ARCADIS
Infrastructure, environment, facilities

Imagine the result

Mount Vernon

Mount Vernon, Ohio

Laundry Color Wash Study: Phase II – Distribution System

April 14, 2009

ARCADIS

Gary L. Hoffman, PE
Senior Vice President

Laundry Color Wash Study: Phase II – Distribution System

Prepared for:

Mount Vernon, Ohio

Prepared by:

ARCADIS
520 South Main Street
Suite 2400
Akron
Ohio 44311-1010
Tel 330.434.1995
Fax 330.374.1095

Our Ref.:

CL000624.R001

Date:

April 14, 2009

Table of Contents

Appendices

I. Introduction

For over 18 years, customers of the Mount Vernon water system have registered complaints of spotting on clothing after performing laundry. The first recorded complaint of this nature was June 12, 1990. The City has invested significant resources through a number of studies conducted to determine the cause of these incidences. Initially, it was speculated that the use of chlorine dioxide as the disinfection agent at the water treatment plant may have been the cause. This spotting has been generally characterized as "splotching" and typically occurs on dark clothing. However, a final conclusion reached in the Phase I Laundry Study ruled out chlorine dioxide as the cause.

Figure 1 – Faded areas on garment typical of the "splotching" effect

This Phase I Laundry Color Wash Study completed in 2008 was a technical review of the previous efforts to resolve this problem. A summary of the results of these efforts was reviewed and then compiled to develop a matrix of possible sources of this splotching. The matrix illustrated whether the analysis used to determine the splotching disproved or left unanswered a theory for the color spotting. In addition, some general observations were made from the summary results that assessed the need for additional testing or identified gaps in the data.

The objective for the Phase II Study was to determine if the water system was the source of the problem. Identified gaps where an issue had not been previously examined or that may need further analysis included two areas concerning the water distribution system. The first is an examination of water system piping materials and the second is a review of water stability.

This Phase II Laundry Color Wash Study is intended to evaluate and address these two distribution system areas.

Figure 2 – Shirt displays multiple areas of the "splotching"

II. Piping Materials

The focus of water system piping materials concerns corrosion. The control of corrosion is an important task of system operation. Piping systems are deteriorated by corrosion from contact with water. If water has inadequate alkalinity buffer, the water can seek to satisfy the alkalinity demand by absorbing it from the pipe walls. This can result in corrosive action on the pipe. Corrosion results in materials such as lead, copper, iron and zinc being introduced into the water. These chemicals may be harmful to the public, create odors (iron bacteria) or cause staining of fixtures.

Distribution system piping materials used over the last half century have typically included cement lining in the case of ductile iron pipe or the use of plastic piping. Earlier piping systems were typically comprised of cast iron and/or ductile iron pipe which were unlined thereby having the metal piping directly in contact with the water.

Although reports of splotching have been in a widespread geographical area of residents on the system and of persons outside the system on private wells, a number of the complaints appear concentrated in the older, historic areas of the City. A review of this area was done because the population density is greater and it is also the portion of the system served primarily by sand cast iron and galvanized materials for main lines and service connections, respectively. The old piping system would likely be unlined, leading to the theory that these areas may experience corrosion and therefore impact water quality from the release of materials that may contribute to splotching. Both a section of old, unlined cast iron water main and a galvanized service connection were tested for evidence of corrosion and/or coating (scale) formation.

A portion of an unlined, 6-inch diameter water line on Vine Street at the intersection with Park Street was removed by the City and the scale material on the pipe wall tested for calcium, iron, magnesium and manganese. Testing was performed in May 2008 and Appendix A contains the laboratory results.

A portion of a ¾-inch diameter galvanized service connection on East High Street was removed by the City and the scale material on the pipe wall tested for calcium, iron, magnesium and manganese. Testing was performed in November 2008 and Appendix A contains the laboratory results.

A summary of the test results is provided in the table below.

Pipe Materials Coating Contents		
Chemical	**Water Line**	**Service Connection**
Calcium	20,800 mg/Kg-dry	17,700 mg/Kg-dry
Iron	128,000 mg/Kg-dry	149,000 mg/Kg-dry
Magnesium	21,300 mg/Kg-dry	14,500 mg/Kg-dry
Manganese	860 mg/Kg-dry	434 mg/Kg-dry

In review of this data it is observed that there is relative consistency between the proportion of chemical constituents from the two pipe samples tested. Each shows a higher iron content in comparison to the other chemicals. Also, both indicate similar proportions of calcium and magnesium in the coating and very low levels of manganese. The iron content of approximately 13-15% is higher than anticipated but probably reflects the original conditions in the system before lime softening was implemented. The expectation was the highest material content to be calcium if a typical coating (scale-formation) was in place.

Perhaps an explanation of this is that prior to the City beginning to soften their water and removing iron in 1936, a film of iron developed on the pipe walls. This iron deposition remained long after a calcium coating has been formed over top of the iron from the lime softening process. The iron level from the past does not mean corrosion is occurring in the system. In general, the calcium carbonate covers the iron except on the rare occasions when there may be a pipe break or disruption in service that may expose the iron surface in the pipe.

III. Water Stability

Most precipitative softening plants produce water that is slightly over-saturated with calcium bicarbonate (CaCO) and therefore deposit a slight amount of coating onto the piping system. It is preferred to gradually coat or encrust a distribution system as opposed to corroding the piping system. What needs to be avoided is water which is under-saturated or that is over-saturated with calcium carbonate. The former will cause corrosion in the system and the latter will tend to create extreme scaling problems.

There is no indication from available records that the water leaving the plant is corrosive or unstable. Laboratory testing reports the water quality to be very high and well within compliance of standards.

The distribution system was examined to see if there were any reactions taking place in the water once it left the treatment plant that could affect the calcium carbonate levels in the water, particularly in areas with old, unlined pipe materials. Since alkalinity and pH affect the rate of chemical reactions in water, they influence the rate of corrosion. A water is typically less corrosive at higher alkalinity and pH levels. Typical pH values range between 7-10 for public water supplies. This measurement is an indication whether a water may tend to be more corrosive in nature (less than 7) or more likely to deposit harmless scale at higher levels (greater than 7). Standard units for pH are often referred to as "SU" when measured.

An analysis of plant water (Plant Tap) was recommended to be performed along with an Alkalinity Profile. This was done to review alkalinity and pH levels leaving the plant and to see if levels increased in the distribution system thereby perhaps indicating corrosion. As noted earlier, corrosion could potentially lead to the release of local mineral deposits which could then create conditions for splotching.

Before analyzing the data it is important to understand that corrosivity and stability are not the same. Water can be stable while at the same time corrosive depending on system conditions. In turn, stable water leaving a water treatment plant may be corrosive in the system.

The City performed Plant Tap pH and alkalinity testing in August 2008. This data is provided in Appendix B. A discussion of the results follows.

The Plant Tap data was initially evaluated for the two and one-half days provided by the City. A graph was developed for the pH data and is included in Appendix B. The pH data shows a very consistent level of approximately 9.0 SU with little variation throughout the course of a day as well as between days. The pH value of 9.0 SU is reasonable and the consistency of pH is an indication that the City is very efficient in managing chemical usage to accomplish target softening goals without wasting lime. It would also suggest that some scale is forming in the system but not to a significant degree. This is a desirable condition.

The Plant Tap data for alkalinity was evaluated for the same period. A graph was also developed for the alkalinity data and is included in Appendix B. Alkalinity consistently ran at approximately 70 mg/l CaCO on August 26th and through the morning of August 27th. The afternoon and evening on August 27th showed a noticeable rise in alkalinity from approximately 70 mg/l CaCO to 85 mg/l CaCO. Over the course of the morning on the following day, August 28th, the alkalinity began to lower. It appears that the water leaving the plant is stable and therefore a slight coating of the distribution system should be occurring.

Regarding the increase in alkalinity noted in the previous paragraph, the pH remained unchanged during this increase in alkalinity on the afternoon of August 27th. Checking with plant personnel, it was discovered that a load of lime disrupted operations at the plant that day. During that time the system is shut down, which apparently caused a spike in alkalinity with no recarbonation occurring.

Also provided in Appendix B is the Alkalinity Profile data for two areas of the City. One area (Rogers/Braddock) was tested on August 27th and represents a newer system area, installed after 1970. The other (Chestnut) was tested on August 28th and represents an older system area. Graphs of these profiles were developed and are included in Appendix B.

For the Rogers/Braddock area, the pH maintains at 9.0 SU with a slight drop between the 3rd and 4th data points. This drop corresponds to a drop in alkalinity which ranged from approximately 70-75 mg/l CaCO. However, there is no consistent pattern to suggest a gradual reduction in alkalinity as water moves through the system in this area. Also, the sampled points do not represent water moving through the system as they are from different connection points along the Pleasant Street and Coshocton Avenue water mains.

For the Chestnut area, the pH and alkalinity show a gradual increase over the initial three data points as water moves through the system from west to east, with a subsequent leveling. The alkalinity in this area ranged from 75-78 mg/l CaCO which is higher than that recorded in the Rogers/Braddock area.

For the minor variations in pH and alkalinity values measured in the system, a general observation may be made that the distribution reflects the plant consistency of water quality without any distinct departures in the parameters. This would imply a relatively stable system and there is no evidence to conclude that the distribution system experiences any water quality conditions that would lead to splotching.

IV. Summary

The Phase I Study clearly eliminated chlorine dioxide addition at the water treatment plant as being the cause of splotching. It did not rule out defective fabric materials with unstable dyes in the clothing that was damaged. The objective of the Phase II Study was to see if distribution system issues of piping materials and/or water stability could be contributing to conditions for splotching to occur.

In review and evaluation of the piping materials, there is no evidence to suggest old pipe materials are corroding due to unstable water which could possibly lead to release of mineral deposits from piping. The release of these materials was a theory of what may cause the splotching problems, but this has been ruled out. In addition, mineral releases that stain generally show up as distinct spots and not as bleached or faded areas as shown in the clothing samples illustrated in Figure 1 and Figure 2.

In review and analysis of the plant water stability data and Alkalinity Profiles, it is evident that the City is producing consistently stable water in compliance with Ohio EPA standards. This allows for a coating of the distribution system to some extent.

The water treatment plant nor the distribution system provide any evidence that the water quality is associated with the splotching of garments.

The conclusion to the laundry color wash study points to the clothing itself as the cause of the splotching. Sub-standard dyes and dyeing methods can lead to a faded or bleached appearance of garments when washed. The more common occurrence of clothing with unstable sulfur dyes and fabrics not as colorfast as expected due to overseas production methods are the most likely source of the splotching problems.

ARCADIS

Appendix A

Piping Materials Testing Results

Stantec Consulting Services, Inc. Date: *27-May-08*

CLIENT:	Mt. Vernon WWTP	**Client Sample ID:**	VINE ST WATER MAIN
Lab Order:	0805119	**Tag Number:**	
Project:		**Collection Date:**	5/8/2008 2:30:00 PM
Lab ID:	0805119-001A	**Matrix:**	SOLID

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ICP METALS, TOTAL		**6010B**				Analyst: **JP**
Calcium	20800	5.00		mg/Kg-dry	1	5/20/2008
Iron	128000	0.500		mg/Kg-dry	1	5/16/2008
Magnesium	21300	6.00		mg/Kg-dry	1	5/20/2008
Manganese	860	0.500		mg/Kg-dry	1	5/16/2008

Qualifiers:

B	Analyte detected in the associated Method Blank	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	M	Manual Integration used to determine area response
ND	Not Detected at the Reporting Limit	S	Spike Recovery outside accepted recovery limits
X	Value exceeds Maximum Contaminant Level		

Stantec Consulting Services, Inc.

Date: *06-Nov-08*

CLIENT:	Mt. Vernon WWTP	Client **Sample ID:**	405 EAST HIGH
Lab Order:	0810180	Tag Number:	
Project:		**Collection Date:**	10/2/2008
Lab ID:	0810180-005A	Matrix:	SOLID

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ICP METALS, TOTAL		**6010B**		**SW3050A**		Analyst: **JP**
Calcium	17700	5.00		mg/Kg-dry	1	10/29/2008
Iron	149000	500		mg/Kg-dry	1	10/24/2008
Magnesium	14500	6.00		mg/Kg-dry	1	10/29/2008
Manganese	434	5.00		mg/Kg-dry	1	10/24/2008

Qualifiers:

- B Analyte detected in the associated Method Blank
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- X Value exceeds Maximum Contaminant Level
- E Value above quantitation range
- M Manual Integration used to determine area response
- S Spike Recovery outside accepted recover limits

ARCADIS

Appendix B

Alkalinity and pH Data and Graphs

CITY OF MOUNT VERNON DISTRBUTION ALKALINITY STUDY

ROGERS/BRADDOCK AREA

Address 8-27-08 1300-1400 hrs	PH	Alkalinity	Data Point
104 Rogers Street	9.01	73	#1
302 Rogers Street	8.98	73	#2
104 Ringgold Street	9.01	74	#3
401 Braddock Street	8.91	71	#4
605 Braddock Street	8.97	71	#5

CHESTNUT AREA

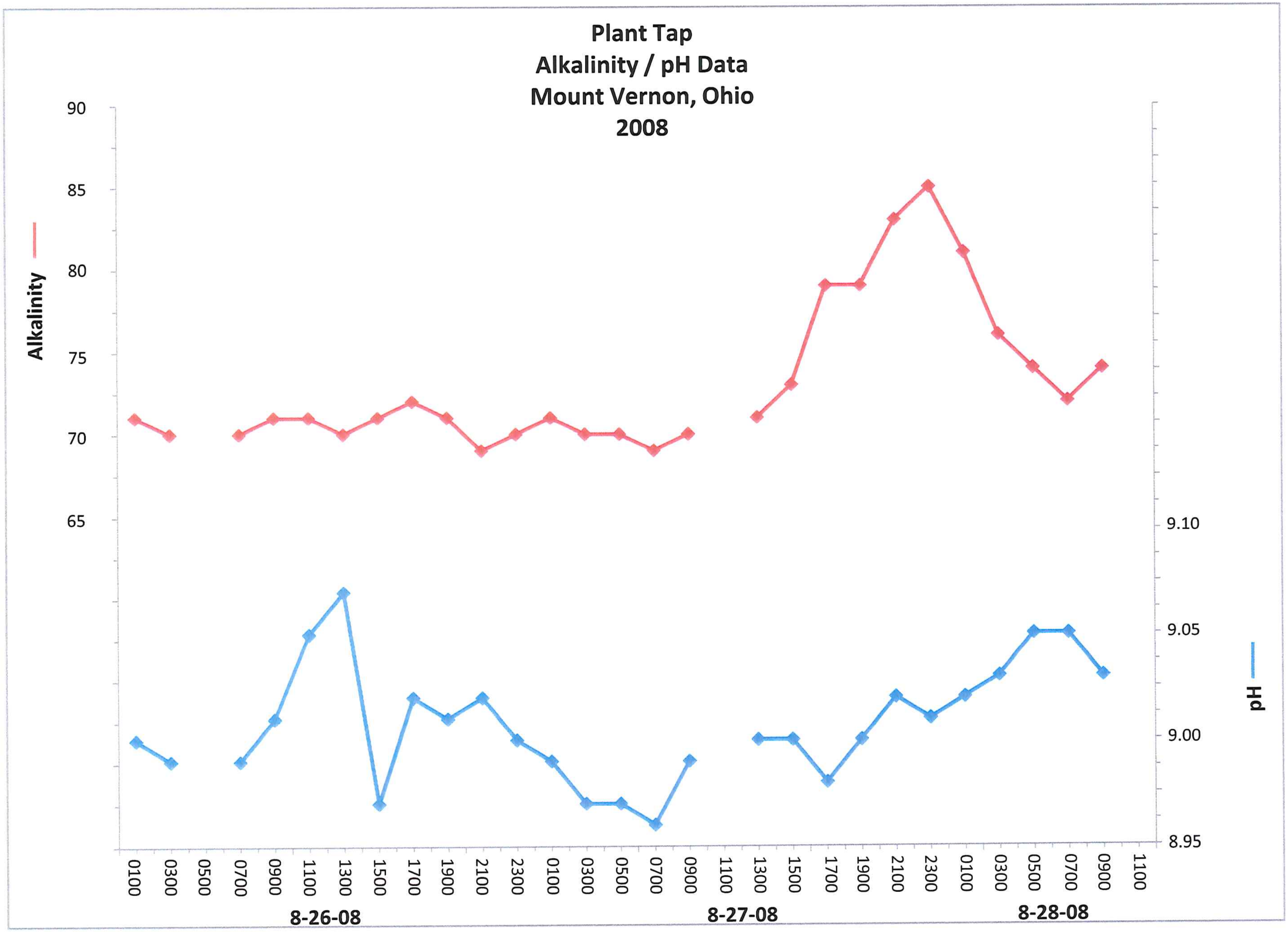
Address 8-28-08 1000-1045 hrs	PH	Alkalinity	Data Point
400 West Chestnut St	8.91	75	#1
5 North Gay Street	8.94	76	#2
304 East Chestnut Street	9.00	78	#3
600 ½ East Chestnut Street	8.98	77	#4
705 East Chestnut	8.99	78	#5

PLANT TAP

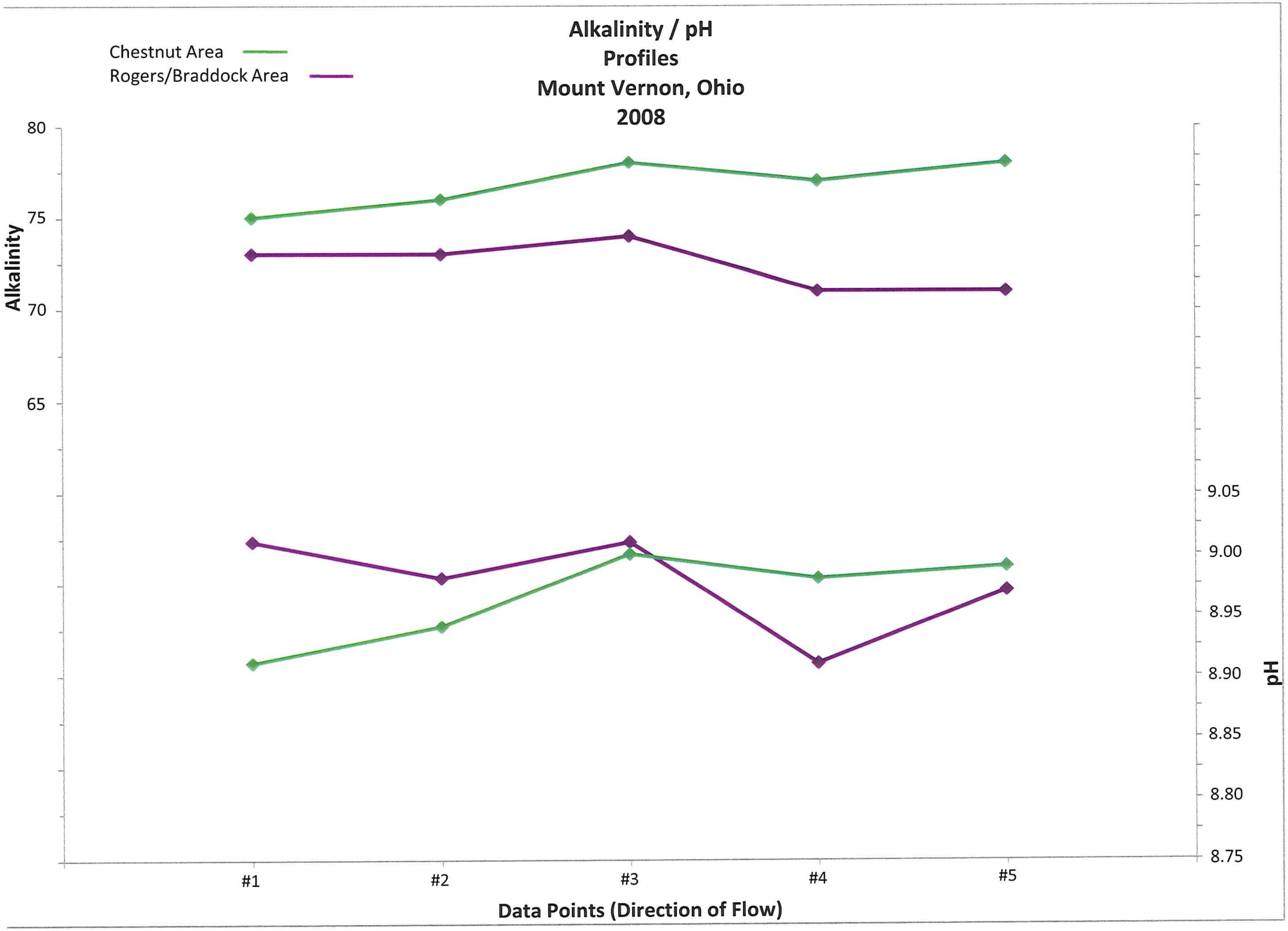
8-26-08	PH	Alkalinity
0100	9.00	71
0300	8.99	70
0500	X	X
0700	8.99	70
0900	9.01	71
1100	9.05	71
1300	9.07	70
1500	8.97	71
1700	9.02	72
1900	9.01	71
2100	9.02	69
2300	9.00	70

8-27-08	PH	Alkalinity
0100	8.99	71
0300	8.97	70
0500	8.97	70
0700	8.96	69
0900	8.99	70
1100	X	X
1300	9.00	71
1500	9.00	73
1700	8.98	79
1900	9.00	79
2100	9.02	83
2300	9.01	85

8-28-08	PH	Alkalinity
0100	9.02	81
0300	9.03	76
0500	9.05	74
0700	9.05	72
0900	9.03	74
1100		
1300		
1500		
1700		
1900		
2100		
2300		



Plant Tap
Alkalinity / pH Data
Mount Vernon, Ohio
2008
Alkalinity
90
85
80
75
70
65
pH
9.10
9.05
9.00
8.95
0100
0300
0500
0700
0900
1100
1300
1500
1700
1900
2100
2300
0100
0300
0500
0700
0900
1100
1300
1500
1700
1900
2100
2300
0100
0300
0500
0700
0900
1100
8-26-08
8-27-08
8-28-08



Alkalinity / pH
Profiles
Mount Vernon, Ohio
2008
Chestnut Area
Rogers/Braddock Area
Alkalinity
80
75
70
65
pH
9.05
9.00
8.95
8.90
8.85
8.80
8.75
#1
#2
#3
#4
#5
Data Points (Direction of Flow)