					260
		1			79	12	4	>13	41	13.6	Y	0	56.1		264
24		1		3:00	9.5	2	2	2.93	85.1	47.5					266
		1			29	6	4	2.84	#N/A	#N/A					270
		1		1-Jul	39	8	2	2.78	64.4	31.7					272
		1			76	12	4	14.72	46.9	11.2	Y	0	56.28		276

Appendix IV (Continued)
Table IV.1 (Continued)

25	1	1		11:30am	9.5	2	2	2.75	67	54.3					278
	1	1			28.5	6	4	2.91	#N/A	#N/A					282
	1	1		5-Jul	41	8	2	3.31	54	43					284
	1	1			77	12	4	>13	45.3	14.7	Y	0	56.1		288
26	0	1		3:30pm	10	2	2	2.82	82.6	54.3					290
	0	1			31	6	4	3	#N/A	#N/A					294
	0	1		5-Jul	41.5	8	2	3.18	60.2	34					296
	0	1			#N/A	10	2	>13	45.5	17.6	Y	0	56.14		298
27	1	2		11:45	17	2	2	3.25	10.7	8.48					300
	1	2			42	6	4	3.5	#N/A	#N/A					304
	1	2		7-Jul	64	8	2	#N/A	18.6	13.6					306
	1	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	56.24		306
28	0	1		#N/A	18	2	2	2.56	78.2	38.7					308
	0	1			34	6	4	2.85	#N/A	#N/A					312
	0	1		#N/A	42	8	2	2.9	20.6	30					314
	0	1			72	#N/A	0	8.9	47.1	22.8	Y	0	#N/A		314
29	0	1		2:20 AM	8	4	2	2.47	43.1	33.4					316
	0	1			25.3	6	4	2.59	#N/A	#N/A					320
	0	1		13-Jul	67	8	2	2.57	46.1	31.1					322
	0	1			92	12	4	4.72	50	28.2	Y	0	56.12		326
30	1	2		#N/A	16	3	2	3.28	8.81	9.47					328
	1	2			37.5	6	4	2.87	#N/A	#N/A					332
	1	2		#N/A	75	8	2	#N/A	11	7.6					334
	1	2			#N/A	#N/A	0	#N/A	#N/A	#N/A	Y	0	55.62		334
31	1	1		#N/A	9	2	2	2.35	77.7	55.6					336
	1	1			28.5	7	4	2.53	#N/A	#N/A					340
	1	1		#N/A	37	9	2	2.563	66.6	43.6					342
	1	1			68.5	12	4	23.03	45.5	22.2	Y	0	56.42		346

Appendix IV (Continued)
Table IV.2 Particle size data

Influent Pond						Effluent Pond				
Sample 6 - Run 2						Sample 7 - Run 1				
DF	3.73					DF	1.3			
Diameter	Counts	P/mL	Num %	Num % > Dia		Diameter	Counts	P/mL	Num %	Num % > Dia
0.514	31100	116003	9.52%	9.52%		0.514	5074	6596.2	16%	15.52%
0.542	22556	84133.88	6.90%	16.42%		0.542	3364	4373.2	10%	25.82%
0.572	33822	126156.06	10.35%	26.77%		0.572	4366	5675.8	13%	39.18%
0.604	31362	116980.26	9.60%	36.36%		0.604	3700	4810	11%	50.50%
0.637	21514	80247.22	6.58%	42.95%		0.637	2198	2857.4	7%	57.22%
0.673	27186	101403.78	8.32%	51.26%		0.673	2518	3273.4	8%	64.92%
0.71	15868	59187.64	4.86%	56.12%		0.71	1386	1801.8	4%	69.17%
0.749	15210	56733.3	4.65%	60.77%		0.749	1296	1684.8	4%	73.13%
0.791	13946	52018.58	4.27%	65.04%		0.791	1138	1479.4	3%	76.61%
0.835	11010	41067.3	3.37%	68.41%		0.835	854	1110.2	3%	79.23%
0.881	10102	37680.46	3.09%	71.50%		0.881	778	1011.4	2%	81.61%
0.93	8698	32443.54	2.66%	74.16%		0.93	560	728	2%	83.32%
0.982	9478	35352.94	2.90%	77.06%		0.982	606	787.8	2%	85.17%
1.036	8500	31705	2.60%	79.66%		1.036	548	712.4	2%	86.85%
1.093	7204	26870.92	2.20%	81.87%		1.093	404	525.2	1%	88.09%
1.154	6078	22670.94	1.86%	83.73%		1.154	338	439.4	1%	89.12%
1.218	6762	25222.26	2.07%	85.79%		1.218	388	504.4	1%	90.31%
1.286	4252	15859.96	1.30%	87.10%		1.286	238	309.4	1%	91.04%
1.357	5474	20418.02	1.67%	88.77%		1.357	222	288.6	1%	91.71%
1.432	4458	16628.34	1.36%	90.13%		1.432	166	215.8	1%	92.22%
1.512	3752	13994.96	1.15%	91.28%		1.512	154	200.2	0%	92.69%
1.595	3424	12771.52	1.05%	92.33%		1.595	120	156	0%	93.06%
1.684	2964	11055.72	0.91%	93.24%		1.684	124	161.2	0%	93.44%
1.777	2342	8735.66	0.72%	93.95%		1.777	102	132.6	0%	93.75%
1.876	2166	8079.18	0.66%	94.62%		1.876	66	85.8	0%	93.95%
1.98	1484	5535.32	0.45%	95.07%		1.98	58	75.4	0%	94.13%

Appendix IV (Continued)
Table IV.2 (Continued)

2.09	1286	4796.78	0.39%	95.46%		2.09	48	62.4	0%	94.28%
2.205	1518	5662.14	0.46%	95.93%		2.205	48	62.4	0%	94.43%
2.328	1018	3797.14	0.31%	96.24%		2.328	52	67.6	0%	94.58%
2.457	1054	3931.42	0.32%	96.56%		2.457	38	49.4	0%	94.70%
2.593	660	2461.8	0.20%	96.76%		2.593	28	36.4	0%	94.79%
2.737	920	3431.6	0.28%	97.05%		2.737	28	36.4	0%	94.87%
2.889	654	2439.42	0.20%	97.25%		2.889	24	31.2	0%	94.95%
3.049	882	3289.86	0.27%	97.52%		3.049	32	41.6	0%	95.04%
3.218	614	2290.22	0.19%	97.70%		3.218	22	28.6	0%	95.11%
3.396	496	1850.08	0.15%	97.86%		3.396	40	52	0%	95.23%
3.585	464	1730.72	0.14%	98.00%		3.585	40	52	0%	95.36%
3.783	460	1715.8	0.14%	98.14%		3.783	44	57.2	0%	95.49%
3.993	422	1574.06	0.13%	98.27%		3.993	42	54.6	0%	95.62%
4.215	488	1820.24	0.15%	98.42%		4.215	66	85.8	0%	95.82%
4.448	466	1738.18	0.14%	98.56%		4.448	134	174.2	0%	96.23%
4.695	488	1820.24	0.15%	98.71%		4.695	438	569.4	1%	97.57%
4.955	256	954.88	0.08%	98.79%		4.955	152	197.6	0%	98.04%
5.23	362	1350.26	0.11%	98.90%		5.23	28	36.4	0%	98.12%
5.52	298	1111.54	0.09%	98.99%		5.52	24	31.2	0%	98.19%
5.826	204	760.92	0.06%	99.05%		5.826	8	10.4	0%	98.22%
6.149	314	1171.22	0.10%	99.15%		6.149	12	15.6	0%	98.26%
6.49	236	880.28	0.07%	99.22%		6.49	8	10.4	0%	98.28%
6.85	292	1089.16	0.09%	99.31%		6.85	18	23.4	0%	98.34%
7.23	250	932.5	0.08%	99.39%		7.23	20	26	0%	98.40%
7.631	168	626.64	0.05%	99.44%		7.631	22	28.6	0%	98.46%
8.054	248	925.04	0.08%	99.51%		8.054	26	33.8	0%	98.54%
8.5	186	693.78	0.06%	99.57%		8.5	12	15.6	0%	98.58%
8.972	182	678.86	0.06%	99.63%		8.972	10	13	0%	98.61%
9.469	164	611.72	0.05%	99.68%		9.469	28	36.4	0%	98.70%
9.994	142	529.66	0.04%	99.72%		9.994	24	31.2	0%	98.77%
10.548	142	529.66	0.04%	99.76%		10.548	18	23.4	0%	98.83%
11.133	156	581.88	0.05%	99.81%		11.133	8	10.4	0%	98.85%

Appendix IV (Continued)
Table IV.2 (Continued)

11.751	114	425.22	0.03%	99.85%		11.751	24	31.2	0%	98.92%
12.402	92	343.16	0.03%	99.87%		12.402	20	26	0%	98.98%
13.09	76	283.48	0.02%	99.90%		13.09	30	39	0%	99.08%
13.816	58	216.34	0.02%	99.91%		13.816	20	26	0%	99.14%
14.582	56	208.88	0.02%	99.93%		14.582	10	13	0%	99.17%
15.39	40	149.2	0.01%	99.94%		15.39	20	26	0%	99.23%
16.244	24	89.52	0.01%	99.95%		16.244	16	20.8	0%	99.28%
17.145	20	74.6	0.01%	99.96%		17.145	12	15.6	0%	99.31%
18.095	30	111.9	0.01%	99.97%		18.095	28	36.4	0%	99.40%
19.099	18	67.14	0.01%	99.97%		19.099	8	10.4	0%	99.42%
20.158	24	89.52	0.01%	99.98%		20.158	14	18.2	0%	99.47%
21.275	12	44.76	0.00%	99.98%		21.275	8	10.4	0%	99.49%
22.455	14	52.22	0.00%	99.99%		22.455	10	13	0%	99.52%
23.7	4	14.92	0.00%	99.99%		23.7	6	7.8	0%	99.54%
25.014	18	67.14	0.01%	99.99%		25.014	4	5.2	0%	99.55%
26.401	6	22.38	0.00%	100.00%		26.401	12	15.6	0%	99.59%
27.865	0	0	0.00%	100.00%		27.865	8	10.4	0%	99.61%
29.41	0	0	0.00%	100.00%		29.41	6	7.8	0%	99.63%
31.041	4	14.92	0.00%	100.00%		31.041	14	18.2	0%	99.68%
32.762	0	0	0.00%	100.00%		32.762	12	15.6	0%	99.71%
34.579	2	7.46	0.00%	100.00%		34.579	2	2.6	0%	99.72%
36.497	4	14.92	0.00%	100.00%		36.497	12	15.6	0%	99.76%
38.52	0	0	0.00%	100.00%		38.52	8	10.4	0%	99.78%
40.656	4	14.92	0.00%	100.00%		40.656	8	10.4	0%	99.80%
42.911	0	0	0.00%	100.00%		42.911	10	13	0%	99.83%
45.29	0	0	0.00%	100.00%		45.29	8	10.4	0%	99.86%
47.801	0	0	0.00%	100.00%		47.801	8	10.4	0%	99.88%
50.452	0	0	0.00%	100.00%		50.452	10	13	0%	99.91%
53.249	0	0	0.00%	100.00%		53.249	4	5.2	0%	99.93%
56.202	0	0	0.00%	100.00%		56.202	8	10.4	0%	99.95%
59.318	0	0	0.00%	100.00%		59.318	6	7.8	0%	99.97%
62.607	0	0	0.00%	100.00%		62.607	4	5.2	0%	99.98%

Appendix IV (Continued)
Table IV.2 (Continued)

66.079	0	0	0.00%	100.00%		66.079	2	2.6	0%	99.99%
69.743	0	0	0.00%	100.00%		69.743	2	2.6	0%	99.99%
73.61	0	0	0.00%	100.00%		73.61	0	0	0%	99.99%
77.692	0	0	0.00%	100.00%		77.692	2	2.6	0%	100.00%
82	0	0	0.00%	100.00%		82	0	0	0%	100.00%
86.547	0	0	0.00%	100.00%		86.547	0	0	0%	100.00%
91.346	0	0	0.00%	100.00%		91.346	0	0	0%	100.00%
96.411	0	0	0.00%	100.00%		96.411	0	0	0%	100.00%
101.757	0	0	0.00%	100.00%		101.757	0	0	0%	100.00%
107.399	0	0	0.00%	100.00%		107.399	0	0	0%	100.00%
113.354	0	0	0.00%	100.00%		113.354	0	0	0%	100.00%
119.64	0	0	0.00%	100.00%		119.64	0	0	0%	100.00%
126.274	0	0	0.00%	100.00%		126.274	0	0	0%	100.00%
133.276	0	0	0.00%	100.00%		133.276	0	0	0%	100.00%
140.666	0	0	0.00%	100.00%		140.666	0	0	0%	100.00%
148.466	0	0	0.00%	100.00%		148.466	0	0	0%	100.00%
156.698	0	0	0.00%	100.00%		156.698	0	0	0%	100.00%
165.387	0	0	0.00%	100.00%		165.387	0	0	0%	100.00%
174.558	0	0	0.00%	100.00%		174.558	0	0	0%	100.00%
184.237	0	0	0.00%	100.00%		184.237	0	0	0%	100.00%
194.453	0	0	0.00%	100.00%		194.453	0	0	0%	100.00%
205.235	0	0	0.00%	100.00%		205.235	0	0	0%	100.00%
216.615	0	0	0.00%	100.00%		216.615	0	0	0%	100.00%
228.626	0	0	0.00%	100.00%		228.626	0	0	0%	100.00%
241.304	0	0	0.00%	100.00%		241.304	0	0	0%	100.00%
254.684	0	0	0.00%	100.00%		254.684	0	0	0%	100.00%
268.806	0	0	0.00%	100.00%		268.806	0	0	0%	100.00%
283.711	0	0	0.00%	100.00%		283.711	0	0	0%	100.00%
299.443	0	0	0.00%	100.00%		299.443	0	0	0%	100.00%
316.047	0	0	0.00%	100.00%		316.047	0	0	0%	100.00%
333.571	0	0	0.00%	100.00%		333.571	0	0	0%	100.00%

Appendix IV (Continued)
Table IV.2 (Continued)

352.068	0	0	0.00%	100.00%		352.068	0	0	0%	100.00%
371.59	0	0	0.00%	100.00%		371.59	0	0	0%	100.00%
392.194	0	0	0.00%	100.00%		392.194	0	0	0%	100.00%
413.941	0	0	0.00%	100.00%		413.941	0	0	0%	100.00%
436.894	0	0				436.894	0	0		
461.12	0	0				461.12	0	0		
486.689	0	0				486.689	0	0		

Appendix IV (Continued)

Table IV.3 Particle size data for three influent samples

F5 PW					F5 Syn					F6 PW			
Dia.	P/mL	Num %	C. Num %		Dia.	P/mL	Num %	C. Num %		Dia.	P/mL	Num %	C. Num %
0.411	0	0.00%	0.00%		0.411	0	0%	0%					
0.435	0	0.00%	0.00%		0.435	0	0%	0%					
0.46	0	0.00%	0.00%		0.46	0	0%	0%					
0.486	0	0.00%	0.00%		0.486	0	0%	0%					
0.514	103818.8	12.68%	12.68%		0.514	65170.04	5%	5%		0.514	116003	10%	10%
0.543	138903.8	16.97%	29.65%		0.543	109703.1	9%	14%		0.542	84133.88	7%	16%
0.575	105776.3	12.92%	42.57%		0.575	112663.2	9%	23%		0.572	126156.1	10%	27%
0.607	78348.75	9.57%	52.14%		0.607	103466	8%	31%		0.604	116980.3	10%	36%
0.642	57003.75	6.96%	59.10%		0.642	91356.46	7%	39%		0.637	80247.22	7%	43%
0.679	39982.5	4.88%	63.98%		0.679	74738.04	6%	45%		0.673	101403.8	8%	51%
0.718	36971.25	4.52%	68.50%		0.718	77506.78	6%	51%		0.71	59187.64	5%	56%
0.759	30157.5	3.68%	72.18%		0.759	70031.78	6%	56%		0.749	56733.3	5%	61%
0.803	20805	2.54%	74.72%		0.803	53102.4	4%	61%		0.791	52018.58	4%	65%
0.849	17880	2.18%	76.91%		0.849	48162.92	4%	65%		0.835	41067.3	3%	68%
0.897	21937.5	2.68%	79.58%		0.897	60798.66	5%	69%		0.881	37680.46	3%	71%
0.949	21180	2.59%	82.17%		0.949	59148.18	5%	74%		0.93	32443.54	3%	74%

Appendix IV (Continued)
Table IV.3 (Continued)

1.003	19586.25	2.39%	84.56%		1.003	52384.8	4%	78%		0.982	35352.94	3%	77%
1.06	15142.5	1.85%	86.41%		1.06	37865.36	3%	81%		1.036	31705	3%	80%
1.121	12075	1.47%	87.89%		1.121	30593.68	2%	84%		1.093	26870.92	2%	82%
1.185	10410	1.27%	89.16%		1.185	24948.56	2%	86%		1.154	22670.94	2%	84%
1.253	8835	1.08%	90.24%		1.253	21821.02	2%	88%		1.218	25222.26	2%	86%
1.325	8670	1.06%	91.30%		1.325	21240.96	2%	89%		1.286	15859.96	1%	87%
1.401	7316.25	0.89%	92.19%		1.401	17443.66	1%	91%		1.357	20418.02	2%	89%
1.481	7218.75	0.88%	93.07%		1.481	16546.66	1%	92%		1.432	16628.34	1%	90%
1.566	6296.25	0.77%	93.84%		1.566	15344.68	1%	93%		1.512	13994.96	1%	91%
1.656	5392.5	0.66%	94.50%		1.656	13090.22	1%	94%		1.595	12771.52	1%	92%
1.751	4871.25	0.59%	95.10%		1.751	11547.38	1%	95%		1.684	11055.72	1%	93%
1.851	3896.25	0.48%	95.57%		1.851	10225.8	1%	96%		1.777	8735.66	1%	94%
1.957	3075	0.38%	95.95%		1.957	8234.46	1%	97%		1.876	8079.18	1%	95%
2.069	2823.75	0.34%	96.29%		2.069	6661.72	1%	97%		1.98	5535.32	0%	95%
2.188	2441.25	0.30%	96.59%		2.188	5387.98	0%	98%		2.09	4796.78	0%	95%
2.313	2036.25	0.25%	96.84%		2.313	4419.22	0%	98%		2.205	5662.14	0%	96%
2.446	1815	0.22%	97.06%		2.446	3773.38	0%	98%		2.328	3797.14	0%	96%
2.586	1552.5	0.19%	97.25%		2.586	3223.22	0%	99%		2.457	3931.42	0%	97%
2.734	1455	0.18%	97.43%		2.734	2696.98	0%	99%		2.593	2461.8	0%	97%

Appendix IV (Continued)
Table IV.3 (Continued)

2.89	1293.75	0.16%	97.59%		2.89	2469.74	0%	99%		2.737	3431.6	0%	97%
3.056	1372.5	0.17%	97.75%		3.056	1967.42	0%	99%		2.889	2439.42	0%	97%
3.231	1106.25	0.14%	97.89%		3.231	1512.94	0%	99%		3.049	3289.86	0%	98%
3.416	1155	0.14%	98.03%		3.416	1453.14	0%	99%		3.218	2290.22	0%	98%
3.612	1046.25	0.13%	98.16%		3.612	1088.36	0%	99%		3.396	1850.08	0%	98%
3.819	896.25	0.11%	98.27%		3.819	1034.54	0%	99%		3.585	1730.72	0%	98%
4.038	836.25	0.10%	98.37%		4.038	1016.6	0%	100%		3.783	1715.8	0%	98%
4.269	907.5	0.11%	98.48%		4.269	873.08	0%	100%		3.993	1574.06	0%	98%
4.514	896.25	0.11%	98.59%		4.514	771.42	0%	100%		4.215	1820.24	0%	98%
4.772	896.25	0.11%	98.70%		4.772	550.16	0%	100%		4.448	1738.18	0%	99%
5.046	723.75	0.09%	98.79%		5.046	550.16	0%	100%		4.695	1820.24	0%	99%
5.335	772.5	0.09%	98.88%		5.335	412.62	0%	100%		4.955	954.88	0%	99%
5.64	731.25	0.09%	98.97%		5.64	376.74	0%	100%		5.23	1350.26	0%	99%
5.963	780	0.10%	99.07%		5.963	358.8	0%	100%		5.52	1111.54	0%	99%
6.305	738.75	0.09%	99.16%		6.305	275.08	0%	100%		5.826	760.92	0%	99%
6.666	596.25	0.07%	99.23%		6.666	227.24	0%	100%		6.149	1171.22	0%	99%
7.048	577.5	0.07%	99.30%		7.048	197.34	0%	100%		6.49	880.28	0%	99%
7.452	633.75	0.08%	99.38%		7.452	191.36	0%	100%		6.85	1089.16	0%	99%
7.879	603.75	0.07%	99.45%		7.879	191.36	0%	100%		7.23	932.5	0%	99%
8.33	465	0.06%	99.51%		8.33	89.7	0%	100%		7.631	626.64	0%	99%
8.808	472.5	0.06%	99.57%		8.808	71.76	0%	100%		8.054	925.04	0%	100%
9.312	390	0.05%	99.61%		9.312	59.8	0%	100%		8.5	693.78	0%	100%
9.846	442.5	0.05%	99.67%		9.846	35.88	0%	100%		8.972	678.86	0%	100%
10.41	386.25	0.05%	99.71%		10.41	5.98	0%	100%		9.469	611.72	0%	100%
11.006	337.5	0.04%	99.76%		11.006	17.94	0%	100%		9.994	529.66	0%	100%
11.637	273.75	0.03%	99.79%		11.637	11.96	0%	100%		10.548	529.66	0%	100%
12.303	251.25	0.03%	99.82%		12.303	0	0%	100%		11.133	581.88	0%	100%
13.008	221.25	0.03%	99.85%		13.008	5.98	0%	100%		11.751	425.22	0%	100%

Appendix IV (Continued)
Table IV.3 (Continued)

13.754	165	0.02%	99.87%		13.754	5.98	0%	100%		12.402	343.16	0%	100%
14.542	172.5	0.02%	99.89%		14.542	0	0%	100%		13.09	283.48	0%	100%
15.375	146.25	0.02%	99.91%		15.375	5.98	0%	100%		13.816	216.34	0%	100%
16.256	157.5	0.02%	99.92%		16.256	5.98	0%	100%		14.582	208.88	0%	100%
17.187	108.75	0.01%	99.94%		17.187	0	0%	100%		15.39	149.2	0%	100%
18.171	78.75	0.01%	99.95%		18.171	5.98	0%	100%		16.244	89.52	0%	100%
19.213	67.5	0.01%	99.96%		19.213	0	0%	100%		17.145	74.6	0%	100%
20.313	63.75	0.01%	99.96%		20.313	5.98	0%	100%		18.095	111.9	0%	100%
21.477	67.5	0.01%	99.97%		21.477	0	0%	100%		19.099	67.14	0%	100%
22.707	33.75	0.00%	99.98%		22.707	0	0%	100%		20.158	89.52	0%	100%
24.008	30	0.00%	99.98%		24.008	0	0%	100%		21.275	44.76	0%	100%
25.384	15	0.00%	99.98%		25.384	0	0%	100%		22.455	52.22	0%	100%
26.838	26.25	0.00%	99.98%		26.838	0	0%	100%		23.7	14.92	0%	100%
28.376	30	0.00%	99.99%		28.376	0	0%	100%		25.014	67.14	0%	100%
30.001	15	0.00%	99.99%		30.001	0	0%	100%		26.401	22.38	0%	100%
31.72	15	0.00%	99.99%		31.72	0	0%	100%		27.865	0	0%	100%
33.538	15	0.00%	99.99%		33.538	0	0%	100%		29.41	0	0%	100%
35.459	7.5	0.00%	99.99%		35.459	0	0%	100%		31.041	14.92	0%	100%
37.49	7.5	0.00%	100.00%		37.49	0	0%	100%		32.762	0	0%	100%
39.638	11.25	0.00%	100.00%		39.638	0	0%	100%		34.579	7.46	0%	100%
41.909	7.5	0.00%	100.00%		41.909	0	0%	100%		36.497	14.92	0%	100%
44.31	3.75	0.00%	100.00%		44.31	0	0%	100%		38.52	0	0%	100%
46.849	3.75	0.00%	100.00%		46.849	0	0%	100%		40.656	14.92	0%	100%
49.533	0	0.00%	100.00%		49.533	0	0%	100%		42.911	0	0%	100%
52.371	0	0.00%	100.00%		52.371	0	0%	100%		45.29	0	0%	100%
55.371	0	0.00%	100.00%		55.371	0	0%	100%		47.801	0	0%	100%
58.543	3.75	0.00%	100.00%		58.543	0	0%	100%		50.452	0	0%	100%

Appendix IV (Continued)
Table IV.3 (Continued)

61.897	0	0.00%	100.00%		61.897	0	0%	100%		53.249	0	0%	100%
65.444	0	0.00%	100.00%		65.444	0	0%	100%		56.202	0	0%	100%
69.193	0	0.00%	100.00%		69.193	0	0%	100%		59.318	0	0%	100%
73.157	0	0.00%	100.00%		73.157	0	0%	100%		62.607	0	0%	100%
77.348	0	0.00%	100.00%		77.348	0	0%	100%		66.079	0	0%	100%
81.78	0	0.00%	100.00%		81.78	0	0%	100%		69.743	0	0%	100%
86.465	3.75	0.00%	100.00%		86.465	0	0%	100%		73.61	0	0%	100%
91.419	0	0.00%	100.00%		91.419	0	0%	100%		77.692	0	0%	100%
96.656	0	0.00%	100.00%		96.656	0	0%	100%		82	0	0%	100%
102.194	0	0.00%	100.00%		102.194	0	0%	100%		86.547	0	0%	100%
108.048	0	0.00%	100.00%		108.048	0	0%	100%		91.346	0	0%	100%
114.239	0	0.00%	100.00%		114.239	0	0%	100%		96.411	0	0%	100%
120.783	0	0.00%	100.00%		120.783	0	0%	100%		101.757	0	0%	100%
127.703	0	0.00%	100.00%		127.703	0	0%	100%		107.399	0	0%	100%
135.02	0	0.00%	100.00%		135.02	0	0%	100%		113.354	0	0%	100%
142.755	0	0.00%	100.00%		142.755	0	0%	100%		119.64	0	0%	100%
150.934	0	0.00%	100.00%		150.934	0	0%	100%		126.274	0	0%	100%
										133.276	0	0%	100%
										140.666	0	0%	100%
										148.466	0	0%	100%
										156.698	0	0%	100%