Pilot Study Report

for

Z-88™ Radium Treatment Process

conducted at the

The Town of Cortland, Illinois

December 2, 2003

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Executive Summary

The Town of Cortland, owns and operates a Public Water System (PWS) to supply potable water to approximately 2,100 residents. Raw water is pumped from a deep sandstone well, chlorinated and then fed to the distribution system. Naturally occurring radionuclides in Cortland's raw water source exceed current Maximum Contaminant Levels (MCL's) for Gross Alpha Emitters and Combined Radium.

Cortland selected Water Remediation Technology's (WRT) Z-88™ Radium Removal Process as a possible cost effective solution for their radium problem. WRT provided a one GPM (gallons per minute) pilot plant, which was delivered and installed on September 22, 2003.

The purpose of this pilot study is to demonstrate the effectiveness of the treatment process on high radium and gross alpha water, establish design parameters for the full scale systems and meet regulatory piloting requirements.

The pilot unit successfully lowered the gross alpha and radium levels during the planned 30 day study, but exceeded the MCL's later in the test, due to the relatively high barium concentration in the feed water and the small amount of Z-88™ media in the pilot system.

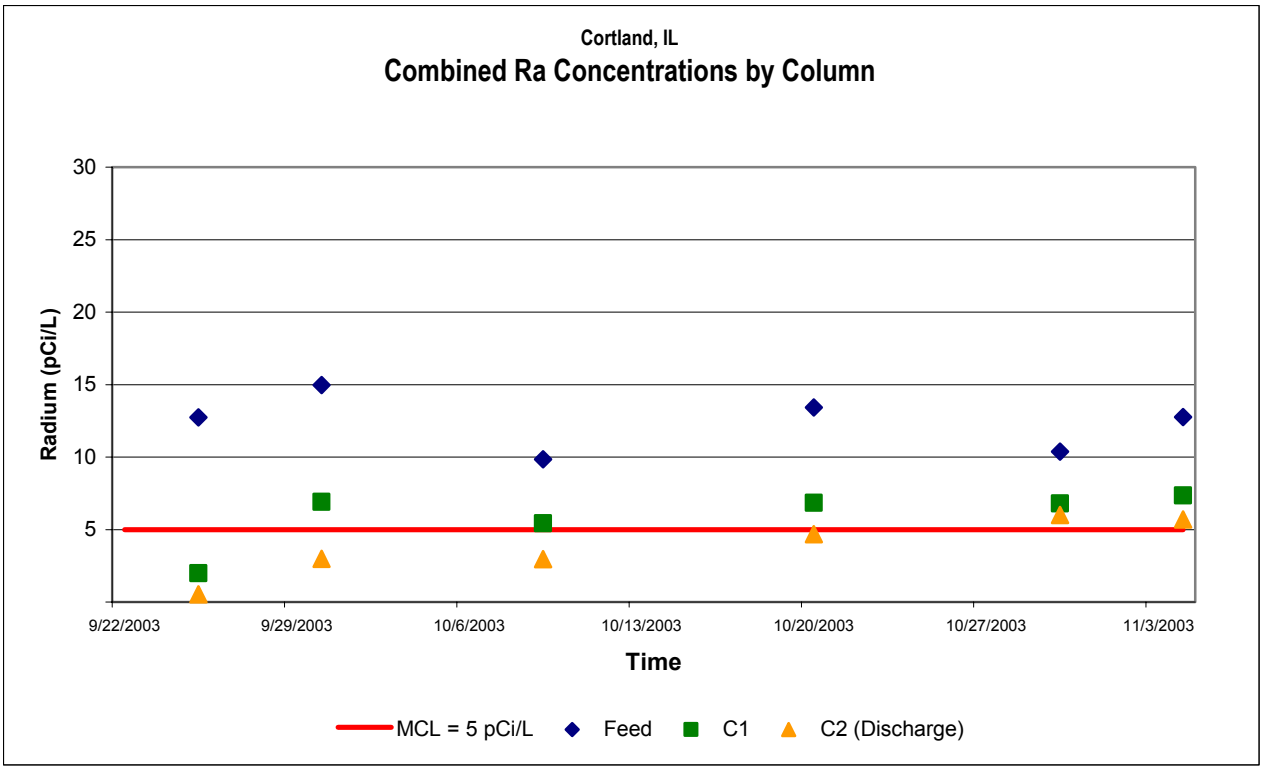

Figure 1

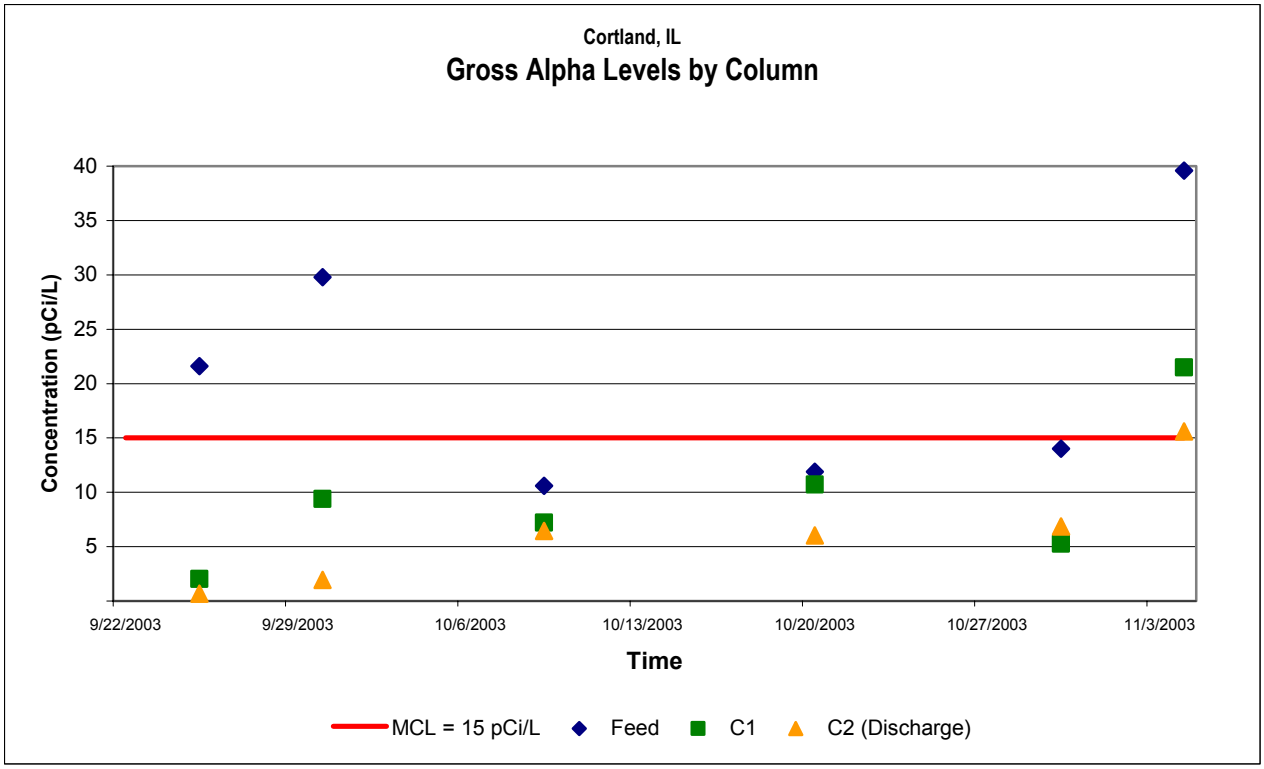

Figure 2

The results are also shown in Table 1. The average feed concentration of gross alpha, 21.25 pCi/L (pico Curies per Litre) was reduced to an average of 6.26 pCi/L after column 2 during this test. The last data point, 15.60 pCi/L, slightly exceeded the gross alpha MCL. Similarly, the average feed concentration of radium, 12.35 pCi/L, was reduced to 3.52 pCi/L after column 2 and has yet to exceed 6.01 pCi/L. The final two data points for radium were slightly above the combined radium MCL.

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

	Feed (pCi/L)	Discharge @ Column 2 (pCi/L)
Gross Alpha MCL	**NA**	**15**
Average	21.25	6.26
Highest value	39.60	15.60
Lowest Value	10.60	0.68
Radium MCL	**NA**	**5**
Average	12.35	3.52
Highest value	14.96	6.01
Lowest Value	9.84	0.53

Technology Overview

Water Remediation Technology's (WRT) Z-88™ Radium Treatment Process utilizes Z-88™ patent pending adsorptive media in a series of up flow treatment vessels to reduce gross alpha and remove radium 226 and 228 from drinking water. The water is moved through the treatment system using the water pressure generated from the well source. Pressure drop through a full-scale system is approximately 10-15 PSI. No chemicals are added to the water for the treatment process. After the media is loaded with radium, it is removed from the circuit and permanently disposed of in a licensed facility. WRT designs, manufactures and provides the facility and produces the media used in the facility. The handling and exchange of new media for spent media, as well as the shipping and disposal into licensed disposal sites, is conducted or arranged for by WRT staff. The Z-88™ process media is ANSI/NSF Standard 61 certified for use in drinking water.

Equipment Overview

The pilot equipment was installed in the well pump house. The treatment train used for this pilot study consists of two 4" diameter by 4' vertical height columns, each containing 25" of Z-88™ process media mounted on a frame within the pump house. 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 column 2 in series (see Figure 3). 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.

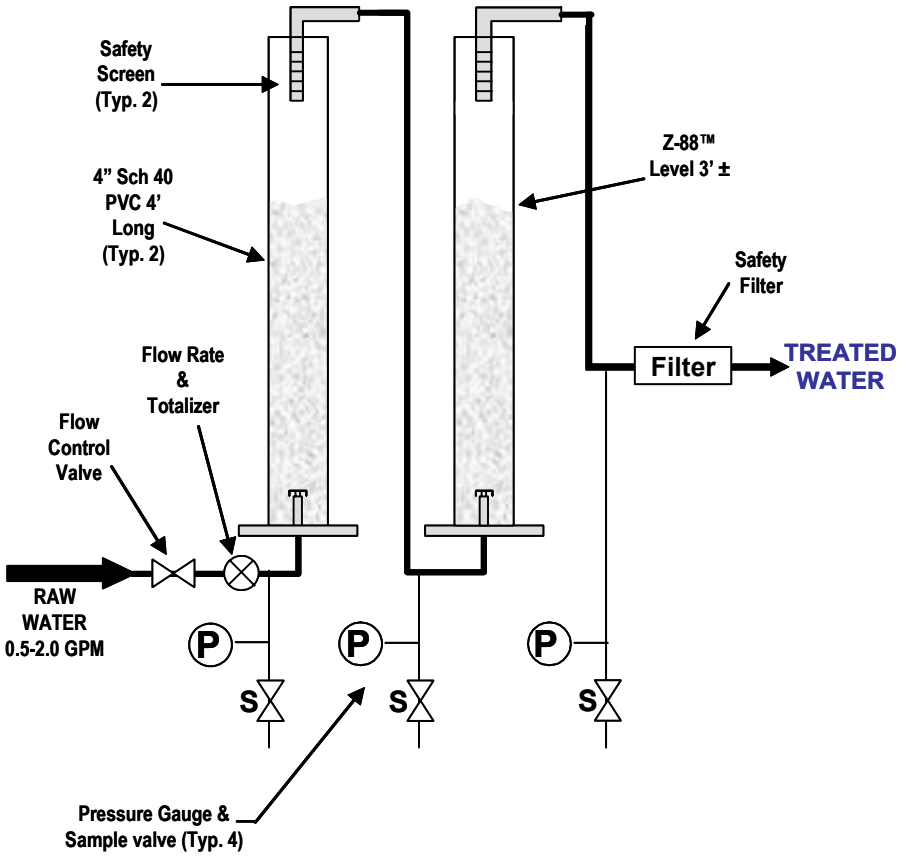

Figure 3. Typical Process Flow Diagram

The pilot unit provides for an Empty Bed Contact Time through two columns of 0.78 minutes. The pilot unit differs from the permanent equipment design as the permanent system utilizes two treatment tanks in series which effectively increases the EBCT available. The purpose of the short columns in the pilot plant is to allow more data to be collected and faster evaluation of the radium loading on the Z-88™ media.

Statement of Purpose

The contaminant levels during the pilot study in the well were as high as 39.60 pCi/L for gross alpha and 14.96 pCi/L for combined radium, both exceeding the Environmental Protection Agency (EPA) mandated MCL's.

The purposes of this pilot study are to:

- Demonstrate the ability of the WRT Z-88™ Radium Treatment Process to consistently and effectively reduce the gross alpha and radium content to below the MCL on this specific water.
- Demonstrate the reliability and ease of operation of the WRT Process.
- Comply with regulatory piloting requirements.
- Develop design criteria for the full-scale facility.

Delivery and Installation of Pilot Unit

The pilot unit was delivered and installed on September 22, 2003. Set up consists of mounting the columns to a frame and connecting the water source and a discharge line to a sanitary sewer. The pilot study began the same day. Initial water samples were taken at that time. Data was collected for 43 days prior to writing this report and testing continues to establish optimum media life.

Operator training for pilot unit operation, monitoring and sampling was conducted on the day of installation, and a schedule for sampling was established. Samples were collected from ½" valves located in the feed line and after discharge from each respective test column, at sample intervals prescribed by the Illinois Environmental Protection Agency (IEPA).

Analytical

The samples were sent to ACZ Laboratories, a National Environmental Laboratory Accreditation Program certified laboratory, for analysis. Methods for analysis were:

Gross Alpha	EPA 900.0
Radium 226	EPA 903.1
Radium 228	EPA 904.0

Results

The sampling results are shown in Tables 3 and 4. Feed samples were collected immediately prior to the first column of Z-88™. Samples C1 and C2 were taken after each respective column, prior to discharge. Analytical laboratory certificates are attached as Appendix B. Figures 1 and 2 show gross alpha and combined radium 226 and 228 levels in the feed water entering the pilot unit, and treated water exiting the pilot unit. The graphs clearly show that during the first five weeks of the test the pilot unit successfully reduced the gross alpha and combined radium levels to satisfactory levels.

However, during the final two weeks of the test, combined Radium MCL was exceeded, and the gross alpha was exceeded during the last week of this test. The relatively high barium content of the feed water, coupled with the small EBCT available, is responsible for this excursion.

Table 3. Radium Test Results

Ra-226	Column Concentrations (pCi/L)		
Date	Feed	C1	C2
9/22/03			
9/25/03	9.2	1.0	0.1
9/30/03	9.2	3.4	0.9
10/9/03	7.0	3.8	1.4
10/20/03	8.1	3.7	2.3
10/30/03	8.0	5.4	4.2
11/4/03	9.7	5.8	3.7

Ra-228	Column Concentrations (pCi/L)		
Date	Feed	C1	C2
9/22/03			
9/25/03	3.6	1.0	0.4
9/30/03	5.7	3.5	2.1
10/9/03	2.9	1.6	1.5
10/20/03	5.3	3.1	2.4
10/30/03	2.3	1.4	1.9
11/4/03	3.1	1.6	2.0

Ra Combined	Column Concentrations (pCi/L)		
Date	Feed	C1	C2
9/22/03			
9/25/03	12.7	2.0	0.5
9/30/03	15.0	6.9	3.0
10/9/03	9.8	5.4	3.0
10/20/03	13.4	6.9	4.7
10/30/03	10.4	6.8	6.0
11/4/03	12.8	7.4	5.7

Tables 3 and 4 show C2 discharge levels, which would be indicative of the results from the first stage of a two stage, full-scale, treatment system. The pilot plant provided for an Empty Bed Contact Time of 0.78 minutes after column number two. The full scale system is designed with an EBCT of 7.7 minutes. This additional time will effectively capture more radium and gross alpha than the pilot. Support documentation for Tables 3 and 4 is attached as Appendix A.

Table 4. Gross Alpha Test Results

Gross Alpha	Column Concentrations (pCi/L)		
Date	Feed	C1	C2
9/22/03			
9/25/03	21.6	2.0	0.7
9/30/03	29.8	9.4	1.9
10/9/03	10.6	7.2	6.4
10/20/03	11.9	10.7	6.0
10/30/03	14.0	5.3	6.9
11/4/03	39.6	21.5	15.6

Water Quality

A water quality analysis was performed on feed water to the pilot unit and on treated water exiting the WRT pilot unit treatment process to document any changes in water quality through the Z-88™ treatment process. The results of those tests are shown in Table 7. Due to the chemical similarities between radium and barium, Z-88™ media will remove barium. This effect is demonstrated in Table 5 by a feed of 1.29 ppm and a discharge of 0.818. The barium loading contributes to lower radium removal and is the main factor in this test not meeting the MCL at its conclusion. Other than barium, there is no significant change to the water quality other than the desired reduction of gross alpha and radium. Support documentation for Table 5 and 7 are attached as Appendix A.

Table 5. Barium Test Results

	Feed (ppm)	Discharge @ Column 2 (ppm)
Barium MCL	**NA**	**2**
Average	1.348	0.680
Highest value	1.560	0.994
Lowest Value	1.260	0.027

Hydraulic Loading Rate

The flow rate during the pilot test period averaged 0.87 GPM, which equates to 9.95 gallons per minute per square foot hydraulic loading rate. Table 6 shows the total treated flow by sample date. Data for Table 6 can be found in Appendix B. The full scale system is designed at a similar hydraulic loading rate of 10.9 GPM per square foot, but

has 11 feet of media as compared to the 4.2 feet in the pilot unit. This media depth will effectively provide over 9 times the EBCT in the full scale system.

Table 6. Cumulative treated flow in gallons

Sample Data	Treated Flow in Gallons
9/22/03	0
9/25/03	870
9/30/03	7,458
10/9/03	19,798
10/20/03	27,226
10/30/03	47,025
11/4/03	53,749

Table 7. Water Quality Data entering and exiting the Z-88™ treatment process

Well No. 3 Cortland, IL – Water Quality Data			
Item	**Pre WRT Process**	**units**	**Post WRT Process**
Aluminum	<	mg/L	<
Barium	1.3500	mg/L	0.9940
Calcium	69.6	mg/L	72.9
Iron	0.20	mg/L	0.15
Magnesium	30.3	mg/L	31.7
Potassium	3.3	mg/L	3.5
Sodium	15.6	mg/L	16.3
Strontium	0.55	mg/L	0.54
Uranium	<	mg/L	<

Note: < is below detection levels

Radiation Safety

The initial long term radium pilot studies conducted by WRT consisted of a detailed radiation safety plan which was prepared and implemented for the course of the pilot study to insure the safety of plant staff and the general public. The safety plan includes radiation level monitoring, logging each time people entered and exited the pilot trailer, radiation level monitoring badges assigned to staff personnel that would frequently enter the pilot trailer and emergency procedures and equipment. Data from this safety plan was monitored by the WRT Radiation Safety Officer during the pilot studies to ensure compliance to internal WRT standards.

The total amount of radiation that members of the public can be exposed to is 2 mrem per hour and 100 mrem over the course of a year.

As part of the long term pilot tests, a monitoring badge was attached to the bottom of Column 1, the point of highest radiation level, and a monitoring badge was placed far away from the pilot unit, in a safety equipment locker located greater than 50 feet from the test unit.

Data collected after 9 months of continuous operation, showed that the highest radiation level measured at the base of column 1, which contains the highest loaded media, was 0.2 mrem per hour, or approximately 10% of the permitted hourly exposure level. At a distance of 3 feet from the equipment, no discernable difference from background levels could be detected.

The dosimeter located on column 1 averaged 0.14 mrem per hour exposure after nine months of operation. The average exposure over the course of this 9 month pilot study was 0.06 mrem per hour.

Based upon WRT's experience with this and other long term radium pilot studies and the long term radiation data collected from those studies, it was concluded that an abbreviated pilot study of less than 180 days does not require dosimetry badge monitoring.

Any full-scale system will include equipment and personnel monitoring radiation dosimetry badges, and a corresponding safety plan to monitor that information.

Operational Results

An operation log was maintained during the pilot study, and is attached as Appendix B. The pilot unit removed radium and gross alpha to acceptable levels during the first five weeks of this test. During the last two weeks, due to the relatively high barium and the limited amount of Z-88™ in the system, the test unit slightly exceeded the MCL for radium and gross alpha. Other than the relatively small excedance of the MCL at the end of the test, the unit operated satisfactorily and without unusual operator attention throughout the test period.

Design Considerations for Full Scale System

The full scale system design has addressed the higher barium content in Cortland's water by providing a large volume of media. WRT has determined that barium does affect the amount of radium that can be removed in its process. The proposed design at Cortland

uses several stages of media, at a relatively low hydraulic loading, to provide the maximum EBCT for this relatively low radium-content water. WRT has considered the barium interference in its loading and media change projections.

Conclusion

The WRT Z-88™ Radium Treatment Process successfully reduced gross alpha and combined radium 226 and 228 during the majority of this test. Due to a small amount of media and barium competition, the discharge levels of 15 pCi/L and 5 pCi/L for gross alpha and combined radium were not met continuously, however. Full scale plant design parameters, such as media loading rate, EBCT and number of columns required, have been interpreted from the pilot study data and incorporated into the basis of design.

WRT would like to thank the personnel and staff of the Town of Cortland and Simmons & Associates for their cooperation and assistance during this test.

Appendices available upon request