



Pilot Study Report

for

Z-92[®] Uranium and Z-88[®] Radium Treatment Processes



conducted for

Borough of Hopewell, New Jersey

February 22, 2010

Executive Summary

This uranium, radium and gross alpha removal pilot study was conducted for the Borough of Hopewell, New Jersey's combined entry point of Well's No. 2 and 5 located at the Burton Avenue treatment facility. Hopewell's water system contains concentrations of uranium, radium and gross alpha in excess of the Maximum Contaminant Levels (MCL).

The Borough of Hopewell selected Water Remediation Technology's (WRT) Z-92[®] Uranium and Z-88[®] Radium Treatment Processes as a possible cost effective solution for their uranium, radium and gross alpha problem. WRT provided a 1.3 GPM (gallons per minute) treatment system, which was delivered and installed on May 26, 2009.

The purpose of this pilot study is to document the effectiveness of the WRT system on high uranium, radium and gross alpha water and to provide information necessary to meet regulatory compliance.

The treatment system has successfully met uranium, radium and gross alpha compliance at all times during the pilot study. The system was in operation for 133 days prior to writing this report and effectively reduced the level of uranium (Figure 1), radium (Figure 2) and gross alpha (Figure 3) to less than the MCL (Maximum Contaminant Level).

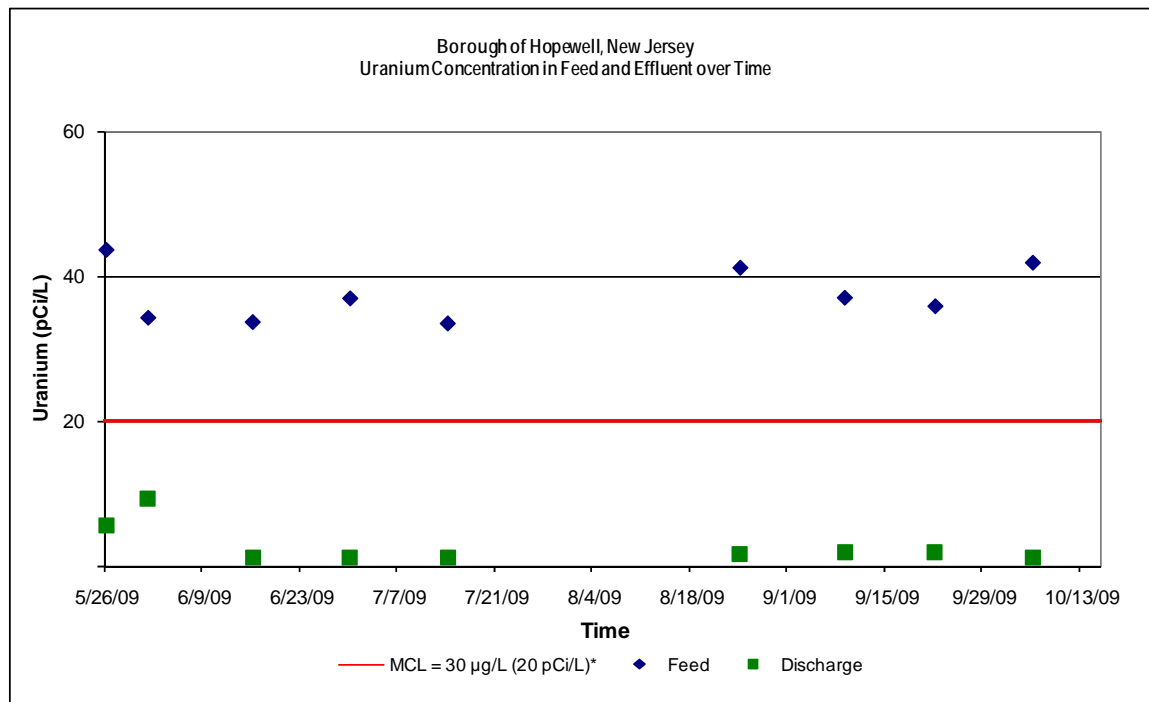


Figure 1

* USEPA MCL for uranium is published as 30 $\mu\text{g/L}$; New Jersey has determined 20 pCi/L as the equivalent allowable limit.

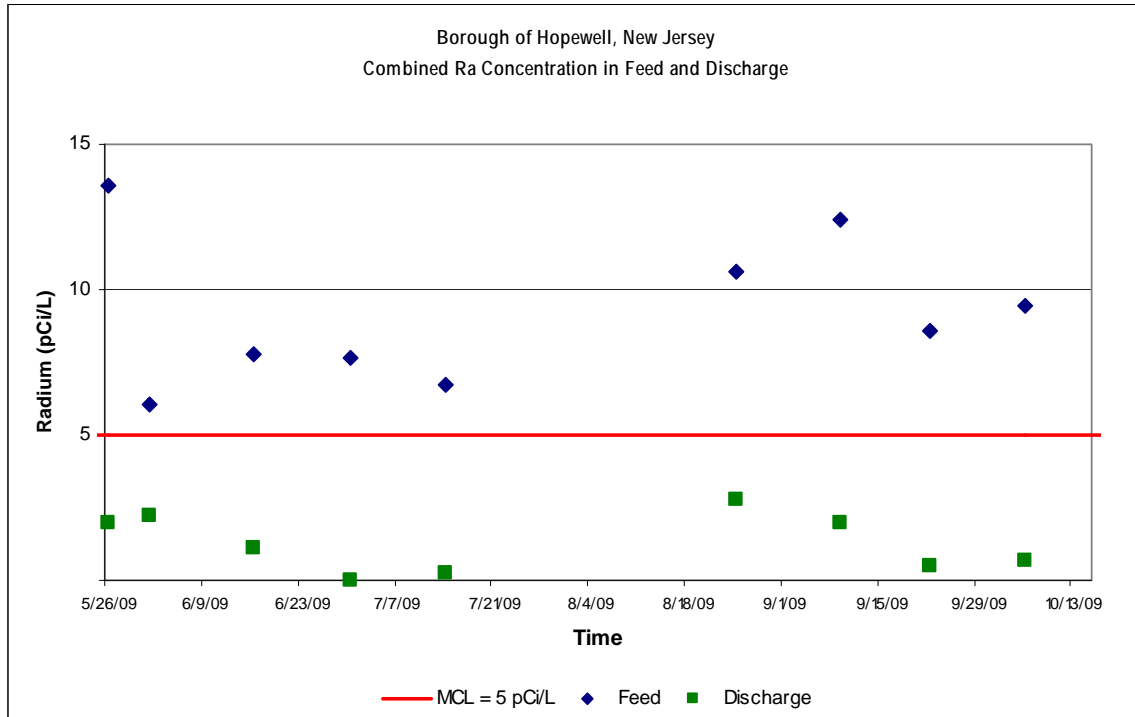


Figure 2

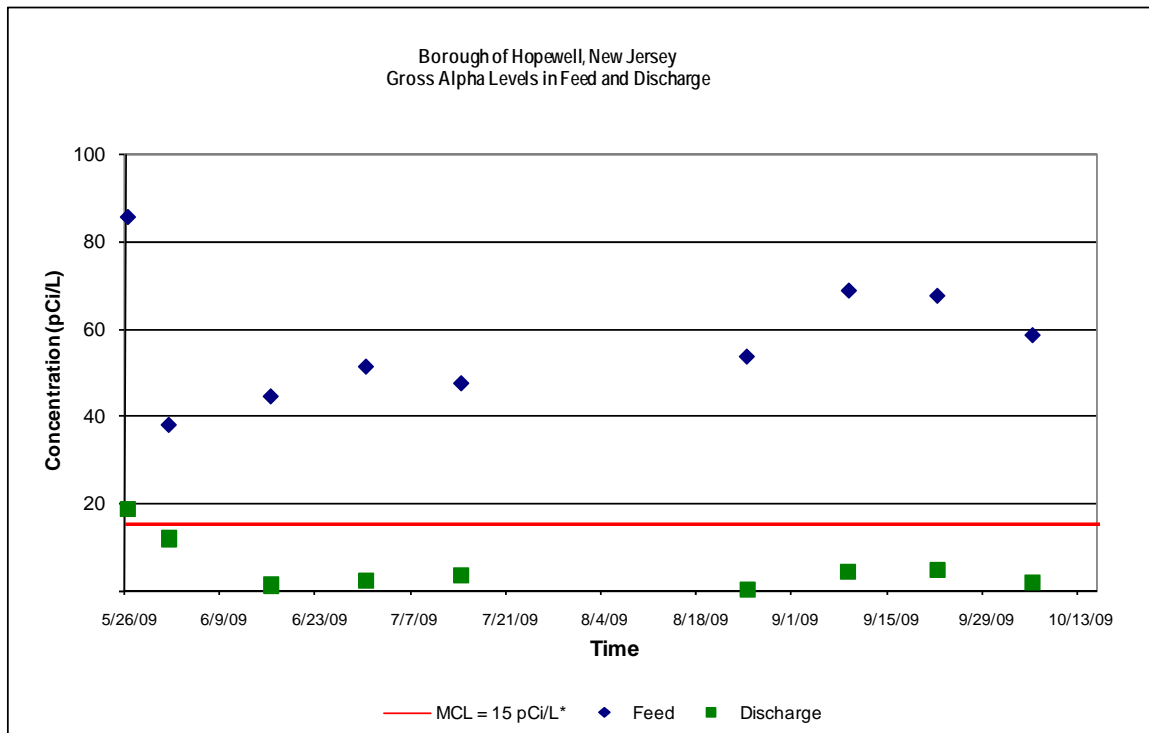


Figure 3

The results are also shown in Table 1. The average feed concentration of uranium, 37.5 pCi/L, (pico Curies per Liter) was reduced to an average of 2.6 pCi/L; well below the MCL of 20 pCi/L. The average feed concentration of combined radium, 9.2 pCi/L, was reduced to an average of 0.9 pCi/L; well below the MCL of 5 pCi/L. The average feed concentration of gross alpha, 57.3 pCi/L, was reduced to 5.5 pCi/L; well below the MCL of 15 pCi/L.

Table 1. Uranium, Radium and Gross Alpha levels in feed and discharge water.

Uranium	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
Uranium MCL	NA	20*
Average	37.5	2.6
Highest value	43.7	9.2
Lowest Value	33.4	1.0
Combined Radium	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
Radium MCL	NA	5.0
Average	9.2	1.3
Highest value	13.6	2.8
Lowest Value	6.0	0.0
Gross Alpha	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
Gross Alpha MCL	NA	15.0
Average	57.3	5.5
Highest value	85.6	18.7
Lowest Value	38.1	0.4

* USEPA MCL for uranium is published as 30 µg/L; New Jersey has determined 20 pCi/L as the equivalent allowable limit.

Note: Negative results are recorded as 0.0

Application Information

The historic community of the Borough of Hopewell, New Jersey is located approximately 15 miles north of Trenton in Mercer County. The combined entry point of Well’s No. 2 and 5 located at the Burton Avenue treatment facility was selected for this pilot study. The combined wells produce 350 gallons per minute (GPM). Hopewell’s Well No. 4 is the only other well in operation that provides water to the community of 2,000 residents, in addition to an interconnection with New Jersey American Water Company, from whom they purchase the majority of their water. Hopewell’s water source is the Potomac Raritan Magothy Aquifer. Hopewell has continued to operate its



own water system for the past 94 years and has one currently operating well within the Borough. The Borough operated storage reservoir holds approximately a day and a half supply of treated water.

Technology Overview

Water Remediation Technology's (WRT) Z-92[®] Uranium and Z-88[®] Radium Treatment Processes utilize proprietary adsorptive media in a series of up flow treatment vessels to reduce gross alpha and remove uranium and radium from drinking water. The water is moved through the treatment system using the water pressure generated from the well source. No chemicals are added to the water for the treatment process. After the media is loaded with uranium and radium, it is removed from the circuit and permanently disposed of in a licensed facility. WRT designs, manufactures and provides the equipment and media used in the facility. The handling and exchange of new media to replace spent media, as well as the shipping and disposal into licensed disposal sites, is handled by WRT. The treatment media are ANSI/NSF Standard 61 certified for use in drinking water.

Equipment Overview

The pilot equipment was installed in a self-contained mobile trailer at Hopewell's combined entry point for Wells No. 2 and 5 at the Burton Avenue treatment facility. The treatment train used for this pilot study consists of seven test columns; the first three columns each of 6" diameter by 40" vertical height contain 30" of Z-92[®] Uranium process media and the last four columns each of 4" diameter by 48" vertical height contain 25" of Z-88[®] Radium process media. The columns in the pilot unit are clear for visual observation of the media and process. The source water enters the unit through a ¾" diameter hose, passes through a control valve and flow meter, and enters the bottom of the first column. All columns operate in an up-flow mode, with the flow exiting the top of the first column, then following the same flow path through columns 2 through 7 in series (see Figure 4). The last component in the system is a safety filter. Sample ports are located prior to the first column, and after each of the columns in the series.

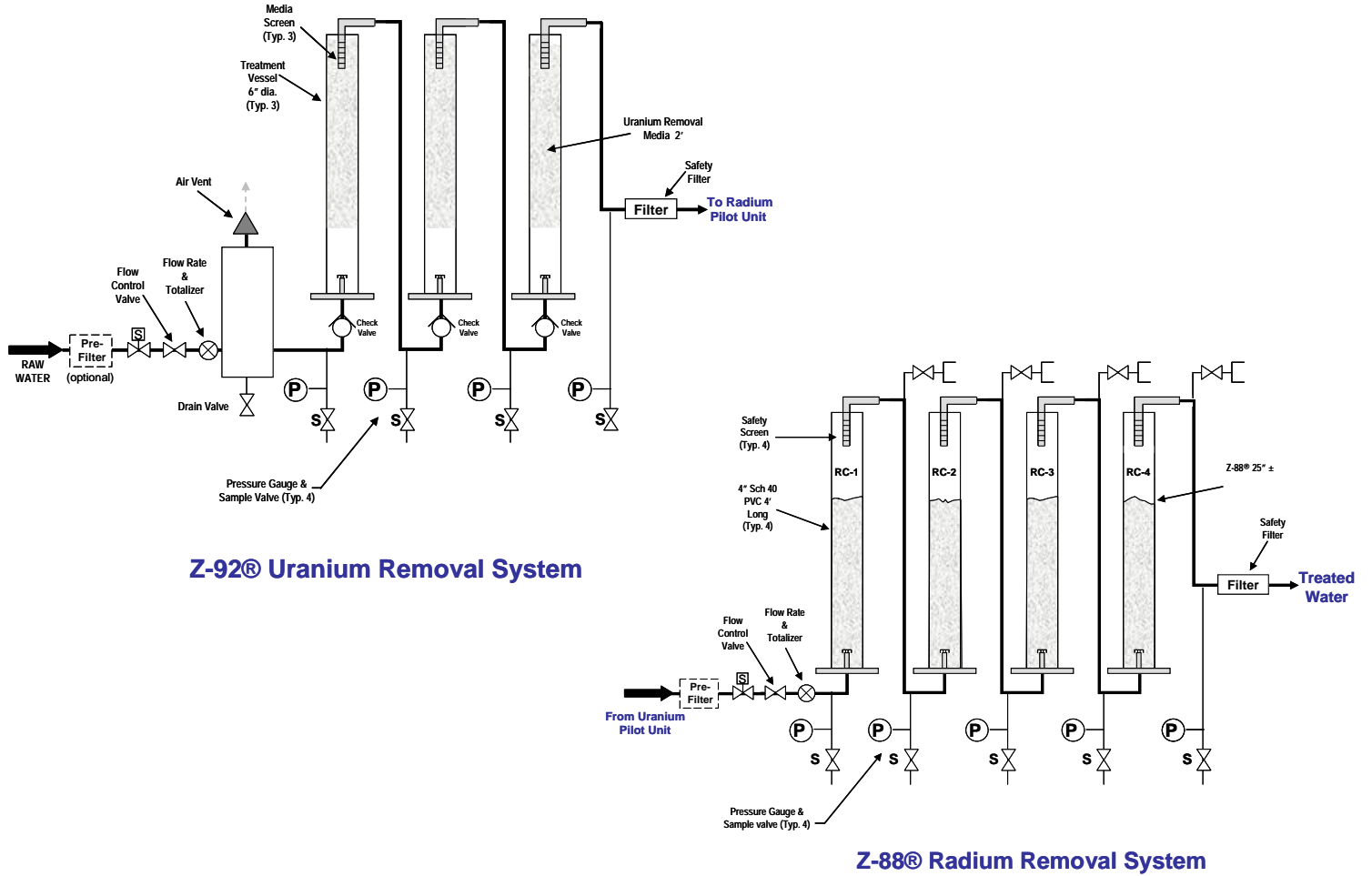


Figure 4. Simplified Process Flow Diagram.



Borough of Hopewell's Z-92[®] Uranium and Z-88[®] Radium treatment system located at the Burton Avenue treatment facility.





Statement of Purpose

The uranium levels in the raw water during the pilot study were as high as 43.7 pCi/L, exceeding the Environmental Protection Agency (EPA) mandated uranium MCL of 20 pCi/L. Similarly, the combined radium was as high as 13.6 pCi/L exceeding the required MCL of 5 pCi/L. Gross alpha was as high as 85.6 pCi/L, also exceeding the required MCL of 15 pCi/L for adjusted gross alpha.

The purposes of this pilot study are to:

- Demonstrate the ability of the WRT Z-92[®] Uranium and Z-88[®] Treatment Processes to consistently and effectively reduce the uranium, radium and gross alpha level to below the MCL on this specific water.
- Demonstrate the reliability and ease of operation of the WRT Process.
- Comply with regulatory requirements.

Delivery and Installation of the Treatment System

The treatment system was delivered and installed on May 26, 2009. Due to the self-contained design of the pilot trailer, set up consisted of securing the trailer and connecting the water source and discharge line. The pilot study began the same day. Data was collected for 133 days prior to writing this report.

Operator training for system operation, monitoring and sampling was conducted on the day of installation, and a schedule for sampling was established. Samples were collected by the Borough of Hopewell personnel from sample valves located in the feed line and after discharge from each respective treatment vessel, at pre-determined sample intervals.

Analytical

The samples were delivered to Waste Stream Technology, Inc. in Buffalo, New York for uranium, radium, and gross alpha analysis. Samples for inorganic water quality analysis, and were delivered to Aqua Pro-Tech Laboratories in Fairfield, New Jersey. Both laboratories are National Environmental Laboratory Accreditation Program certified. Methods for analysis were:

Gross Alpha	N.J.A.C. 7:18-6.4
Uranium	DOE 1990 U-02
Radium 226	7500 RaB
Radium 228	EPA 904.0



Results

The sampling results are shown in Tables 2, 3, and 4. Feed samples were collected immediately prior to the first treatment vessel. Samples UC-1, UC-2, UC-3, and RC-2 were taken after each respective column, and the discharge samples were collected after RC-4, or column 7. Analytical laboratory certificates are attached as Appendix A. Figures 5, 6 and 7 show uranium, combined radium 226 and 228 and gross alpha levels in the feed water entering the pilot unit, and treated water exiting the pilot unit. The graphs show that the pilot unit successfully reduced the uranium, combined radium and gross alpha in the treated water to significantly below the required MCL.

From the initial start up through July 17th the raw water feed for the pilot unit was drawn from a concrete cistern adjacent to the pilot trailer. The water in the cistern was a representative mixture of water from the two wells. After the first five sets of analysis it was determined that the manganese level from the cistern was less than that of each of the two wells. The radium level was also lower than that from the respective wells. It was concluded that there was some radium/manganese co-precipitation occurring in the cistern. As a result the pilot trailer feed was redirected from the cistern to draw a representative sample directly from the two wells. As a result the manganese and radium levels to the pilot columns increased.

Table 2. Uranium Test Results

Uranium Date	Column Concentrations (pCi/L)				
	Feed	UC-1	UC-2	UC-3	MCL
5/26/09	43.7	20.5	3.0	5.5	20.0
6/1/09	34.2	34.3	55.0	9.2	20.0
6/16/09	33.6	14.7	13.8	1.0	20.0
6/30/09	36.9	1.4	5.8	1.0	20.0
7/14/09	33.4	1.9	5.1	1.1	20.0
8/25/09	41.2	2.6	5.0	1.4	20.0
9/9/09	37.0	2.3	7.3	1.7	20.0
9/22/09	35.8	4.4	3.0	1.8	20.0
10/6/09	41.9	3.4	2.7	1.0	20.0

Figure 5 below, presents in graph format, the data in Table 2.

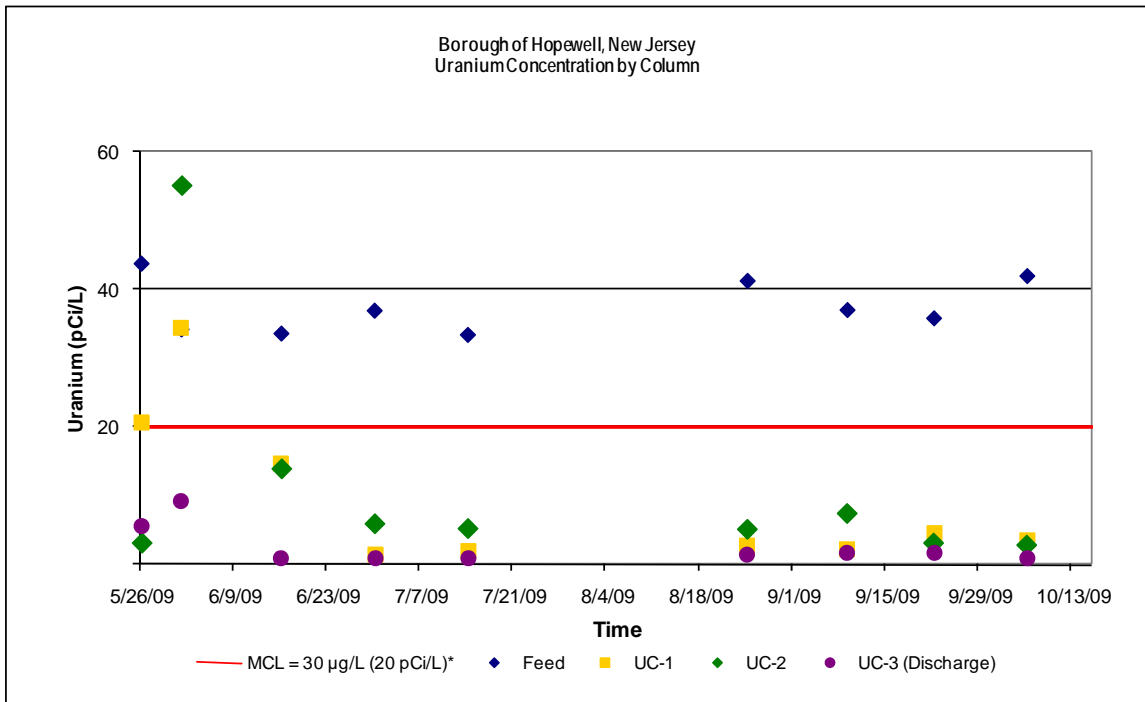


Figure 5

* USEPA MCL for uranium is published as 30 µg/L; New Jersey has determined 20 pCi/L as the equivalent allowable limit.

Table 3. Radium Test Results

Radium 226	Column Concentrations (pCi/L)			
Date	Feed	RC-2	RC-4	MCL
5/26/09	9.8	0.5	1.0	N/A
6/1/09	4.4	0.3	0.4	N/A
6/16/09	4.9	0.3	0.2	N/A
6/30/09	5.7	0.7	0.0	N/A
7/14/09	5.2	0.9	0.2	N/A
8/25/09	7.0	1.9	0.4	N/A
9/9/09	9.0	2.1	0.6	N/A
9/22/09	6.8	1.3	0.5	N/A
10/6/09	7.3	2.9	0.7	N/A

Radium 228	Column Concentrations (pCi/L)			
Date	Feed	RC-2	RC-4	MCL
5/26/09	3.8	0.0	1.0	N/A
6/1/09	1.6	0.0	1.8	N/A
6/16/09	2.9	0.7	1.0	N/A
6/30/09	1.9	0.9	0.0	N/A
7/14/09	1.5	0.0	0.0	N/A
8/25/09	3.6	3.5	2.4	N/A
9/9/09	3.4	1.4	1.4	N/A
9/22/09	1.8	1.8	0.0	N/A
10/6/09	2.2	0.9	0.0	N/A

Combined Radium	Column Concentrations (pCi/L)			
Date	Feed	RC-2	RC-4	MCL
5/26/09	13.6	0.5	2.0	5.0
6/1/09	6.0	0.3	2.2	5.0
6/16/09	7.8	1.0	1.1	5.0
6/30/09	7.6	1.6	0.0	5.0
7/14/09	6.7	0.9	0.2	5.0
8/25/09	10.6	5.4	2.8	5.0
9/9/09	12.4	3.4	2.0	5.0
9/22/09	8.6	3.1	0.5	5.0
10/6/09	9.5	3.8	0.7	5.0

Note: Negative results are recorded as 0.0

Figure 6 below, presents in graph format, the data in Table 3.

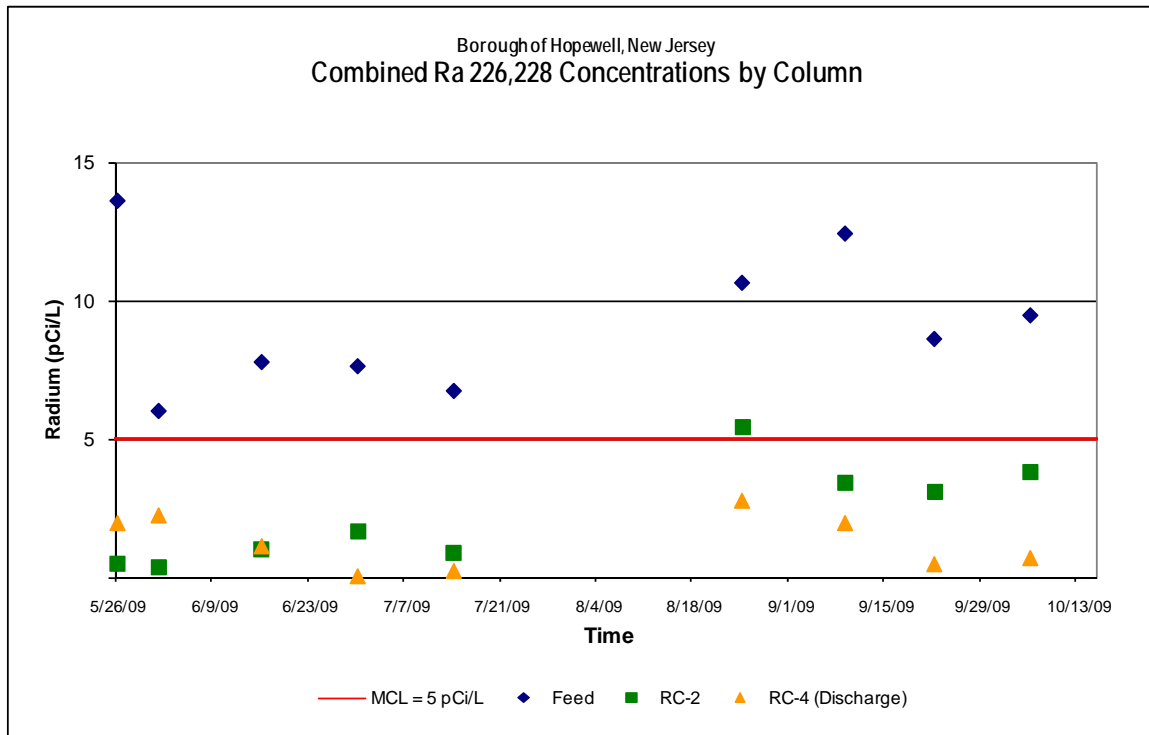


Figure 6

The Borough of Hopewell pilot study Gross Alpha analysis for treated water from measured raw water and the treated water from RC-4 are presented in Table 4 and Figure 7. The initial Gross Alpha RC-4 discharge value is reported as 18.7 pCi/L, apparently above the MCL value of 15.0 pCi/L. Gross Alpha analysis for purposes of reporting to the New Jersey EPA are measured twice at a minimum of a 24 hour increment to allow for daughter product in-growth. This particular analysis initially measured 15.3 pCi/L with a measurement uncertainty of 3.6 pCi/L. The second analysis measured 18.7 pCi/L with a 4.0 pCi/L uncertainty. The highest value is presented here. However, when the uncertainty of the analytical results are taken into consideration, the MCL value of 15 pCi/L falls within the uncertainty range of the analysis in both Gross Alpha measurements.

Table 4. Gross Alpha Test Results

Gross Alpha Date	Column Concentrations (pCi/L)		
	Feed	RC-4	MCL
5/26/09	85.6	18.7	15.0
6/1/09	38.1	12.0	15.0
6/16/09	44.6	1.4	15.0
6/30/09	51.4	2.4	15.0
7/14/09	47.6	3.6	15.0
8/25/09	53.7	0.4	15.0
9/9/09	68.8	4.6	15.0
9/22/09	67.6	4.7	15.0
10/6/09	58.6	1.9	15.0

Figure 7 below, presents in graph format, the data in Table 4.

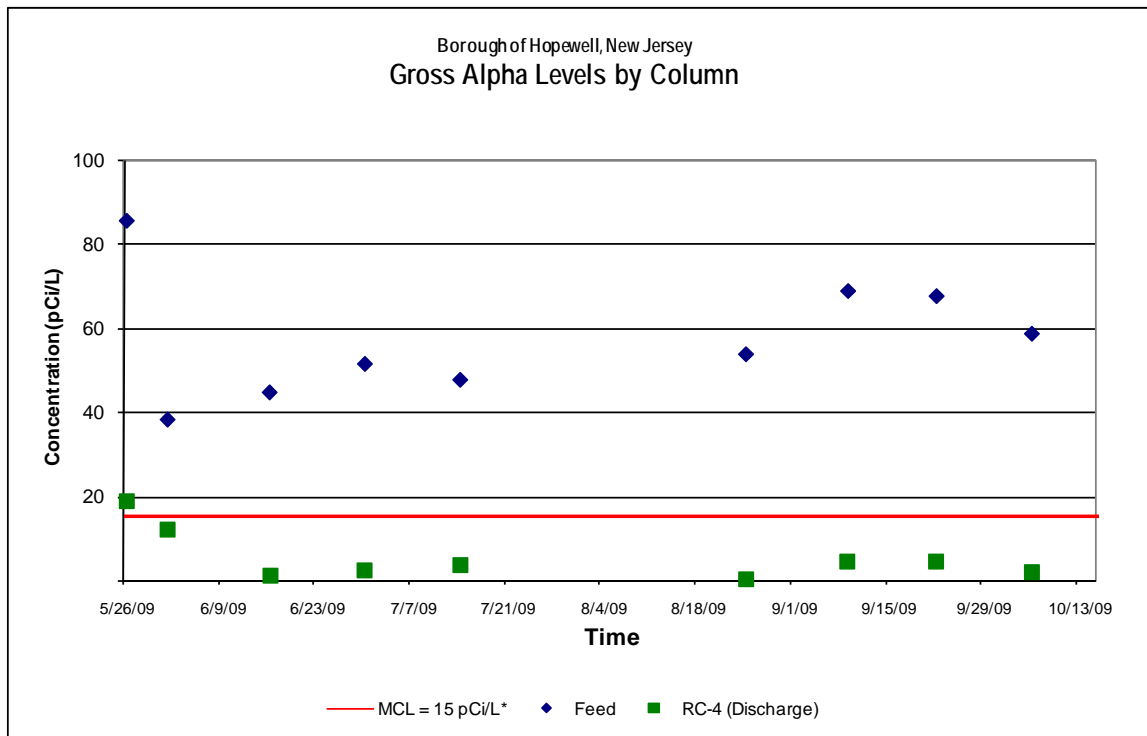


Figure 7



Water Quality

A water quality analysis was performed on feed water entering the treatment system. The results of those tests are shown in Table 5. Treated water exiting the WRT system data was not collected. Support documentation for Table 6 is attached as Appendix B.

Table 5. Water Quality Data entering the WRT treatment process

Borough of Hopewell, New Jersey Water Quality Data		
Item	Raw Water	units
Alkalinity	136	mg/L
Aluminum	<0.01	mg/L
Antimony	<0.002	mg/L
Arsenic	<0.002	mg/L
Barium	0.125	mg/L
Beryllium	<0.001	mg/L
Cadmium	<0.002	mg/L
Chloride	22	mg/L
Chromium	0.013	mg/L
Copper	<0.002	mg/L
Cyanide	<0.01	mg/L
Fluoride	<0.2	mg/L
Hardness, Total	270	mg/L
Iron	<0.05	mg/L
Manganese	<0.002	mg/L
MBAS	<0.1	mg/L
Mercury	<0.0005	mg/L
Nickel	0.002	mg/L
pH	8.0	Unit
Silver	<0.002	mg/L
TDS	238	mg/L
Zinc	<0.002	mg/L

Hydraulic Loading Rate, EBCT

The pilot unit operated at 1.3 gallons per minute, for a HLR of 6.6 gallons per minute per square foot in the Z-92[®] test columns and 14.9 gallons per minute per square foot in the Z-88[®] test columns. The pilot unit ran continuously, from representative mixtures from the two wells. The total gallons treated during the pilot study are summarized in Table 4 and Appendix D.

The EBCT at the test condition HLR is 8.5 minutes and 3.5 minutes through the three Z-92[®] columns and the four Z-88 columns respectively.

Table 4. Cumulative treated flow in gallons

Sample Data	Treated Flow in Gallons
5/26/09	178
6/1/09	4,121
6/16/09	26,752
6/30/09	50,515
7/14/09	75,483
8/25/09	19,551
9/9/09	43,171
9/22/09	57,637
10/6/09	80,239
10/18/09	101,982



Radiation Safety

The treatment system is designed to collect uranium and radium, naturally occurring radioactive materials, while in operation. Because of this action, it gradually becomes radioactive during normal operation. WRT both predicts and monitors the level of radiation present in the treatment system.

The US EPA guidelines for the total amount of radiation that members of the general public can be exposed to is 2 mrem per hour and 100 mrem over the course of a year. The maximum radiation activity measured from WRT's pilot unit is less than half of the hourly exposure limit (<1 mrem). Due to the limited amount of operator attention necessary for the pilot test, the annual exposure limit is also readily met.

WRT has prepared a safety plan for its tests that includes radiation level monitoring, logging time spent in proximity to a test unit, emergency procedures to be followed and an introduction to radiation safety for operators. Operators are instructed in radiation safety before the pilot test is started.

Any full scale system will include appropriate equipment and operating personnel radiation level monitoring, and a corresponding safety plan approved by regulatory authorities will be put into place.

Operational Results

An operation log was maintained during the pilot study, and is attached as Appendix C. The treatment system operated easily and reliably during the study.

Conclusion

The WRT Combined Treatment Process consistently reduced the uranium, radium and gross alpha in the system discharge to levels well below the required MCLs.

WRT would like to thank the personnel and staff of the Borough of Hopewell and Richard H. Moser Consulting for their cooperation and participation in this study.



Appendices available upon request