Technical Note
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Determination of Radium Removal Efficiencies in Illinois Water Supply Treatment Processes

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PREFACE

The Office of Radiation Programs of the U.S. Environmental Protection Agency carries out a national program designed to evaluate population exposure to ionizing and non-ionizing radiation, and to promote development of controls necessary to protect the public health and safety. This report was prepared in order to determine the natural radioactivity source terms associated with radium in water supplies and the radium removal efficiencies in water treatment processes. Readers of this report are encouraged to inform the Office of Radiation Programs of any omissions or errors. Comments or requests for further information are also invited.

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ABSTRACT

Numerous public water supply wells contain significant amounts of naturally occurring radium 226. Because of the possible deleterious effects of ingesting radioactive substances, methods of removing natural radium must be considered.

A study was undertaken to determine the efficiency of radium removal using conventional water softening methods. Five water supplies which were known to have radium 226 in the raw water (ranging from 3.3 to 14.7 pCi/l) and which have existing water softening equipment were chosen for the study. To compare the relative efficiency of various methods of softening, plants using ion exchange and lime softening were investigated.

At the plants using ion exchange softening, samples of raw, aerated, and softened water were collected, analyzed for radium 226 and mineral content, and the radium removal efficiency was calculated. Where applicable, samples of filtered water were also included. At the plants using lime softening, samples of raw and filtered water were analyzed. All plants were operated in a normal manner during sampling.

In general, the ion exchange softening removed the radium 226 more efficiently with 70.2 to 98.2% being removed as compared to 70 to 92% for lime softening. Although the removal efficiency was somewhat lower using lime softening, it was more consistent since the problem of breakthrough at the end of a softener run was not experienced and little or no blend water is required to produce a stable product.

Waste water, resin, and lime sludge were also analyzed to determine the radioactivity concentration in the waste. Radioactivity in brine from the ion exchange plants peaked at levels as high as 300 pCi/l of radium 226. Samples of the resins also indicated significant buildups. At the lime softening plants it appears that most of the radium was precipitated in the sludge. Satisfactory methods for the ultimate disposal of the wastes should be determined.

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CONCLUSIONS

The main purpose, determining the radium removal efficiency of various softening methods at both small and large water treatment facilities, was achieved.

A study undertaken to determine the efficiency of radium removal by conventional water softening methods indicated that both lime and ion exchange softening were effective in removing the major portion of the radium from the water. Lime softening gives more consistent removal since it is not subject to the cycle of the ion exchange softener. Also, in lime softening the hardness is not reduced to as low a level as in ion exchange softening. Consequently, less unsoftened water is required to produce a satisfactory hardness in the finished water.

Ion exchange softening, which is more practical for small communities, can be used successfully if the plant is operated properly. Breakthrough of the radium occurs at approximately the same time as the calcium. Therefore, breakthrough can be detected by monitoring for hardness without the expense of elaborate equipment for monitoring radium. In some cases it will be possible to obtain blend water from a shallower aquifier, reducing the amount of radium entering the distribution system.

RECOMMENDATIONS

During the course of the investigation several questions were raised. Further investigation as to the geologic formations which contribute radium to the water would be helpful. If the radium is leaching from higher levels than the sandstone, selective casing of the well might reduce or, in some cases, eliminate the contaminant.

Disposal of waste from both ion exchange and lime softening plants should be studies. Significant amounts of radium are being concentrated in both the brine rinse and the lime sludges. These in turn are discharged into sewers, directly into watercourses, or disposed of on land. Study of the uptake of radium by growing plants would give an insight into the quantity of radium which enters the food chain via this route.

An investigation into the economic feasibility of recovering minerals such as radium, barium, and possibly magnesium from water plant waste, may lead to a means of utilizing a waste product and eliminating a disposal problem. This would apply not only to lime softening plants, but also to brine waste from the regeneration of zeolite. From our limited information it appears that the major portion of the radium is released from a zeolite softener over a relatively short period of time. With information on the characteristic curve of the release of the radium in the waste discharge, it appears that the major portion of the radium could be collected from a relatively small volume of waste.

Initial investigation indicates that exposure levels in water treatment plants were not significant to employee safety. However, further investigation of the exposure level during cleaning of filters or changing of anthrafilt and zeolite should be observed and investigated. The levels of radioactivity to which employees are exposed under these circumstances should be investigated to determine whether or not a hazard exists. Disposal of the spent material is also a problem.

Water filtered through an anthrafilt iron filter showed significant reduction in radium levels. Backwash water from this filter indicated that most of the radium was removed from the filter. Further investigation is needed to determine the form of the radium as it is pumped from the well and the chemical changes which occur during preliminary water treatment.

The gross alpha data, in all cases, were considerably higher than can be accounted for by the radium data. Further investigation to determine what isotopes are present and their health significance would be helpful in evaluating the effect on the consumer.

1.0 SUMMARY OF THE OVERALL PROGRAM

1.1 INTRODUCTION

Naturally occurring radium 226 is found in numerous public water supply deep wells serving Illinois communities in quantities above the levels recommended by the 1962 Public Health Service Drinking Water Standards. Since radium may be detrimental to the health of the population exposed, much concern exists regarding the use of these wells for drinking purposes. In many cases, these wells are the most suitable source for supplying water to the community. Therefore, considerable interest in methods of radium removal exists.

1.2 OBJECTIVES

The Illinois Environmental Protection Agency, under contract with the United States Environmental Protection Agency, conducted a study on the efficiency of radium removal using conventional water softening methods. It was desired that as many softening methods as possible be studies. Where possible, cost information on both capital investment and operating costs were included.

1.3 DESCRIPTION OF FACILITIES

Five Illinois communities were selected for the study on the following basis:

1. Previous analyses of the water indicated either high gross alpha activity or high radium 226 concentration.[1]

2. The water supply had existing water softening facilities.

3. Both small and large population groups should be represented.

The supplies selected were those serving the Dwight Correctional Center, Herscher, Lynwood, Peru and Elgin. Of these, the supplies at Peru and Elgin utilize the lime softening process and those at the Dwight Correctional Center, Lynwood and Herscher use ion exchange softening. The Lynwood and Herscher supplies use styrene-based zeolite while the unit sampled at the Correctional Center uses natural green sand. The Peru and Elgin supplies serve populations greater than 10,000. The other supplies serve much smaller population groups, ranging from 250 to 4,000.

All of the water supplies studied lie in an area of the State in which the sandstond formations (see Fig. 1) are sufficiently close to the surface to

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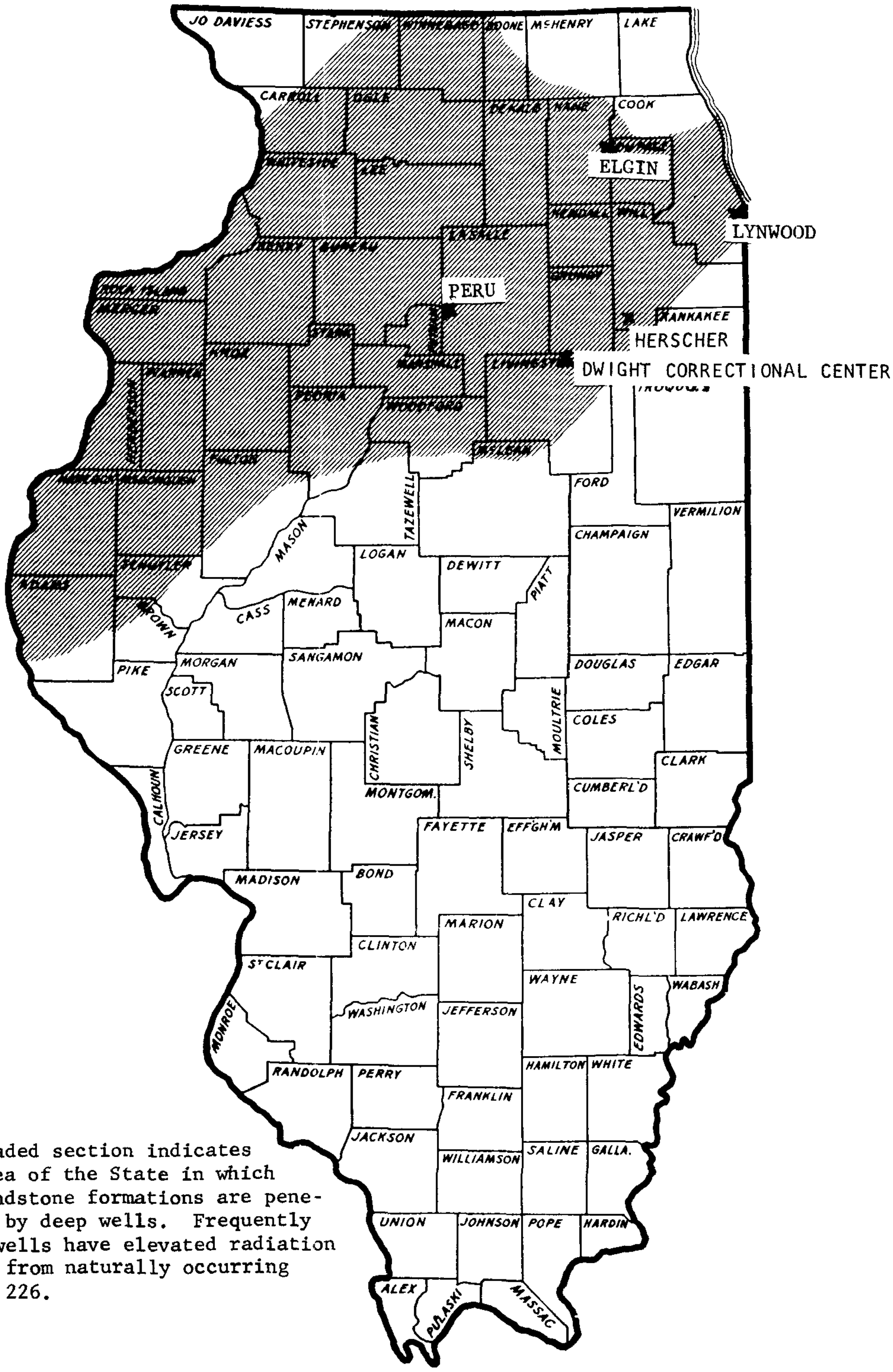
(1) Lucas, Henry F., and Ilcewicz, F. H., "Natural Radium 226 Content of Illinois Water Supplies," Journal AWWA 50:1523 (November 1958)



The shaded section indicates the area of the State in which the sandstone formations are penetrated by deep wells. Frequently these wells have elevated radiation levels from naturally occurring radium 226.

Figure 1 STUDY LOCATIONS AND DISTRIBUTION OF SANDSTONE FORMATION be penetrated by wells. These aquifers provide an abundant supply of water and are utilized by many communities. Work done by Grover H. Emrich (Illinois State Geological Survey) and Henry F. Lucas, Jr., (Argonne National Laboratories) indicates that the Glenwood-St. Peter sandstone contributes significantly to the concentration of radium found in the water with the radium content being low at the area of recharge and increasing down the hydraulic gradient.[2] All of the supplies included in this study have wells which are open to the St. Peter sandstone formation (see Fig. 2).

More recent investigations indicate that the radium may not be in the sandstone itself, but may be in the overlying shale. It is theorized that water passing slowly through this less permeable layer, leaches the radioactive material from the shale and carries it to the underlying sandstone aquifer.

1.4 SAMPLING AND ANALYTICAL PROCEDURES

Samples were collected from each location on three separate occasions at approximately one-week intervals. The plants were operated in a normal manner during this time. Samples of raw, aerated, filtered, and softened water were collected so that any changes in the radium 226 content of the raw water could be observed and the removal efficiency calculated. Difficulties in collecting the softened water were experienced at both Peru and Lynwood. At Lynwood, blending of softened water and raw water is done automatically to maintain a predetermined level of hardness. This blending occurs at the bottom of the softening unit, and no tap is available for obtaining samples of the softened water only. Sampling devices are shown in Figures 3 and 4.

Sampling of waste water presented a number of problems. In the lime softening plants, an attempt was made to obtain a composite sample using small pumps during backwashing of the filters. Frequent clogging occurred because of the heavy solids in the water. Because of this, it was necessary to go to a manual method which made it difficult to get a representative sample during the entire backwash cycle. At the zeolite plants, some means of determining the exact time when the radium is released from the softener is important. It was learned through a special sampling program at Herscher, that radium levels peak during brine rinse and then drop off rapidly. Unless samples are collected at the same point in the cycle it is impossible to make a meaningful comparison of radium being removed by the ion exchange softener during each cycle. A curve developed from numerous samplings taken during regeneration would be necessary to determine the actual amount

(2) Emrich, Grover H., Lucas, Henry F., "1968 Geologic Occurrence of Natural Radium 226 in Ground Waters in Illinois," International Association of Scientific Hydrology-VIII^{e} Annee No. 31963, pp. 5-19.

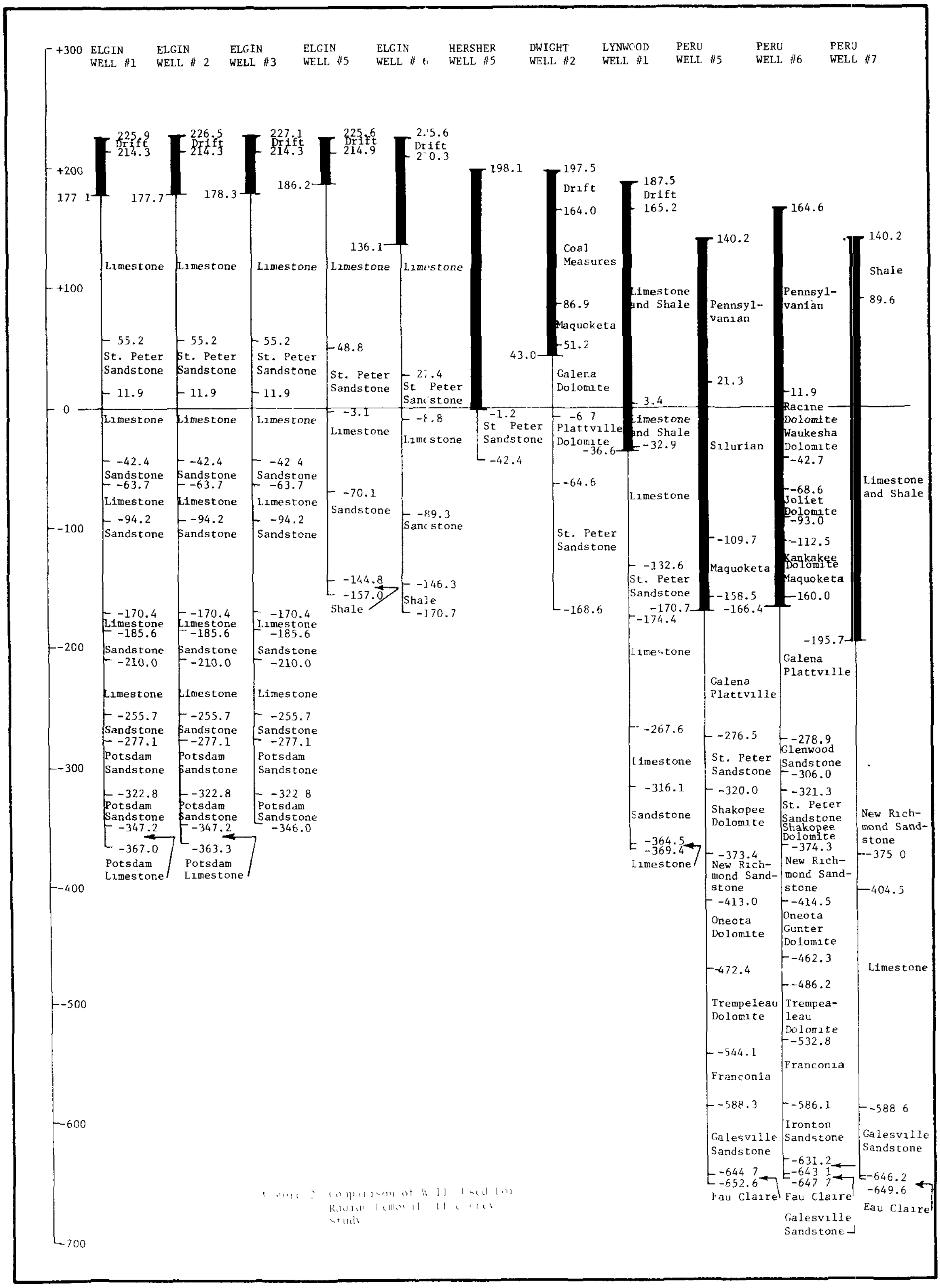


Figure 2 Comparison of Wells Used for Radium Removal [illegible] Study

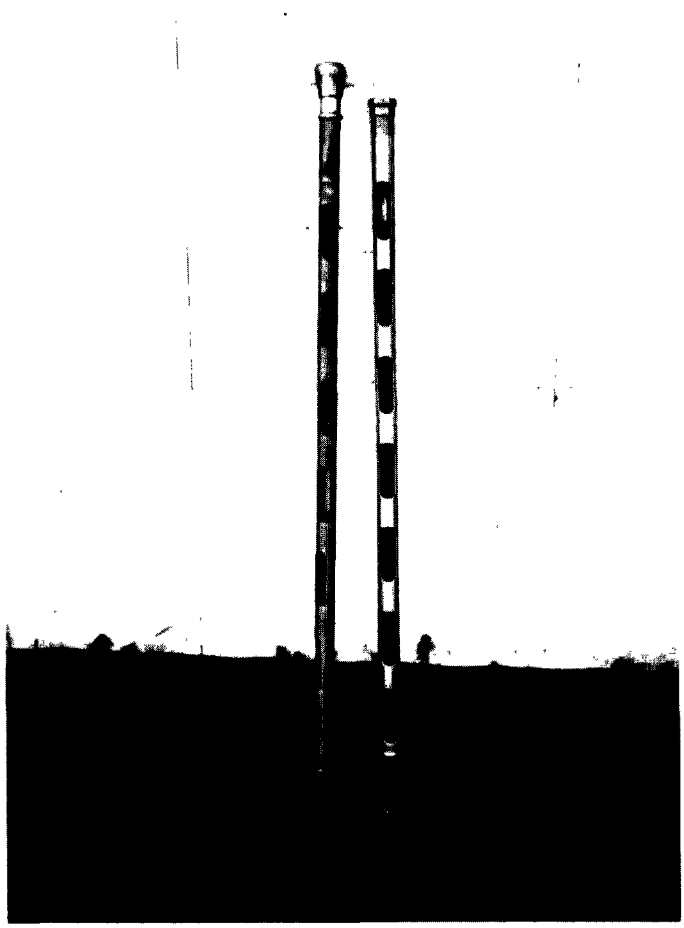


Figure 3 Grain Sampler Used For Collecting Resin & Filter Media Samples

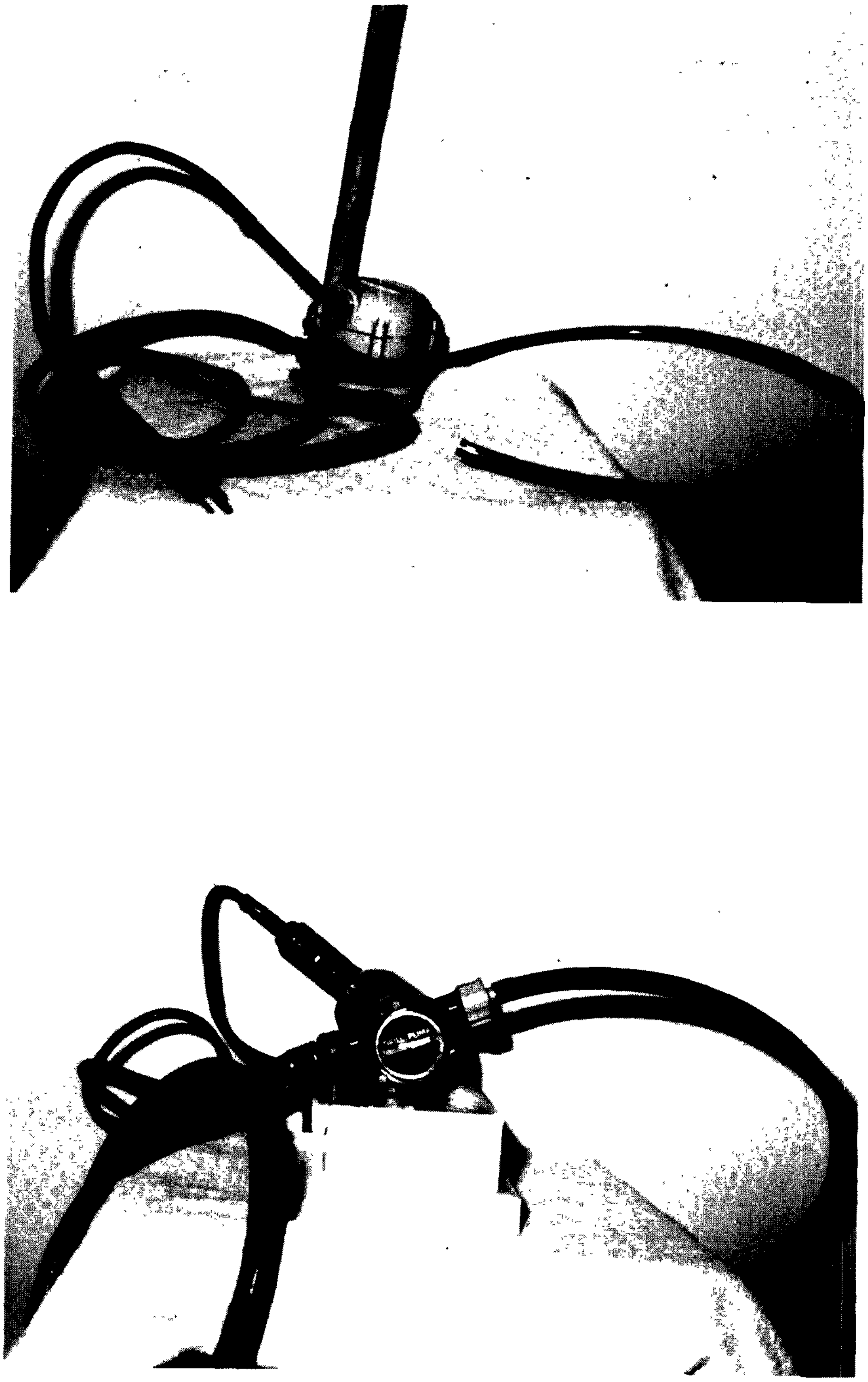


Figure 4 Pumps Used For Collecting Waste Water Samples

of radium discharged to waste. Without this information it is impossible to develop a mass balance of the radium going through the plant.

In an effort to correlate radium with other naturally occurring elements, mineral and trace metal analyses were done on all raw water samples. Analyses of wastes coming from the plants were also done to determine where the radium removed from the water was being discharged. Radium analyses were performed by Argonne National Laboratories using the radon emanation method. Resin samples were also analyzed by gamma-ray spectrometry using a Ge-Li detector. Duplicate analyses were done on 29 samples to ensure quality control. All sampling containers were prepared by Argonne Laboratories using disodium EDTA as a preservative to prevent plating of radium on the container walls during transport to the laboratory.

A limited number of samples were analyzed for both radium 226 and radium 228 by the United States Environmental Protection Agency. The samples were analyzed by gamma spectrometry using a Ge-Li detector.

All mineral, trace metal, and gross radiation analyses were performed by the Chicago section of the Illinois Environmental Protection Agency Laboratory. All testing was done in accordance with the Agency's quality control program. Under this program, every seventh sample is diluted (90% sample, 10% water) with deionized water and run as a duplicate to determine the precision of the analysis. Double deionized water is used as the diluent for the trace metal samples.

Disposable containers were supplied by the laboratory for all sampling. In order to ensure that the sampling containers were free of contamination, each lot underwent a quality control check. This check consisted of adding distilled water and preservative to the container, and performing all analyses on the water.

Preservatives were added to the sampling containers, where necessary, to prevent change in the sample while in transit to the laboratory. Redistilled nitric acid (20 ml of 1:1/ℓ of sample) was added to the sample for trace metal analysis to prevent plating of the metals on the walls of the container. Sodium hydroxide (1 ml of 5N/6 oz. sample) was added to the samples used for cyanide analyses. This was sufficient to maintain this portion of the sample at a pH of 12. All samples were refrigerated during transport to minimize changes in alkalinity and nitrate.

The gross radioactivity of the samples was determined by counting with an internal proportional counter. The counting error was determined at the 95% confidence level.

1.5 RESULTS AND CONCLUSIONS

The removal of radium, in general, was good for both ion exchange softening and lime softening. It does appear that ion exchange softening removes with a greater efficiency than lime softening, if the unit is regenerated as soon as calcium and magnesium begin to break through.

The removal efficiency of the ion exchange plants ranged from 70.2% to 98.2%. The efficiency at Dwight Correctional Center, which has a natural green sand unit, does not appear to be as high as the others, when figured as a percentage. In all cases, however, the radium 226 leaving the softener unit is less than 1 pCi/l. The plant at Lynwood (styrene-based zeolite), which has an automatic regeneration system, has the most consistently satisfactory removal. The softeners in this plant automatically regenerate as the hardness of the water begins to increase. As a result, the plant is always operating with a freshly regenerated zeolite unit. Starting with a radium 226 concentration of approximately 15 pCi/l, the highest concentration leaving the softener unit was 0.77 pCi/l.

At Herscher (styrene-based zeolite) significantly greater quantities of radium passed through the softener at breakthrough. In all samplings, greater than 2 pCi/l of radium was passing into the softened water at the end of the cycle. This could undoubtedly be overcome by more frequent regeneration.

The efficiency of radium removal appears to change as the cycle progresses. Although additional sampling would be required to reach a definitive answer, it appears that both green sand and styrene-based zeolite remove most efficiency at the midpoint* of the softener run. The apparent poor quality of removal at the beginning of the cycle should, however, be investigated further. Since the samples were collected immediately after regeneration, the slightly higher radium results may be due to incomplete rinsing, rather than to less complete removal. Samples representing the start of the cycle could be controlled by monitoring chloride content of the water and collecting samples only after normal background levels are reached. Radium begins to break through the softener at about the same time as the calcium and magnesium. The age of the resin should also be considered. The unit studies at Lynwood, which shows the highest efficiency, has been in use for about two years. Both of the other plants are using resin which has been in the softeners for ten or more years. The removal efficiency is shown in Table I.

The lime softening plants at Peru and Elgin did not remove radium 226 as efficiently as the ion exchange softening units. The removal efficiencies ranged from 70% to 92%. In general, the plant at Peru did not function as well as the plant at Elgin. Both plants have similar levels of radium 226 in the raw water (6-7 pCi/l). The softened water at Peru had a radium 226

*The term midpoint is used throughout this report to indicate <u>during</u> the cycle run.

concentration greater than 1 pCi/l (1.33-1.62) while the level in the softened water at Elgin was consistently less than 1 (see Table II).

TABLE I. RADIUM 226 REMOVAL EFFICIENCY OF PLANTS UTILIZING ION-EXCHANGE SOFTENING

	First Sampling (percent)	Second Sampling (percent)	Third Sampling (percent)	Average Removal (percent)
Dwight Correctional Center				
Regenerated	88.9	88.4	91.6	89.6
Mid-point	96.0	92.7	90.6	93.1
Near breakthrough	98.2	70.2	83.7	84.0
Herscher				
Regenerated	92.0	95.3	86.0	91.1
Mid-point	97.2	97.8	95.7	96.9
Near breakthrough	85.4	84.5	83.8	84.6
Lynwood				
Regenerated	97.3	97.0	94.7	96.3
Mid-point	98.3	97.6	98.2	98.0
Near breakthrough	97.3	96.5	98.2	97.3

TABLE II. RADIUM 226 REMOVAL EFFICIENCY OF PLANTS UTILIZING LIME SOFTENING

	pH	First Sampling (percent)	Second Sampling (percent)	Third Sampling (percent)	Average Sampling (percent)
Peru	10.2	92.0	70.0	75.7	79.2
Elgin	8.4	89.9	86.0	87.8	87.6

Blending the water to reach a satisfactory hardness in the distribution system raises the levels of radium which reach the user. Because lime softened water is not reduced to near zero hardness, little or no blend water is required to produce a stable product. In this study, however, both extremes of blending were observed. At Elgin all water is softened so that the figures for softened water represent water going to the distribution system. At the other extreme, water at Peru is blended with raw water at a high ratio (40% raw, 60% softened). Consequently, levels of radium going to the user are notably increased at Peru.

The near zero hardness of the zeolite-softened water requires that either unsoftened water or artificial hardness be added to prevent corrosive action in the distribution system. In order to avoid adding significant quantities of radium to the softened water, it may be possible to look for wells in a shallower aquifer to use for blend water. While the production from such a well would not be sufficient to supply the communities water needs, it may be sufficient to supply the blend water.

It should also be noted that the anthrafilt pressure filters at Herscher removed significant quantities of radium 226 before the water went to the zeolite softener. From 48 to 56% of the radium was removed by this step in the treatment process. Exposure profiles of these tanks developed during the field survey further verified that considerable quantities of the radium were retained in this process.

Careful consideration should be given to the disposal of the radium waste from the plant. Presently, most water plant waste is either discharged to a sewer, or directly to a receiving stream. Analysis of the wastes indicate that sizable quantities of radium (up to 300 pCi/l) are being released in the waste water. The advisability of discharging such waste to the sewer should be reviewed.

Lime sludge coming from the plants at Peru and Elgin contained a considerable concentration of radium-226. Samples of both the sludge and the blow-off sludge blanket were collected in order to determine if any differences in the radium content occurred. Results were inconclusive. At Peru, all concentration values are essentially the same regardless of the point of collection. At Elgin, two samples taken from the sludge blanket contained significantly lower concentrations of radium (1.26 $\pm$ 0.0 and 3.15 $\pm$ 0.09 pCi/g) while one sample had a relatively high level (12.53 $\pm$ 0.19). Samples taken from the lagoon appeared to have higher concentrations (6.01 $\pm$ 0.18 and 30 $\pm$ 2 pCi/g). It appears that the characteristic deposit of radium in the sludge varies from plant to plant and is probably dependent on the mineral content of the water. Considerably more study involving a number of lime softening plants would be required to determine what characteristics of the mineral content of the water affect the removal of radium.

Ultimate disposal of lime sludge also presents a serious problem. Although the actual amount of radium in each gram of sludge is very small, the total amount discharged becomes rather large. Each plant uses several thousand kilograms of lime each month. This amount is significantly increased by the calcium and magnesium precipitated from the water. Returning the sludge to a watercourse may result in sufficient dilution to avoid a significant problem. However, if the velocity of the stream is insufficient to disperse the sludge, it may settle out and produce a build up of radioactive waste on the stream bottom. Land disposal may present an even more serious problem if the concentrated radium builds up in a small area. The possibility of take-up by plants growing in soil treated with this lime sludge should be studied to determine whether or not radium is entering the food chain.

The studies have also indicated that considerable radium is retained in the zeolite and in the anthrafilt. A field survey of the plants studied shows that this does not present a hazard to personnel working in the plant under normal conditions. It may, however, present a sizable reservoir of radioactive material if it becomes necessary to remove these media from the tanks for replacement.

Exposure levels at each plant were studied during a field survey. In general, the exposure levels were insignificant except in the immediate area of the filter tanks or softeners. At Elgin, one sand filter that had been drained for maintenance was observed to have significantly increased exposure rates near the surface of the sand. It was felt that this did not constitute a hazard to the workmen since they were exposed for only short periods of time.

Other trace elements are also concentrated in the lime sludge. This was evident in the build up of barium in the sludge at Elgin. The water at Elgin contains significant amounts of barium which are removed by the softening process and precipitated into the sludge.

2.0 DWIGHT CORRECTIONAL CENTER

2.1 INTRODUCTION

The Dwight Correctional Center is a state owned institution located in Livingston County about two miles west of the village of Dwight (see Fig. 1). This system serves a population of about 235. The average daily pumpage is 112.4 m^3 (3 x 10^4 gpd).

2.2 DESCRIPTION

All water which was pumped through the system during this study was from well #2. This well was drilled in 1948 to a depth of 366 m. The well is cased with a 53-cm drive pipe from 0 to 27.8 m. Inside this, there is a 30-cm casing from 0 to 42.7 m, and a 25-cm casing from 42.7 to 155.4 m. A 38-cm liner extends from 78 m to 128 m.

The water is aerated, primarily for hydrogen sulfide removal. The aerator is a coke tray unit consisting of four trays, 2.81 m^2 each, with a total area of 11.3 m^2. Water is passed through the unit at an approximate rate of 58.1 m^3/day.

The supply has two pressure ion exchange softener units which are 1.83 m in diameter and 2.13 m tall. The rated capacity is 151.4 m^3/day. The units were originally installed in 1944. They were rebuilt in 1954 and new gravel and zeolite added. At that time, the units were filled with a natural green sand ion exchange material obtained from the Elgin Softening Company. Since then, one unit has been replaced (1964) with the new unit having styrene based zeolite. The softeners are used on an alternate basis so that one unit is recharged each day. In order to test the radium removal efficiencies of as many materials as possible, the unit containing the natural green sand was chosen for this study.

The water is further treated by the addition of caustic soda and sodium silicate for corrosion control before passing to the distribution system. Approximately 10% aerated water is blended with the softened water. See Appendix A for detailed description of the facilities and equipment at the Dwight Correctional Center.

2.3 SAMPLING AND ANALYSIS

Samples were collected from this supply on February 4 and 5; 13 and 14; and 19 and 20, 1975. Raw, softener influent (aerated) and softener effluent samples were collected immediately after regeneration of the softener, at midpoint in the cycle and at breakthrough. An additional composite sample of the waste water was also collected. The approximate composition of the waste water is as follows:

Backwash water	3,078 liters
Brine	923 liters
Rinse water	10,206 liters

The waste water sample was composited by placing a sump pump into the pit where the waste is discharged.

A sample of the green sand was also collected. The port on these softeners is located on the side of the unit, making it very difficult to sample at any great depth. Consequently, the sample was collected at a depth of only 22.9 to 30.5 cm below the surface. Analyses for radium were done by both Argonne National Laboratory (ANL) and the United States Environmental Protection Agency laboratory. Considerable variation in the results was noted, ranging from 28.66 $\pm$ 0.46 pCi/gm (ANL) to 46.4 $\pm$ 5.5 pCi/gm (USEPA).

Argonne attempted to extract the radium from the resin using hydrochloric acid and EDTA. The acid extracted sample gave a radium 226 content of 34.22 $\pm$ 0.55 pCi/gm compared to 28.66 $\pm$ 0.46 pCi/gm from the EDTA extraction. The sample analyzed by the USEPA was done by gamma-ray spectrometry using a Ge-Li detector.

A gamma scan of the resin conducted by ANL indicated the presence of both thorium 228 and radium 228. The radium 228 is apparently in excess, in contrast to the ratio which is normally expected for transient equilibrium. Analyses for radium 228 in the USEPA laboratory by gamma-ray spectrometry and a Ge-Li detector indicated a concentration of 59.0 $\pm$ 2.2 pCi/gm.

The exposure rate vertical profile on the side of the green sand tank indicated a maximum level of 29 μR/hr near the center of the tank (see Fig. 5). The samples were collected considerably above this in an area of the tank which indicated a rate of 20 to 23 μR/hr.

Exposure rates measured at other locations within the plant were 7.0 $\pm$ 1.0 μR/hr above a natural background rate, outside the plant, of 6.7 μR/hr.

2.4 RADIUM REMOVAL

The radium data indicate that the radium content of the raw water is fairly constant, ranging from 3.12 $\pm$ 0.09 pCi/l to 3.46 $\pm$ 0.10 with an average of 3.26 $\pm$ 0.12. The radium 226 content of the softened water was low, ranging from 0.056 to 0.98 pCi/l. The average radium content was 0.36 $\pm$ 0.27 pCi/l. The finished water going to the distribution system is a blend of 90% softened water and 10% aerated water. Assuming that no radium is lost during aeration, the calculated radium 226 content for the blended water would range from 0.36 to 1.23 pCi/l. Reduction of the radium 226 by the natural green sand unit is shown in Table III.

Comparing the three samplings, there is no clear cut indication of when the

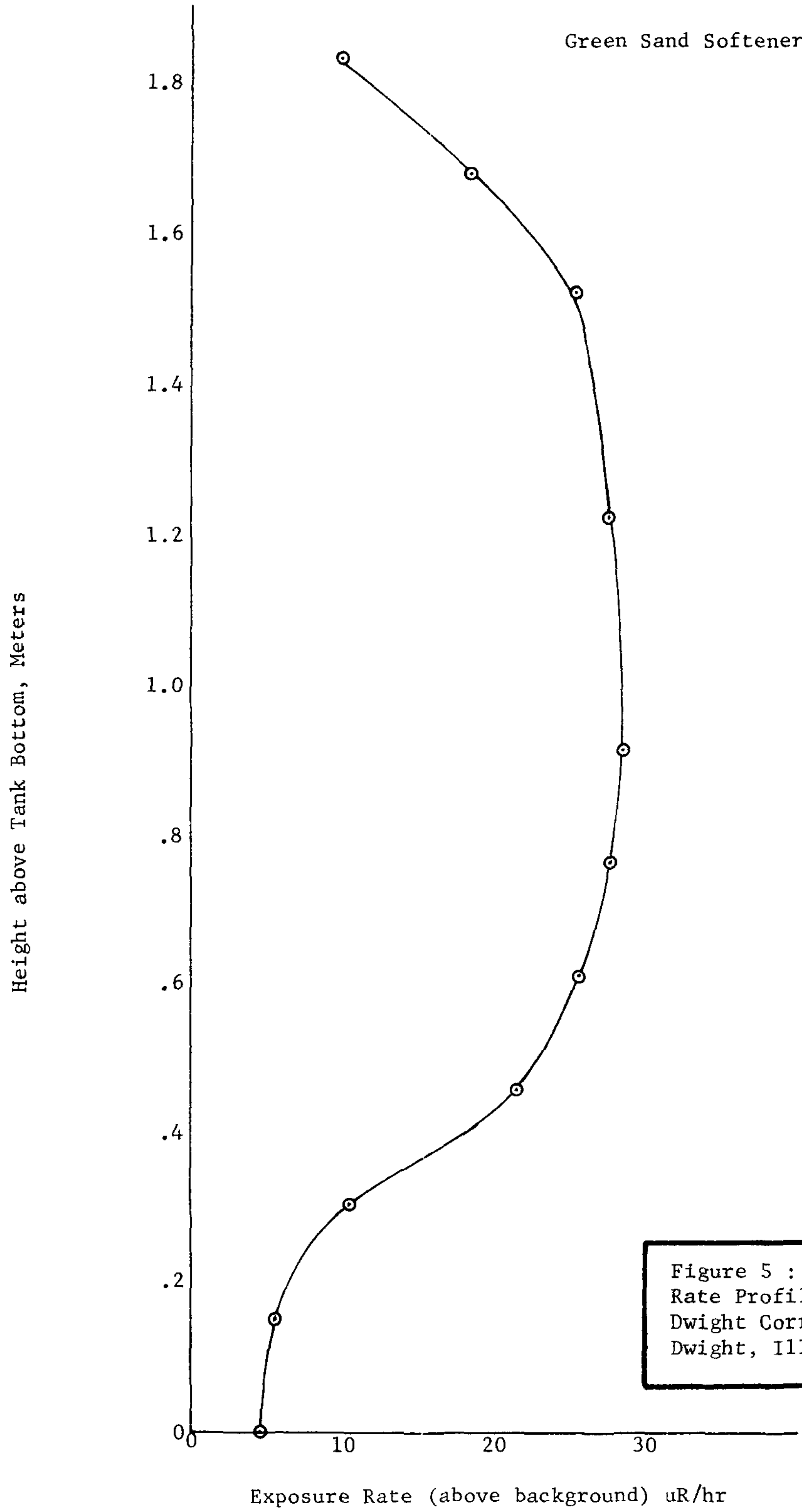


Figure 5 : Exposure Rate Profile, Dwight Correctional Center Dwight, Illinois

TABLE III. REDUCTION OF RADIUM AND HARDNESS
DWIGHT CORRECTIONAL CENTER

	Sampling Date	Radium 226 Content Raw Water (pCi/l)	Hardness Raw Water (mg/l as $CaCO_3$)	Radium 226 Content Softened Water (pCi/l)	Hardness Softened Water (mg/l as $CaCO_3$)	Percent Reduction Radium 226	Percent Reduction Hardness
Regenerated	2/4/75	3.24	289	0.36	19.0	88.8	93.4
Midpoint	2/5/75	3.23	282	0.13	7.0	95.9	97.6
Near Breakthrough	2/5/75	3.13	292	0.056	129.0	98.3	55.2
Regenerated	2/13/75	3.46	286	0.40	16.0	88.0	94.3
Midpoint	2/14/75	3.31	284	0.25	4.1	92.5	98.6
Near Breakthrough	2/14/75	3.29	279	0.98	131.0	70.7	53.7
Regenerated	2/19/75	3.22	285	0.27	9.3	91.5	96.8
Midpoint	2/19/75	3.19	286	0.30	0	90.6	100.0
Near Breakthrough	2/19/75	3.12	289	0.50	74.0	84.3	74.2

softener is most efficient. During the first two samplings, it appears to be more efficient at the midpoint than at the beginning of the softener run. During the second and third sampling, breakthrough of radium was occurring at the end of the softener run. More frequent sampling would be required to determine just when breakthrough occurred.

The gross alpha activity is much higher than the activity attributable to the radium content, and also showed considerably more variation from sample to sample. The range on the raw water samples was from 9.4 to 43.2 pCi/l. It appears that the aerator is removing a considerable part of the radioactive materials.

Radium 226 analyses were not done on the aerated water samples. Further study should be done to determine whether or not the coke bed itself may be retaining a portion of the radioactive material.

2.5 MISCELLANEOUS CHEMICAL DATA

While not directly related to this study, the fluoride data show an unusual phenomenon. The fluoride content of the raw water is consistently 1.4 to 1.5 mg/l. Immediately after regeneration, the fluoride is sloughed off of the green sand in the softener and the fluoride content of the softened water is quite high ranging from 3.4 to 4.8 mg/l. By midpoint in the cycle, the fluoride is again being retained in the softener and the softener effluent has a fluoride content of 0.9 to 1.4 mg/l. At the end of the cycle, the fluoride content of the softened water had decreased to 0.5 to 0.6 mg/l. Very little of the fluoride is released at regeneration, with the waste water containing only 2 to 2.5 mg/l. Potassium is also tied up in the softener, with breakthrough occurring at approximately the same time as the calcium breakthrough.

All chemical and radiological data are included as Appendix Table A-1.

An attempt at a material balance of the radium 226 proved unsuccessful. Since the radium is apparently released from the softener at an uneven rate, the composite of the waste water was not representative of waste coming off. Further studies, which would include numerous samples taken during the backwash, brine, and rinse cycles would be required to give a value of the actual amount of radium 226 being discharged into the waste stream.

2.6 COST DATA

Cost figures on the initial installation and on salaries are not available. However, it is estimated that the operator spends 1.5 hr/day in actual water plant operation.

The chemical and electrical costs on a daily basis for operation of the plant are as follows:

Salt	609 kg	@ $.0343/kg	$20.88
Sodium silicate	3.27 kg	@ $ .187/kg	.61
Caustic soda	1 kg	@ $ .04/kg	.04
			$21.53

It is also estimated that electrical costs for pumpage averages $2.00/day. Based on a plant capacity of 112.4 m^3/day, the chemical and electrical costs are about $0.78/1000 gal.

3.0 PERU

3.1 INTRODUCTION

The city of Peru, located along the Illinois River in LaSalle County has an estimated population of 12,400 people (see Fig. 1). The water treatment plant which is presently in use, was put into operation in 1932. Presently, the average daily pumpage being processed at this plant is 6,832 m^3 (1.8×10^6 gpd).

3.2 DESCRIPTION

Water is drawn from three deep wells, aerated, treated with lime and sodium aluminate at a pH of 8.4, clarified, settled, recarbonated, chlorinated and filtered before being pumped to the distribution system.

Well number five was drilled in 1931, and is located two blocks west of the filtration plant. The well is cased from the surface to 312.7 m. From 312.7 m to 450.5 m there is a 38 cm open rock hole. A 42.5 cm liner was placed between 450.5 m and 492.5 m. The balance of the well is open. Radium 226 analyses of the water samples collected were 4.57 and 4.78 pCi/l with the average being 4.68 pCi/l.

Well number six, located on a bluff above the plant at Plumb and Center Streets, was drilled in 1952 to a depth of 82.3 m (see Fig. 4). The radium 226 content of this well was 3.08 and 3.73 pCi/l and averaged 3.41.

Well number seven, located on the north side of Water Street near the foot of West Street, was drilled in 1963 to a depth of 789.7 m (see Fig. 6). It is cased to a depth of 335.9 m and is open for the rest of the depth. The drillers log is not as detailed as the logs for Wells number five and number six. However, because of the proximity of the wells, it can be assumed that the geologic formation would be very similar. The radium 226 content averaged 6.07 pCi/l which is considerably higher than the levels found in the other wells. During the time of sampling, this well was being used as the major source of water.

See Appendix B for detailed description of the facilities and equipment at the Peru waterplant.

3.3 SAMPLING AND ANALYSIS

Samples of raw, aerated, and filtered water for mineral, trace metal, and radium analyses were collected on February 20, 25, and March 4, 1975. Inadvertently, the samples of filtered water collected on February 20 and 25, 1975, were actually blended water as it was going to the distribution system. To compensate for this error, an additional sample of filtered

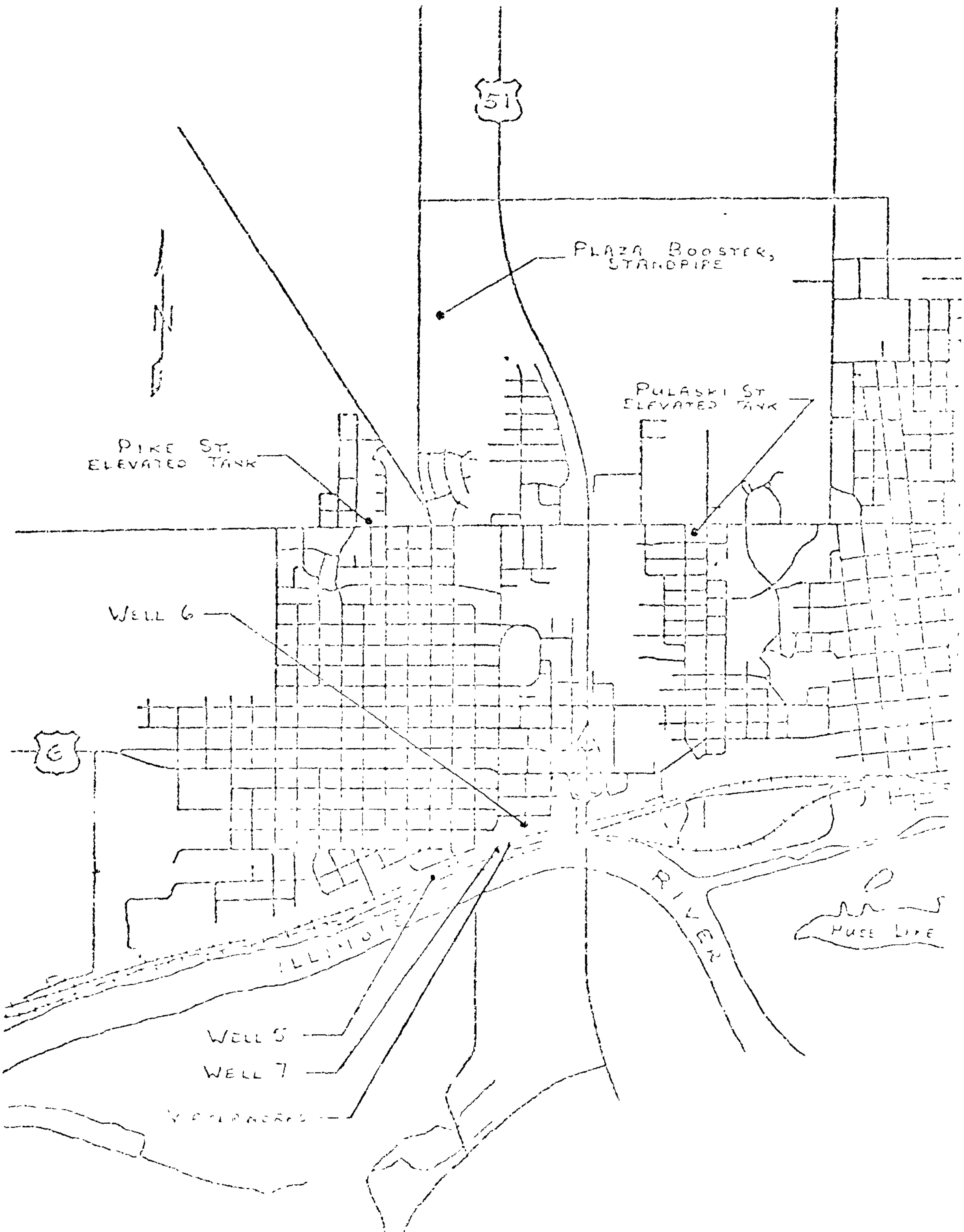


Figure 6 Well Locations in Peru, Illinois

water was collected on March 19, 1975.

Samples of clarifier sludge from the blow-off well and backwash water were also collected and analyzed for radium content. The backwash sample was collected by using either a sump pump or "SKIL" drill pump. Approximately 19 liters of the dilute slurry were pumped from the settling tank and were allowed to settle, and the supernatant liquid poured off, leaving the solids.

The sludge sample was collected from the sludge pit manually with a scoop.

This plant has three filters, each with an area of 15.6 m^2. The filter medium is composed of anthracite, sand, and gravel. Over the years, the anthracite has become completely encrusted with what appeared to be a lime scale. An analysis of a sample of the filter media conducted in the Illinois EPA laboratory indicated that the material contained 29% calcium and 0.2% magnesium. Analysis for gross radioactivity indicated an alpha activity of 116.0 $\pm$ 41.4 pCi/gm and a beta activity of 116.3 $\pm$ 24.6 pCi/gm. Analysis of a sample collected during a plant visit indicated a radium 226 content of 4.6 $\pm$ 1.3 pCi/gm and a radium 228 concentration of 3.6 $\pm$ 0.4 pCi/gm.

The filters are backwashed once each day at a rate of 7570 l/min. for a period of three minutes. Radium analyses of composite samples of backwash water show considerable variation with the range being 9.65 pCi/l to 87.7 pCi/l. Presumably, the method of sample collection was responsible for this wide variation. Because of clogging of the pump, it was extremely difficult to accurately composite the sample during the entire backwash cycle.

Samples of the lime sludge were collected on February 19 and 25, and March 4, 1975, from both the sludge pit and from the blow-off sludge to determine whether or not the radium value was consistent in the various fractions of the sludge. There was no appreciable variation in the radium results on the sludge samples with the radium 226 content ranging from 8.84 to 9.31 pCi/gm with an average of 9.06 pCi/gm.

Sludge samples were also collected on March 18 and analyzed by the United States Environmental Protection Agency using gamma-ray spectrometry with a Ge-Li detector. The concentration of radium 226 was 3.9 $\pm$ 1.0 pCi/gm and of radium 228 was 3.1 $\pm$ 0.3 pCi/gm.

3.4 RADIUM REMOVAL

The softening process reduced the radium 226 by 70.6 to 92.4%. Since samples were collected from the individual wells on February 25 and March 4, 1975, the radium 226 content of the raw water was calculated on the basis of pumpage from each well.

During the first two samplings, samples were taken of the blended water rather than from the softened water. The content of the softened water was calculated from the blend ratio. Values and reduction are indicated in Table IV.

The radium content of the blended water is quite consistent and averages 2.94 pCi/l of radium 226 which is going to the consumer.

Exposure rates at the plant indicated no measurable increase above background, except for an area above the clarifier sludge pit and near the aerator where there were quantities of fly ash from the adjacent coal fired power station. Levels near the aerator were 20 μR/hr and above the sludge pit, 3 μR/hr above background. Natural background exposure was about 10 μR/hr.

3.5 MISCELLANEOUS CHEMICAL DATA

Mineral analyses of the three wells indicate that the water from well number seven is somewhat higher in total dissolved mineral content than the other wells with the major difference in the chloride content. As previously noted, the radium content is also higher. At the time of sampling, 78 to 87% of the water being processed at the plant was coming from this well. Heavy pumping of this nature could influence the quantity of water being drawn from a given portion of the aquifer and thus directly influence the mineral character of the water.

Trace metals are negligible, with the possible exception of barium which is present in very small quantities in nearly all of the raw water samples.

All chemical and radiological data are available in Appendix Table B-1.

3.6 COST DATA

Cost figures for the plant and equipment are not available. Power and maintenance costs are combined with other city utilities and cannot be separated with accuracy.

Chemicals used at the plant over a period of twelve days were:

Lime	18,273 kg
NaAlO (Dearborn 502 alkaline coagulant)	680 liters

for an average daily use of:

Lime	1,523 kg
NaAlO	56.7 liters

TABLE IV REDUCTION OF RADIUM AND HARDNESS

PERU

Sampling Date	Radium 226 Content Raw Water (pCi/1)	Hardness Raw Water (mg/1 as CaCo)	Radium 226 Content Softened Water (pCi/1)	Hardness Softened Water (mg/1 as CaCo)	Percent Reduction Radium 226	Percent Reduction Hardness
2/19/75	6.39	329	0.48	70	92.4	78.7
2/25/75	5.49	320	1.61	100	70.6	68.8
3/04/75	5.48	329	1.21	112	77.9	66.0

Approximate cost of these materials is \$75.00/day. Based on a plant capacity of 6,832 m^3/day, the chemical costs are about \$0.04/1000 gal.

4.0 HERSCHER

4.1 INTRODUCTION

The village of Herscher is located in the west central part of Kankakee County (see Fig. 1). The estimated population served by the public water supply is 1,000 with the average daily pumpage being 379 m^3 (1×10^5 gpd).

4.2 DESCRIPTION

The present water treatment facilities were placed in operation in 1965. The water is aerated, settled, chlorinated, filtered, treated with polyphosphate and potassium permanganate, softened, and pumped to the distribution system.

Water used for this study was obtained from well number five, drilled in 1953 to a depth of 240.5 m. The well is cased from 0.46 m above the floor level to a depth of 199.3 m. At that point, sandstone was reached.

The aerator is 1.11 m^2 and 3.65 m high, steel coated with plastic and has steel baffles. A blower forces air up through the falling water. It is located above a 4.3 x 4.9 x 3 m collecting reservoir. The water is filtered through an anthrafilt filter before passing to the softener. The pressure filters are 1.8 m in diameter and 1.5 m high and have a total capacity of 567 l/min. The filters are backwashed twice a week.

From the filters, the water is passed to the zeolite softener. The softener is 1.67 m in diameter and 2.13 m high and contains 2.4 m^3 of styrene-based zeolite.

See Appendix C for detailed description of the facilities and equipment at the Herscher water plant.

4.3 SAMPLING AND ANALYSIS

Samples were collected on March 25, April 1, and April 8, 1975. Samples of raw water, filter influent, filter effluent, and softener effluent were collected immediately after regeneration, at mid-point in the cycle, and near breakthrough.

4.4 RADIUM REMOVAL

Radium content of the raw water was relatively constant, ranging from 13.95 to 14.94 pCi/l with the average being 14.34 $\pm$ 0.37.

Reduction of the radium 226 is illustrated in Table V.

Removal of radium by aeration was unpredictable. In one case a reduction of

TABLE NO. V

REDUCTION OF RADIUM-226 AND HARDNESS - HERSCHER

	Sampling Date	Ra-226 Raw Water pCi/l	Hardness Raw Water mg/l as $CaCO_3$	Ra-226 Aerated Settled Water, pCi/l f.	Ra-226 Reduction thru Settler	Ra-226 Filter Eff. pCi/l	Ra-226 Reduction thru Filter	Ra-226 Softener Eff. pCi/l	Hardness Softener Eff. mg/l as $CaCO_3$	Ra-226 Reduction thru Softener	Hardness Reduction	Ra-226 Total Reduction
Regenerated	03/25/75	14.91	412	13.08	12.3%	6.64	49.2%	1.25	18	81.2%	95.6%	91.6
Midpoint	03/25/75	14.34	[illegible]	13.74	[illegible]	6.94	49.5%	0.42	12	93.9%	97.2%	[illegible]
Near Breakthrough	03/25/75	14.27	417	14.32	----	6.88	51.8%	2.07	184	69.9%	55.8%	[illegible]
Regenerated	04/01/75	14.49	421	13.38	7.7%	6.37	52.4%	0.68	11.8	89.3%	97.2%	[illegible]
Midpoint	04/01/75	14.22	386	13.92	2.1%	6.94	50.1%	0.43	9.1	93.8%	97.6%	[illegible]
Near Breakthrough	04/01/75	13.96	439	13.94	0.1%	6.34	50.9%	2.16	225	68.4%	48.7%	84.[illegible]
Regenerated	04/0?/75	13.95	386	13.84	0.8%	7.26	47.5%	1.93	19	73.4%	95.1%	[illegible]
Midpoint	04/0?/75	14.0?	386	14.24	----	6.4	54.5%	0.60	9	90.6%	97.6%	[illegible]
Near Breakthrough	[illegible]	[illegible]	366	13.30	6.9%	6.51	51.1%	2.31	261	64.5%	28.7%	[illegible]

12.3% was noted, while in others, no removal or even a slight increase was indicated. Since these samples were taken from the collecting reservoir, the amount of suspended material in the sample may vary from one time to another. To fully evaluate this step of the treatment process, the water would require filtering at the time of sampling.

Water at Herscher has a very high level of hydrogen sulfide. It is treated with potassium permanganate after aeration to further aid the control of odor. The anthrafilt filters are designed to remove any insoluble sulfur compounds, rather than for iron removal. Approximately 50% of the radium is removed by filtration through the anthrafilt. The efficiency of the filter appears to remain nearly constant throughout the filter run.

Since considerable radium 226 is found in the filter backwash water, most of the radium is probably removed by physical filtration. Potassium permanganate is used to oxidize the sulfide prior to filtration. If the radium is in a soluble form when pumped from the well, it could combine with the oxidized sulfur to form insoluble radium sulfate.

Exposure rate profiles vertically on the side of the filters (see Fig. 7) indicate that the highest concentration of activity is approximately 0.6 meters from the bottom of the tank. A sample of anthrafilt was collected from approximately 0.762 m below the surface of the medium. Analysis of the sample indicated a radium 226 concentration of 111.6 $\pm$ 3.4 pCi/gm and a radium 228 concentration of 38.9 pCi/gm.

The radium 226 is further removed in the zeolite softener. The efficiency of the softener is greatest at the midpoint of the cycle with 90.6 to 93.9% removal. Near breakthrough, the efficiency of removal is reduced to about 64.5%. At this point, 22 to 42% of the calcium and 76 to 100% of the magnesium are also passing through the softener, indicating that the softener should have been regenerated sooner, and that breakthrough had already occurred.

Wastewater coming from the filters and softener contains considerable quantities of radium. The average radium 226 content of the filter backwash water was 150 pCi/l. From 17,000 to 28,000 liters of water are put through during each backwashing of the filter. It is impossible to determine the exact amount of radium removed from the filter, since the method of compositing the sample may not be accurate.

A special group of samples of waste water from the softener regeneration cycle was collected on April 8, 1975. During this regeneration cycle, samples were collected at approximately six minute intervals with the first sample being collected seven minutes after the start of the brine phase and continuing until the end of the fast rinse cycle (see Fig. 8). For the first 26 minutes of the cycle, the radium 226 concentration in the waste water remained approximately constant or even decreased slightly. From 26 minutes to 43 minutes, the concentration rose sharply, peaking at 315 pCi/l. From this point on

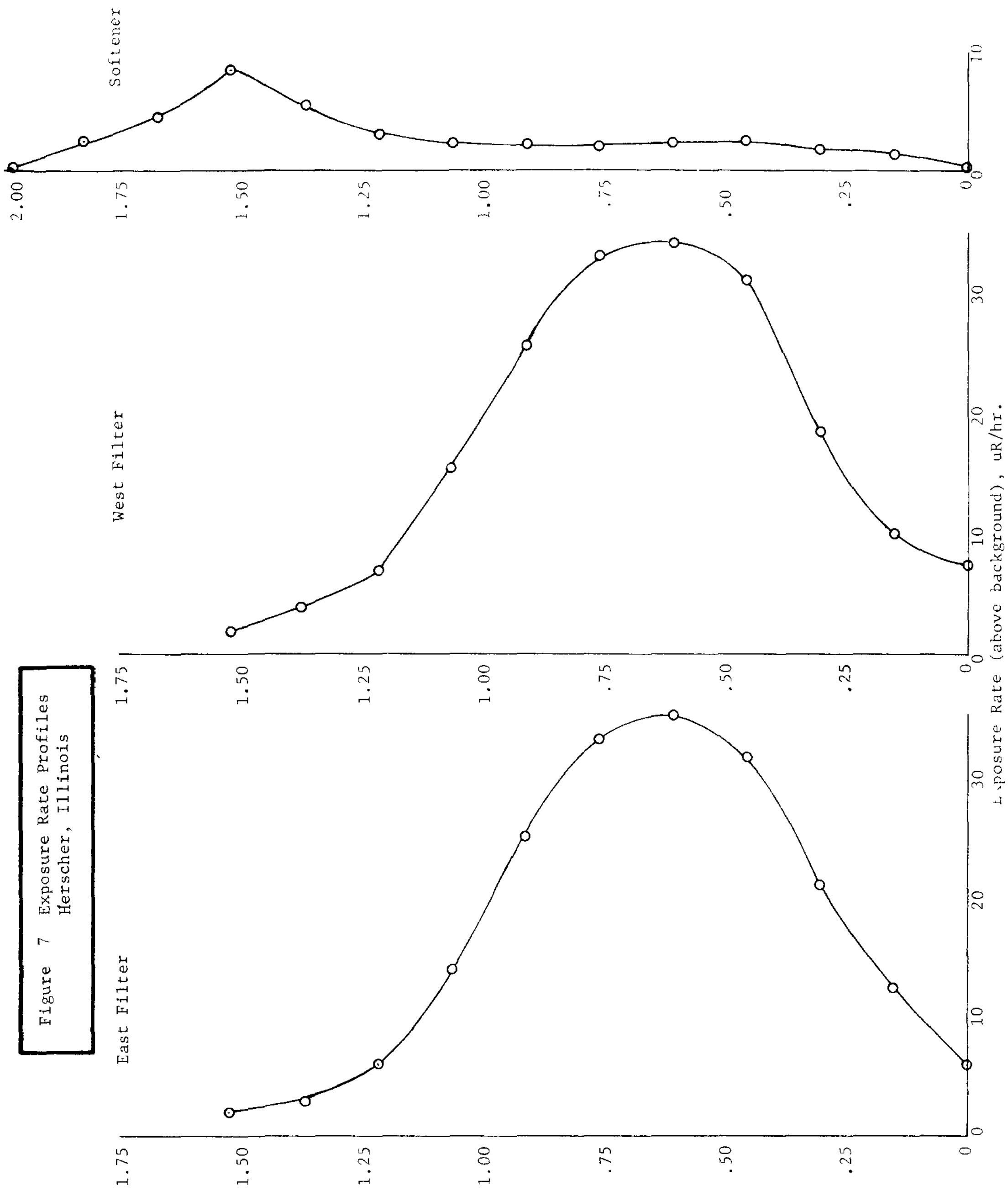


Figure 7 Exposure Rate Profiles
Herscher, Illinois

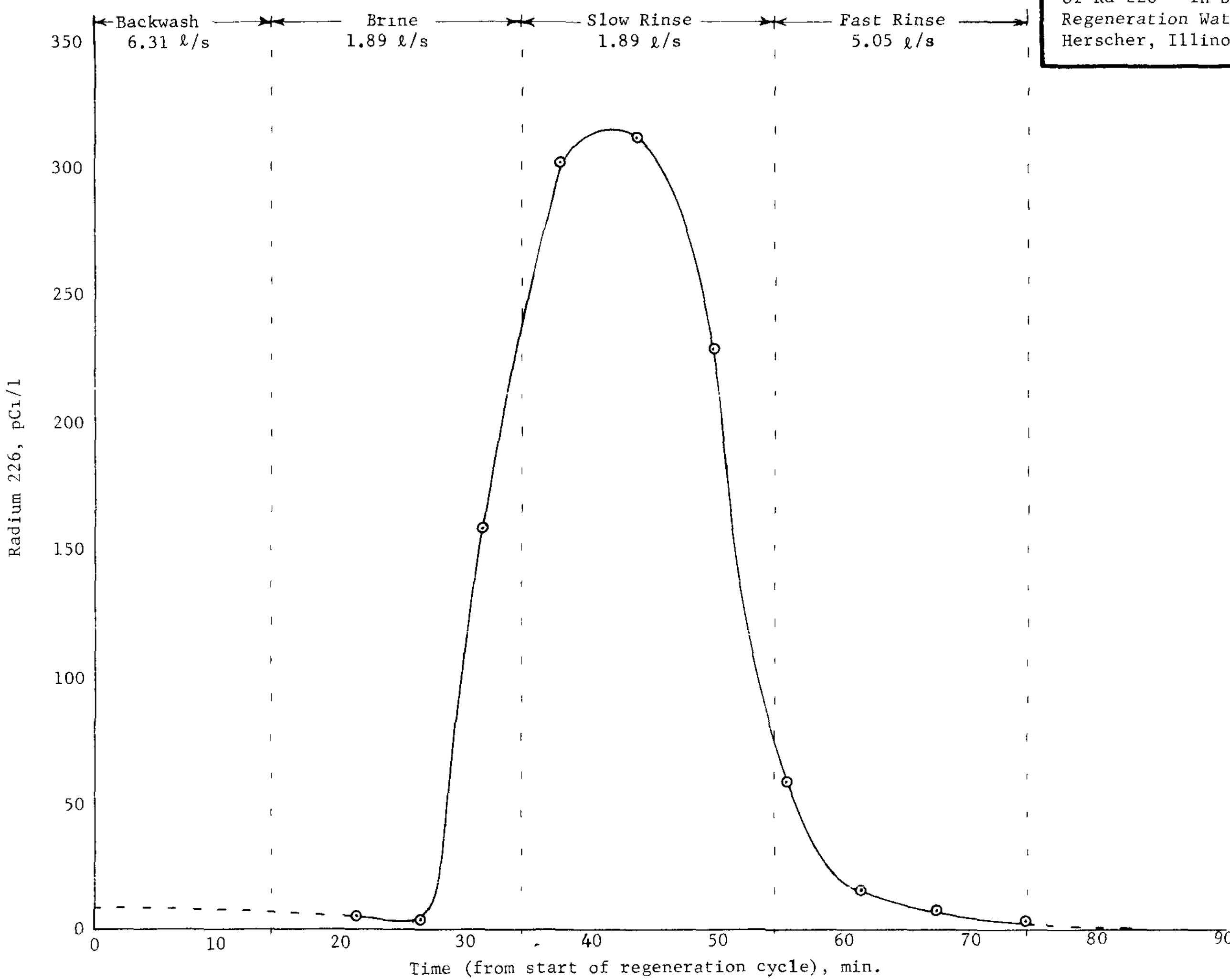


Figure 8 Concentration of Ra 226 - in Softeners Regeneration Water Herscher, Illinois 4/8/75

through the remainder of the cycle, the concentration decreases rapidly.

Figure 8 was plotted based on time; however, since there are different flow rates for each phase of the regeneration cycle, this gives a somewhat distorted view. Therefore, the data were replotted in Fig. 9 with radium concontration versus wash water used. From this curve, the calculated radium 226 concentration in the 16,000 liters of waste water was approximately 54 pCi/l for a total of 0.864 μCi of radium 226 removed.

Using the sample analysis of the composite regeneration waste, the average radium 226 concentration was 79.3 pCi/l for a total of 1.30 μCi of radium 226 removed. Using the average values of the softener influent and effluent and an average of 250,000 liters between regeneration, the total radium 226 removed is calculated to be 1.25 μCi. As can be seen from these figures, more accurate data concerning the quantity of the water filtered, quantity of regenerated water, and levels at which radium 226 comes out in the waste water are needed.

Eighteen percent filtered water is blended with the softened water to produce a satisfactory hardness in the distribution system. This would result in an average concentration of 2.37 pCi/l of radium 226 reaching the water user.

4.5 MISCELLANEOUS CHEMICAL RESULTS

The overall water quality of both the raw and finished water at Herscher is somewhat poor. The raw water is highly mineralized, having a residue of 1450-1500 mg/l. Both the chlorides and the sulfates are higher than desirable for an esthetically pleasing water. The natural sodium is high enough to be unsatisfactory for persons on a sodium-restricted diet. Softening the water by means of ion exchange increased the sodium to an even higher level. Barium was present at 0.2 mg/l. No other metals of any significance were found.

All chemical and radiological data are included in Appendix Table C-1.

4.6 COST DATA

No cost data were available from this plant.

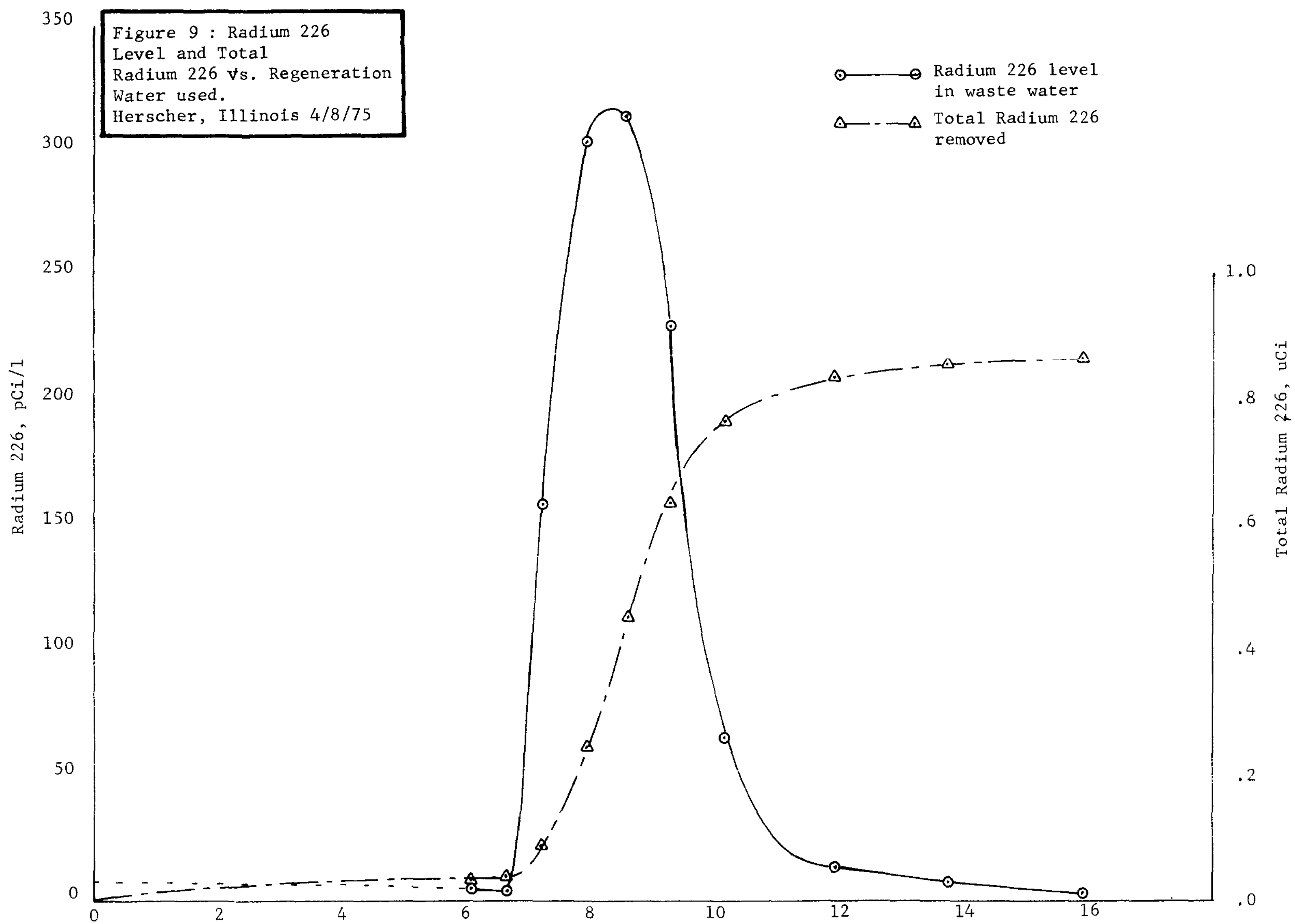


Figure 9 : Radium 226 Level and Total Radium 226 Vs. Regeneration Water used. Herscher, Illinois 4/8/75

5.0 ELGIN

5.1 INTRODUCTION

The city of Elgin, located in Kane County (see Fig. 1) has a population of of 58,000. Water for the city is processed in three separate treatment facilities. The Slade Avenue Plant and the West Side Plant both utilize lime softening, while the St. Charles Plant has zeolite softening. Radioactivity levels of the water which feeds the Slade Avenue Plant are much higher than those which go to the West Side Plant. Therefore, even through the facilities are much older than the West Side Plant, the Slade Avenue Plant was chosen for this study. Approximately 25,000 people are served by this plant.

5.2 DESCRIPTION

The original Slade Avenue water plant was built in 1887-1888 and was designed to process water from the Fox River. Because the river water was of such poor quality, wells were drilled in 1904. Portions of the old plant and the wells that were drilled at that time are still in use. The softening units were added in 1937.

Wells which were in service at the time of sampling were wells number one, number two, number three, number five, and number six. Well number one was drilled in 1904 to a depth of 656.2 m. It was opened to a depth of 638.12 m in 1945 and reopened to that depth in 1960. Casing records indicate that it is cased to a depth of 177.09 m. It is located at the south end of the treatment plant.

Well number two, located on the west side of the treatment plant, was drilled in 1904 to a depth of 426.51 m. In 1924 it was deepened to 639.76 m and in 1946 it was further deepened to 644.69 m. It was reopened to 634.84 m in 1946. The well is cased to 177.70 m.

Well number three, located about 98 m north of the treatment plant was also drilled in 1904. The original depth was 426.51 m, but was deepened to 643 m in 1924. In 1961 it was reported to be 588.25 m deep. It is cased to a depth of 178.31 m.

Well number five, drilled in 1949 to a depth of 411.75 m, is located about 164 meters south of the plant. It is cased to a depth of 186.23 m. Well number six, also located south of the plant, was drilled in 1958 to a depth of 426.51 m and is cased to a depth of 136.09 m.

Water from these wells is discharged into a raw water reservoir and then pumped to two air diffusion type aerators to remove the hydrogen sulfide. Lime and ferrous sulfate are added in the mixing basin. The pH is raised to 10.2 during treatment. The water is allowed to settle before filtering through rapid sand filters. See Appendix D for detailed description of the facilities and equipment at the Elgin plant.

5.3 SAMPLING AND ANALYSIS

Samples to determine the radium removal efficiency of this plant were collected on March 7, 14, and 21, 1975. Although the wells are drilled in close proximity and, in general, the mineral data are similar (see Appendix Table D-1), the radium and barium levels are significantly higher in well number six.

5.4 RADIUM REMOVAL

The radium is removed by the softening process as follows:

TABLE NO. VI REDUCTION OF RADIUM AND HARDNESS - ELGIN

	Raw		Filter Effluent		Percent Radium	Percent Hardness
Date sampled	pCi/l	Hardness	pCi/l	Hardness	Reduction	Reduction
03/07/75	7.45*	226	0.75	99	89.9	56.0
03/14/75	5.7	243	0.80	112	86.0	53.9
03/21/75	3.51	242	0.71	95	87.0	60.7

*Calculated on basis of pumpage from individual wells.

All water is treated so that the values given for the filter effluent represents the water which goes to the user.

During each backwash cycle 287,690 liters of water are used for each filter. In addition, 15,142 liters are used for surface wash. The filters are backwashed at approximately 50 hour intervals. This waste water contains significant quantities of radium. The gross alpha counts, however, appear very low when compared to the radium values. This is due to the method of handling the samples in the laboratories. The aliquots for the gross activity determinations were taken from the supernatant portion of the sample, while the aliquots for the radium analyses were taken from the complete sample and contained a portion of the solid material.

Lime sludge is removed from the mixing basin and from the final sedimentation basin by continuous sludge removal equipment. The radium results on the sludge samples are very erratic. Samples #107, 113, and 119 were collected from the sludge blanket by means of a pump. Results were 12.53 ± 0.19; 1.26 ± 0.04, and 3.15 ± 0.09 pCi/g of radium 226. Samples #114 and #120 were taken from the sludge lagoon at the point where the sludge enters the lagoon. The radium 226 concentrations found were 30 ± 2 pCi/g and 6.01 ± 0.18 pCi/g.

All results are expressed on the basis of dry weight.

Records indicate that 1,900 to 3,800 kg of lime are used at this plant each day. It is estimated that approximately 2 kg of sludge (dry weight) are produced for each kg of lime used, which would result in 3,800 to 7,600 kg produced each day. Calculating on the lowest and the highest values of radium 226 found in the sludge, this will result in the deposition of 22.8 to 228 μCi of radium 226 each day.

The supernatant liquid from this lagoon is discharged to the river. Although this waste was not analyzed for radium 226, the gross counts (2.9 ± 1.4, 4.1 ± 1.7, 2.1 ± 1.2 pCi/l) which were done on the supernatant portion of the waste water indicate that the major portion of the radioactive material is in the sludge.

During a survey of the plant, a sample of filter sand was obtained. Analyses indicated a radium 226 concentration of 16.0 ± 1.6 pCi/g and a radium 228 concentration of 8.3 ± 0.4 pCi/g. After the initial analysis of the sample, the fine material which appeared to be clarifier sludge was washed from the sample with water. Analysis of the washed material showed no significant difference.

Exposure rates at the plant indicated 9 μR/hr above the natural background in the area of the evaporation pond. It was, however, not possible to get good measurements in this area because of limited access. Water had been removed from one of the sand filters for maintenance. Measurement just above the surface of the sand filter indicated an exposure rate of 0.5 mR/hr. Over a similar filter which was covered by water, the exposure rate was about 30 μR/hr.

5.5 MISCELLANEOUS CHEMICAL RESULTS

Reduction in the barium levels have also been observed. Although the raw water levels are exceedingly high (6.1 to 18 mg/l), all samples of the softened water contained less than 1 mg/l.

All chemical and radiological data are available in Appendix Table D-1.

5.6 COST INFORMATION

Information on the capital costs of the Slade Avenue Plant are not available. However, the cost for the West Side Plant which was built in 1963, and which is of similar design, have been included.

Cost figures taken from the original bid are as follows:

General Conditions	$ 17,600
Earth Work	5,170
Mason Work	269,772
Misc. Iron and Metal Work	44,662
Carpenter Work	8,930
Pipe Insulation	12,000
Painting	14,900
Rate Controllers	7,000
Flash Mixer	1,400
Recarbonation Equipment	21,000
Lime Storage and Conveying System	12,830
Filter Instrumentation	20,000
Plumbing Work	119,800
Pumping Equipment	14,000
Up FLow Clarifier Equipment	19,410
Flow Meters	4,000
Electrical Work	68,570
Supervisory Control and Telemetering Equipment	38,000
Engine - Generator	42,000
Aeration Equipment	3,000
Heating	7,000
Ventilating Work	300
Service Elevator	13,997
Laboratory Equipment	1,300
System Sterilization	1,600
Chemical Feeders	12,000
Gravimetric Lime Feeders	8,000
Lime Slakers	10,059
Chlorinators	9,000
Sewer Construction	14,000
TOTAL	$821,300

In 1970, it was necessary to expand the West Side Plant. It is felt that this work would be necessary to build an adequate treatment plant at the present time.

Cost figures for the expansion are:

General Conditions	$ 50,000
Preparation of Site	6,000
Mason Work	188,400
Miscellaneous Metal Work	20,000
Carpenter Work	6,000
Painting	15,000
Rate Controllers	10,000
Recarbonation Equipment	6,000
Filter Instrumentation	32,000
Plumbing Work	110,000
Pumping Equipment	17,000
Upflow Clarifier Equipment	40,000
Electrical Work	27,000
System Sterilization	2,000
TOTAL	$529,400

OPERATING COSTS 15,100 m^3/d

Chemicals Used Daily

Lime	$28/3775 m^3	$120.00
Flocculant	3/3775 m^3	12.00
Other Chemicals	1/3775 m^3	4.00
Carbon Dioxide	3/3775 m^3	12.00

Personnel

Operators - 3 @ $40/day	$120.00
Supervision- 1 @ $60/day	60.00

6.0 LYNWOOD

6.1 INTRODUCTION

The village of Lynwood is located in the southeastern part of Cook County (see Fig. 1). This is a fast growing area and, at present, it is estimated that the supply serves about 4,000 people. Approximately 600 m^3 of water is processed at the plant each day. The supply went into operation in 1972, and in 1973 softeners were added to the system.

6.2 DESCRIPTION

All of the water used by this supply is being pumped from one well known as well number two. The well is 599.4 m deep and is cemented to a depth of 240.5 m. The well is open to a sandstone aquifer.

The water is softened by passing it through a styrene-based zeolite softener (Permutit Corporation) and chlorinated before passing to the distribution system. The plant is equipped with a series of three softeners and automatically switches from one to another on the basis of hardness passing through the softener. Raw water is blended automatically, so that the hardness of the water reaching the user is fairly consistent. Consequently, the typical increase in hardness normally observed as the softener is depleted is not evident.

See Appendix E for detailed description of the facilities at the Lynwood Plant.

6.3 SAMPLING AND ANALYSIS

Samples of raw and softened water were collected on March 27, April 2 and 10 at the Lynwood Plant. Samples were analyzed for mineral trace metal and radium content.

Softener backwash, brine and rinse water were composited and analyzed for the same parameters.

6.4 RADIUM REMOVAL

Radium removal by this system is quite consistent. By the design of this plant the water is always passed through a softener which has recently been regenerated.

It was not possible to obtain samples directly from the softener and samples which were obtained were blended water and represented the final product which goes to the user. According to the manufacturer, the units are equipped to detect the hardness of the finished water and automatically adjust the amount of raw water in the blend to keep the hardness of the finished water constant. Assuming that the hardness of the finished water is essentially zero, the blend ratio is approximately 90% softened water and 10% raw water. Near the end of the cycle, it is assumed that a small amount of hardness is passing through the softener, and that the blend ratio is 91% softened water and 9% raw water. Using these assumptions, the radium content of the softened water ranged from 0.26 to 0.77 pCi/l.

The radium content of the raw water is consistent, ranging from 14.28 to 15.19 pCi/l with the average being 14.71 ± 0.24. The radium removal data are shown in Table VII.

TABLE VII. RADIUM REDUCTION--LYNWOOD

	Sampling Date	Radium 226 Content Raw Water pCi/l	Radium 226 Content Softened Water (estimated)	Radium 226 Percent Reduction
Regenerated	3/27/75	14.69	0.40	97.3
Midpoint	3/27/75	14.80	0.26	98.2
Near Breakthrough	3/27/75	14.73	0.40	97.3
Regenerated	4/2/75	14.50	0.44	97.0
Midpoint	4/2/75	14.70	0.36	97.6
Near Breakthrough	4/2/75	14.38	0.51	96.5
Regenerated	4/10/75	14.49	0.77	94.7
Midpoint	4/10/75	14.90	0.27	98.2
Near Breakthrough	4/10/75	15.19	0.27	98.2

The gross alpha activity of the raw water samples is very erratic ranging from 58.4 to 178.4 pCi/l. This may in part be due to the period of time that the samples were in the laboratory before counting. While the radon would be lost through the evaporation process, the solid radon daughters would not. The radon daughters decay rapidly and could account for significant changes in the count. The samples collected on March 27 were counted within three days of collection, and those collected on April 10 were held for five days before counting was started.

Another theory for the widely divergent alpha counts is the possibility that the trace amounts of radioactive materials are plating on the walls of the container. The addition of a preservative may prevent this erratic behavior.

The gross activity is somewhat high compared to the radium content. No information is available as to the isotopes which contribute to the total activity present.

The automated system regenerates the softener after 174,128 liters of water have passed through the unit. For each regeneration, 8,327 liters of water are used for backwash, 757 liters of brine for regeneration, followed by 5,450 liters of water for rinse, and an additional 17,033 liters for fast rinse. The average concentration of radium 226 in the waste water was 72.35 pCi/l. Since a profile of the waste was not done, this may not be representative of the amount of radium 226 being removed from the softeners during the regeneration cycle.

The survey of the plant indicated that there were no measurable exposure rates above background except at the surface of the zeolite tanks. The exposure rate profiles (see Fig. 10) vertically on the sides of the three tanks indicate that the maximum concentration of radium is near the bottom of the zeolite.

Samples of the zeolite were taken at approximately 1.06 m and 2.3 m above the bottom of the tank. Radium concentrations found were as follows:

	226 Ra (pCi/g)	228 Ra (pCi/g)
1.06 meters	9.6 ± 1.8	6.6 ± 0.6
2.3 meters	6.2 ± 1.5	5.0 ± 0.5

These results appear to confirm the exposure rate profile of the tank.

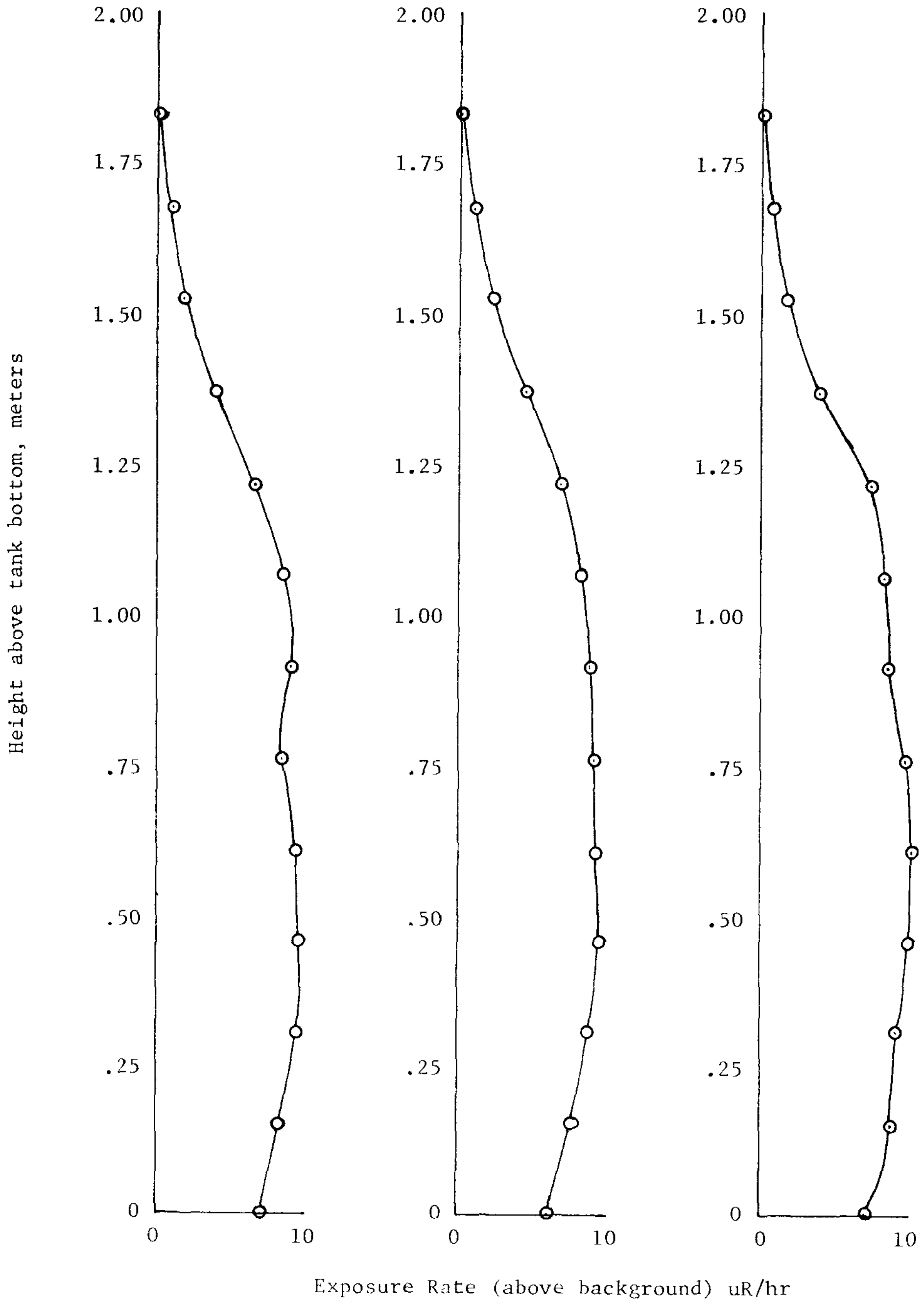
6.5 MISCELLANEOUS CHEMICAL RESULTS

Detailed information on mineral, trace metal and radium analyses are available in Tables E-1 and E-2.

6.6 COST INFORMATION

Cost information for this plant,as built in 1972,give $100,000 for the equipment and $50,000 for installation. Monthly operating costs are about $1,520 with the breakdown being $1,000 for salaries and $520 for salt. This covers the cost of producing 6×10^5 liters of water/day. The operating cost thus are about $0.32/1000 gal.

Figure 10: Exposure Rate Profile Lynwood, Illinois

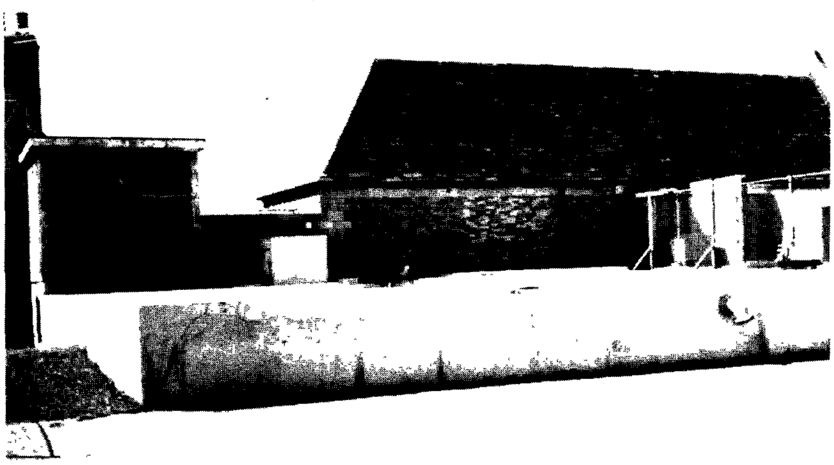


APPENDIX A

DWIGHT CORRECTIONAL CENTER

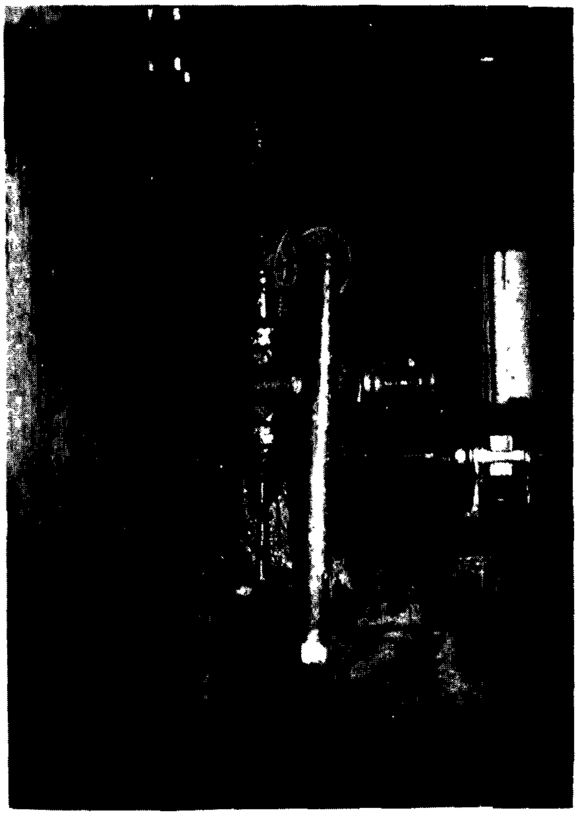
Dwight Correctional Center :R
Office Bldg.

WELL #2 - Showing Sampling Tap
(Above Bucket)



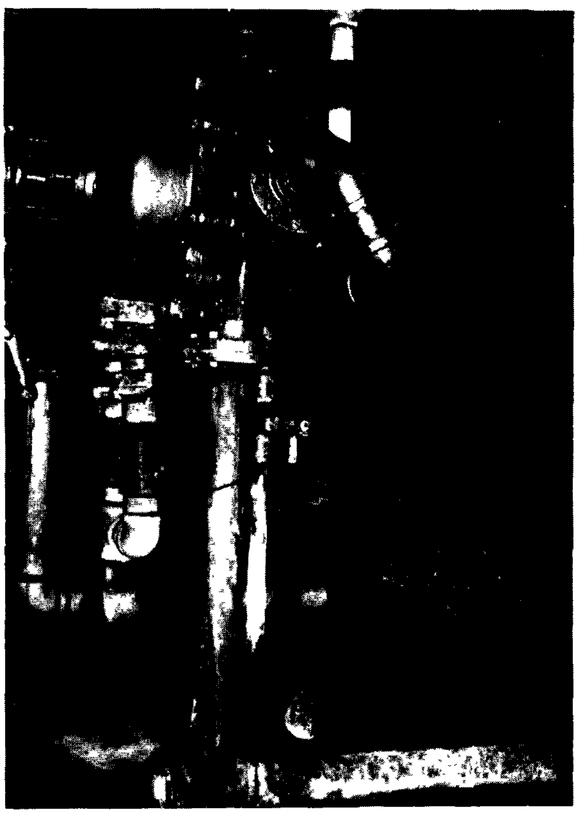
Aerator & Holding Reservoir

Figure A-1 (Cont'd.) Scenes at Dwight Correctional Center Water Treatment Plant



High Service Pump House

Softener Unit & Flow Controls



Softened Water Sample Tap

Softener Flow Control Valve

Figure A-1 (Cont'd Scenes at Dwight Correctional Center Water Treatment Plant

Supply. DWIGHT CORRECTIONAL CENTER

Item Well #2

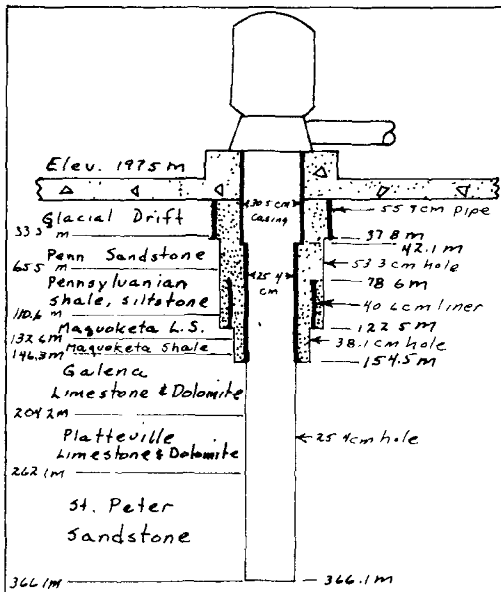
Location: 137.2m North, 30.5m West of the SE corner of Sec. 1 T 30N, R 6E, Livingston County

Pump: 7.57 ℓ/s Pomona Water Lubricated above base discharge

Motor: 14920W, 184.3 rad/s, 3ph, 60 Hz, 220/440V

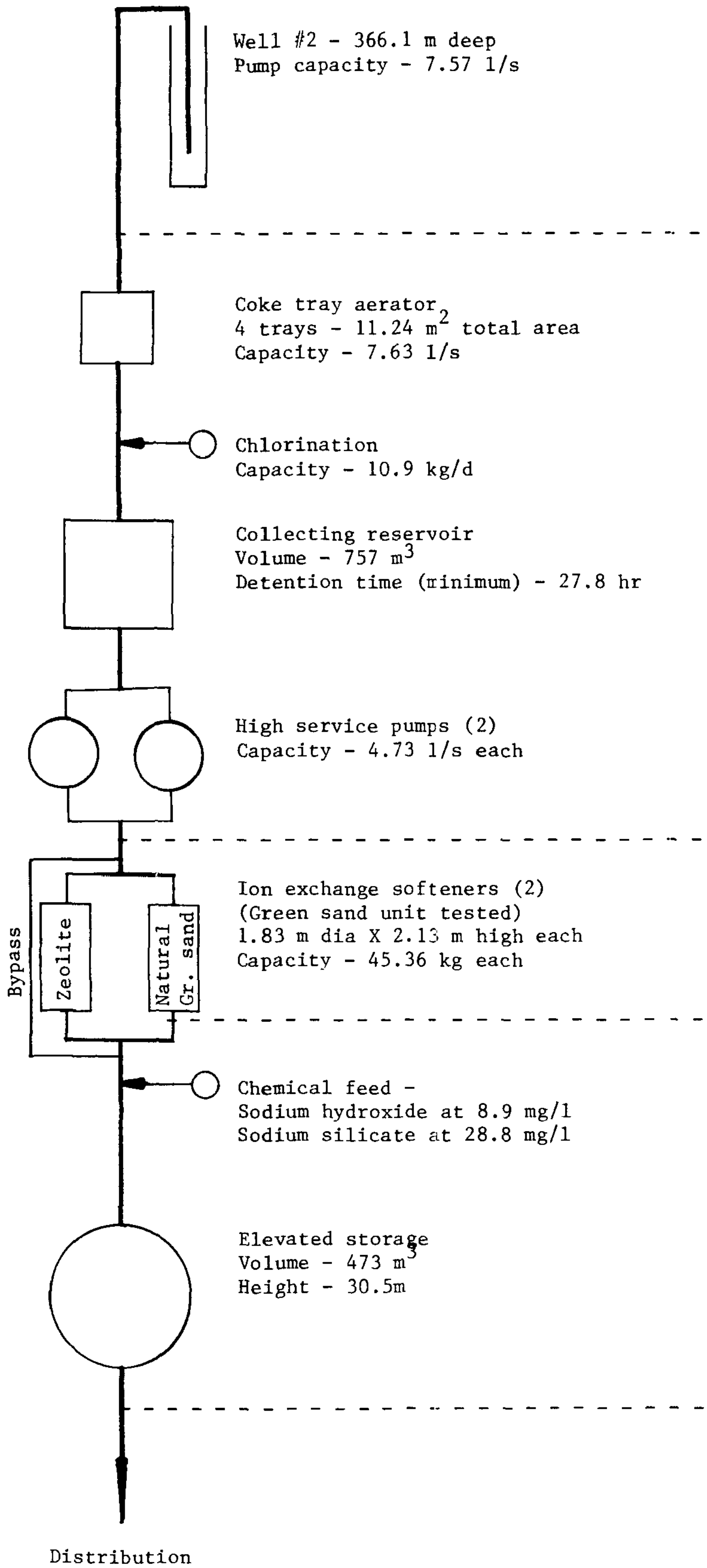
Chronology: Drilled in 1948 by Milaeger Well Drilling Company, Milwaukee, Wisconsin

Notes: Sampling tap



Production Data				
Date:	1951			
Static Level, m	45.1			
Pumping Level, m	64.0			
Pumping Rate, ℓ/s	7.57			
Specific Capacity	0.40			

Figure A-2 Well Log, Well #2, Dwight Correctional Center



PARAMETER AND REMOVAL EFFICIENCY					
Ra226	%	Gross Alpha	%	Hard-ness	%
3.25		22.9		286	
		24.3	-		
0.36	88.9	3.7	83.6	43.2	85
0.65	80	5.6	75.5	67	76.6

Figure A-3 Dwight Flow Schematic

Dwight Correctional Center

Aerator

Location: Atop collecting reservoir at treatment plant
Type: Coke tray with spray nozzles
Construction: Four trays housed in wooden structure with 45 degree louvers screened outside with 24-mesh plastic and stainless steel screens.
Dimensions: Each tray 1.68 m x 1.68 m (5 ½' x 5 ½')
Area: 11.24 m^2 (121 ft^2) total
Capacity: 7.63 L/s at .68 L/m^2s (121 gpm at 1 gpm/ft^2)
Note: Coke changed twice per year

Gas Chlorinator

Location: Service building (not located in isolated room)
Manufacturer: Wallace and Tiernan
Capacity: 10.9 kg/d (24 ppd)
Chlorine Source: One 68 kg (150 lb) cylinder on platform scale
Injects to: Aerator discharge

Collecting Reservoir

Location: Adjacent to north side of treatment plant
Construction: Concrete-two sections with dividing partition
Dimensions: 11.9 m x 16.5 m x 49 m (39' x 54' x 16')
Capacity: 757,000 ℓ (200,000 gal.)
Vents: Vent box on platform cover with fine screen opening
Manholes: Two with raised curbs and overhanging covers.
Overflow: Down turned and screened

High Service Pumps

Location: Pump pit adjacent to south side of collecting reservoir
Manufacturer: American Well Works
Number: Two-pumped one at a time alternated monthly
Capacity: 4.73 ℓ/s (75 gpm) each
Take suction from: Collecting reservoir
Discharge to: Softeners
Power: 5595 W (7.5 HP)
Angular Velocity: 376.9 rad/s (3600 RPM)

Softener #1 (west)

Size: 1.83 m dia x 2.13 m high
Exchange media: Styrene based zeolite
Capacity: 45.36 kg (700 kilograins)
Regeneration: every 132,500 ℓ, (35,000 gal.) using 181.8 kg (400 lbs) salt

Softener #2 (east)

Size: 1.83 m dia (6') x 2.13 m (7') high
Exchange Media: Natural green sand zeolite
Capacity: 45.36 kg (700 kilograins)
Regeneration: every 132,500 ℓ (35,000 gal.) using 272 kg (600 lbs) salt

Chemical Feeder

Location: Service building - east side
Chemical: 1.18 kg (2.4 lb) NaOH and 3.82 kg (8.4 lb) sodium silicate dissolved in 189 ℓ (50 gal.) of water is fed to each 132,500 ℓ (35,000 gal.) of water treated
Type: Positive feed
Manufacturer: Hills McCanno
Fed from: Mixing drum
Injects to: Softener effluent

Elevated Storage Tank

Location: East of main building
Construction: Steel
Tank Dimensions: 7.6 m (12.5') dia x 10.7 m (35') high
Capacity: 473,000 ℓ (125,000 gals.)
Tower Height: 30.5 m (100')
Overflow: screened
Installed: 1930

Dwight Correctional Center

Table A-1

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	1 / 53	2	3 / 54	4 / 60	5	6 / 55	7 / 56	8	9 / 57	10 / 58	11 / 59	12	13 / 62	14 / 63	15	16 / 64
SAMPLING POINT	Well 2 Raw	Aerator Clearwell Soft. Inf.	Softener Effluent	Well 2 Raw	Aerator Clearwell Soft. Inf.	Softener Effluent	Well 2 Raw	Aerator Clearwell Soft. Inf.	Softener Effluent	Softener Backwash Brine Rinse	Raw Well 2	Softener Influent	Softener Effluent	Raw	Softener Influent	Softener Effluent
DATE AND TIME / PARAMETER	2/4/75 1 40P	2/4/75 2·10P	2/4/75 2 15P	2/5/75 10 20A	2/5/75 10:35A	2/5/75 10 40A	2/5/75 2 45P	2/5/75 2 55P	2/5/75 3 00P	2/5/75 3:10-4 10P	2/13/75 10 10A	2/13/75 10·25A	2/13/75 10:25A	2/14/75 9 35A	2/14/75 9:50A	2/14/75 9·55A
pH	8.3	8.5	8.6	8.5	8.5	8.6	8.3	8.5	8.5	8.0	6.8		9.0	8.8		9.0
IRON, mg/1	0.1	0.2	0.6	0.2	0.4	0.0	0.7	0.3	0.1	2.1	0.2		0.2	0.2		0.0
MANGANESE, mg/1	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.08	0.00		0.00	0.00		0.00
CALCIUM, mg/1	63	45	4	62	57	1	62	60	22	670	62		3	61		0
MAGNESIUM, mg/1	32	23	2	31	28	1	33	31	18	320	32		2	32		1
AMMONIUM (NH_4), mg/1	1.5	0.00	0.03	1.5	0.00	0.00	1.3	0.1	0.00	0.05	1.4		0.04	1.3		0.03
SODIUM, mg/1	320	370	540	300	340	470	322	320	370	4200	310		580	320		470
POTASSIUM, mg/1	16.4	12.6	6.8	16.4	15.2	4.8	16.2	15.8	41.2	74	16.2		6.0	16.4		5.5
FLUORIDE, mg/1	1.4	1.4	4.8	1.5	1.5	0.9	1.4	1.5	0.6	2.5	1.4		3.4	1.5		1.1
CHLORIDE, mg/1	350	370	435	350	370	375	350	370	370	8500	375		440	375		390
NITRATE (NO_3), mg/1	0.5	0.6	0.5	0.5	0.7	0.4	0.2	1.1	0.4	0.5	0.1		0.4	0.1		0.3
SULFATE, mg/1	214	240	243	234	226	228	219	216	234	246	216		309	219		228
ALKALINITY, mg/1	282	280	336	284	266	278	320	272	226	272	280		340	276		276
HARDNESS, mg/1	289	207	19	282	258	7	292	278	129	2991	286		16	284		4.1
RESIDUE, mg/1	1186	1220	1432	1198	1198	1222	1190	1208	1196	14652	1212		1530	1222		1272
T S. by E.C., mg/1	1220	1270	1490	1220	1220	1300	1220	1250	1250	13810	1210		1600	1210		1310
ARSENIC, mg/1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00		0.00	0.00		0.00
BARIUM, mg/1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.7	0.1		0.0	0.1		0.1
BORON, mg/1	1.0	1.0	0.8	1.1	1.1	1.2	1.1	1.1	1.0	1.0	1.1		1.6	1.2		1.2
CADMIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00
CHROMIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00
COPPER, mg/1	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.00		0.01	0.00		0.00
LEAD, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00		0.00	0.00		0.00
MERCURY, µg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0
NICKEL, mg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0
SELENIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00
SILVER, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00
ZINC, mg/1	0.00	0.06	0.01	0.00	0.12	0.00	0.05	0.06	0.09	0.22	0.00		0.02	0.00		0.00
SILICA, mg/1	8.0	11.0	6.0	8.0	8.0	10.0	8.0	8.0	9.5	7.0	8.0		7.5	6.0		9.0
CYANIDE, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00
GROSS ALPHA, pCi/1	30.9± 9.7	31.7±10.4	4.2 ±5.2	43.2±11.3	20.2±8.2	12.0±6.9	38.0±10.9	37.1±11.2	10.7±6.4	326.2±99.1	14.9±7.6	7.0±6.1	1.2±5.1	22.7±9.3	17.4±7.6	0.0 ±0.0
GROSS BETA, pCi/1	36.9±6.8	29.7±6.5	27.5±6.3	42.3±7.1	31.2±6.5	8.6±5.0	39.4±7.3	38.1±7.0	47.2±7.4	258.0±67.1	23.3±5.6	37.8±6.6	15.2±5.6	38.1±6.6	24.2±5.6	7.8 ±4.4
RADIUM, pCi/1	3.24±0.08		0.36±0.02	3.26±0.08		0.13±0.02	3.13±0.07		0.056±0.013	27.17±0.37	3.46±0.10		0.40±0.3	3.41±0.10		0.25±0.03
RADIUM (Dup), pCi/1			0.37±0.03	3.19±0.14						26.82±0.63				3.21±0.10		

*Cation-Anion balance not achieved

Dwight Correctional Center

Table A-1 (Cont'd.)

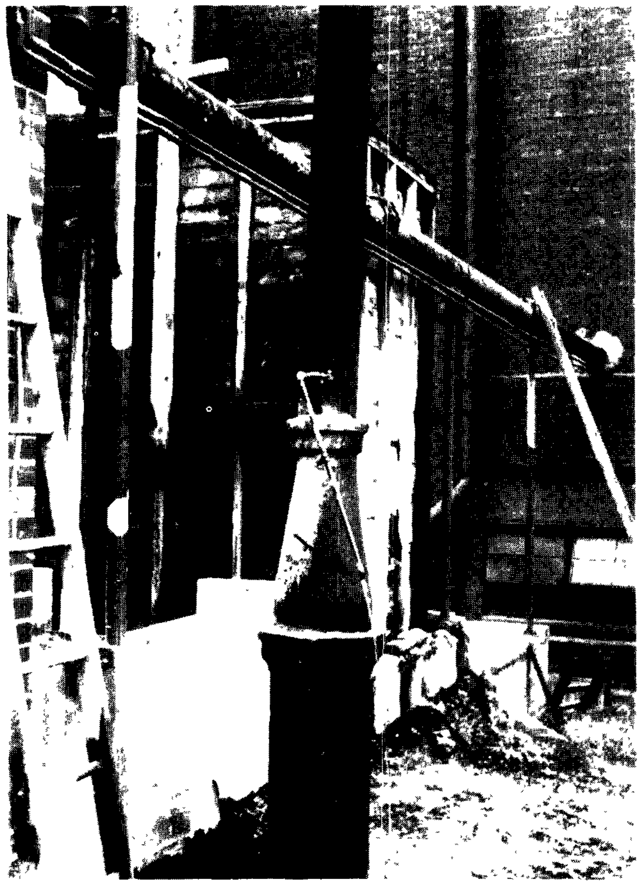
IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	17 / 65	18	19 / 66	20 / 67	21 / 75	22	23 / 76	24 / 77	25	26 / 78	27 / 93	28	29 / 94	30 / 95	31	
SAMPLING POINT	Raw Well 2	Softener Influent	Softener Effluent	Softener Backwash Brine Water	Well 2 Raw	Aerator Effluent	Softener Effluent	Well 2 Raw	Aerator Effluent	Softener Effluent	Well 2 Raw	Aerator Effluent	Softener Effluent	Softener Backwash Brine Water	Resin	
DATE AND TIME / PARAMETER	2/14/75 2:05P	2/14/75 2:05P	2/14/75 2:15P	2/14/75 3:00P	2/19/75 8:50A	2/19/75 9:15A	2/19/75 9:15A	2/19/75 1:15P	2/19/75 1:25P	2/19/75 1:30P	2/20/75 9:50A	2/20/75 10:10A	2/20/75 10:15A	2/20/75 11A	2/20/75 2P	
pH	8.4		9.0 *	8.1	8.0		8.4	8.1		7.9	8.1		8.1	7.8		
IRON, mg/1	1.0		0.0 *	2.1	0.9		0.1	0.1		0.0	0.1		0.0	2.6		
MANGANESE, mg/1	0.02		0.00 *	0.10	0.02		0.00	0.00		0.00	0.00		0.00	0.11		
CALCIUM, mg/1	60		21 *	875	61		2	62		0	63		13	490		
MAGNESIUM, mg/1	31		18 *	400	32		1	32		0	32		10	240		
AMMONIUM (NH_4), mg/1	1.4		0.06 *	0.19	1.3		0.04	1.7		1.7	1.4		0.06	0.13		
SODIUM, mg/1	320		370 *	4700	350		550	340		480	340		420	3700		
POTASSIUM, mg/1	16.6		38 *	92	16.2		7.1	16.8		5.7	16.4		28.5	70		
FLUORIDE, mg/1	1.4		0.6 *	2.0	1.4		3.8	1.5		1.5	1.4		0.5	2.1		
CHLORIDE, mg/1	365		385 *	9600	355		410	360		360	360		385	7000		
NITRATE (NO_3), mg/1	0.2		0.3 *	1.1	0.4		0.3	0.3		1.0	0.3		0.4	1.2		
SULFATE, mg/1	219		225 *	252	225		306	228		215	225		237	252		
ALKALINITY, mg/1	250		250 *	250	304		310	290		288	290		216	278		
HARDNESS, mg/1	279		131 *	3831	285		9.3	286		0.0	289		74	2200		
RESIDUE, mg/1	1208		1200	17086	1184		1442	1174		1176	1186		1200	12252		
T.S. by E.C., mg/1	1240		2160	15760	1210		1490	1210		1240	1220		1250	11990		
ARSENIC, mg/1	0.00		0.00	0.00	0.000		0.000	0.000		0.000	0.000		0.000	0.000		
BARIUM, mg/1	0.1		0.1	1.6	0.2		0.2	0.2		0.0	0.2		0.0	1.3		
BORON, mg/1	1.1		1.1	1.0	0.9		0.7	0.9		1.0	1.1		1.1	0.9		
CADMIUM, mg/1	0.00		0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		
CHROMIUM, mg/1	0.00		0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.02		
COPPER, mg/1	0.01		0.00	0.05	0.00		0.00	0.00		0.00	0.00		0.00	0.04		
LEAD, mg/1	0.00		0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		
MERCURY, μg/1	0.0		0.0	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		
NICKEL, mg/1	0.0		0.0	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		
SELENIUM, mg/1	0.00		0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		
SILVER, mg/1	0.00		0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		
ZINC, mg/1	0.01		0.03	0.24	0.00		0.00	0.00		0.00	0.00		0.02	0.16		
SILICA, mg/1	8.0		9.0	7.0	8.0		7.0	8.5		8.5	8.5		10.0	7.5		
CYANIDE, mg/1	0.00		0.00	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		
GROSS ALPHA, pCi/1	23.0±9.0	16.6±8.0	4.9±5.7	292±104.9	14.3±7.2	5.9±6.0	0.0±5.1	18.7±8.6	7.4±5.8	0.0±0.0	9.4±6.9	4.8±5.4	0.0±0.0	137.8±63.2		
GROSS BETA, pCi/1	36.0±6.5	[illegible]5.4±6.4	43.7±6.9	334.9±56.6	32.4±6.4	30.0±6.4	10.8±5.3	14.3±6.6	31.0±6.3	5.6±4.5	36.9±6.8	28.1±6.2	31.3±6.3	200.5±58.7		
RADIUM, pCi/1	3.29±0.09		0.98±0.04	29.27±0.41	3.22±0.09		0.27±0.02	3.19±0.09		0.30±0.03	3.12±0.09		0.51±0.0[illegible]	21.78±0.46	34.22±0.55 pCi/g (Acid)	
RADIUM (Dup.), pCi/1							0.26±0.02				0.48±0.04				28.66±0.46	(EDTA)

*Cation-Anion balance not achieved

APPENDIX B

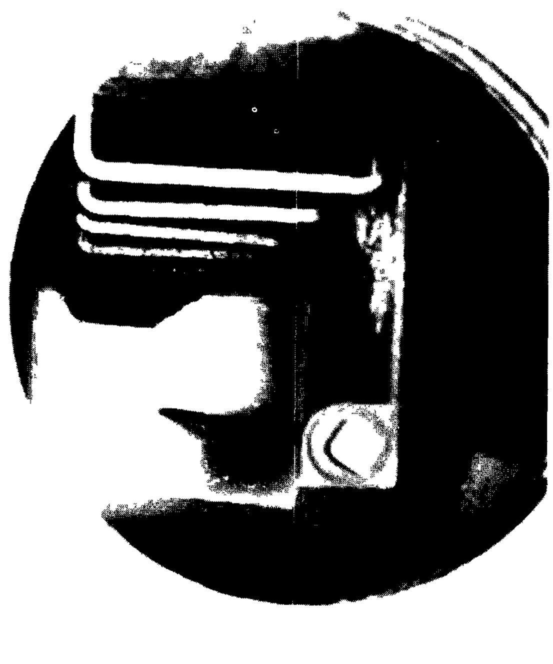
PERU

Peru Water Treatment Plant



Raw Water Inlet & Sampling Tap (Arrow)

Flow Channel From Aerator



Sludge Blow off Pit

Figure B-1 Scenes at Peru Water Treatment Plant

Well #6 Sampling Tap

Filters

Manhole of Clarifier Unit-
Sampling Point for "Sludge Blanket"

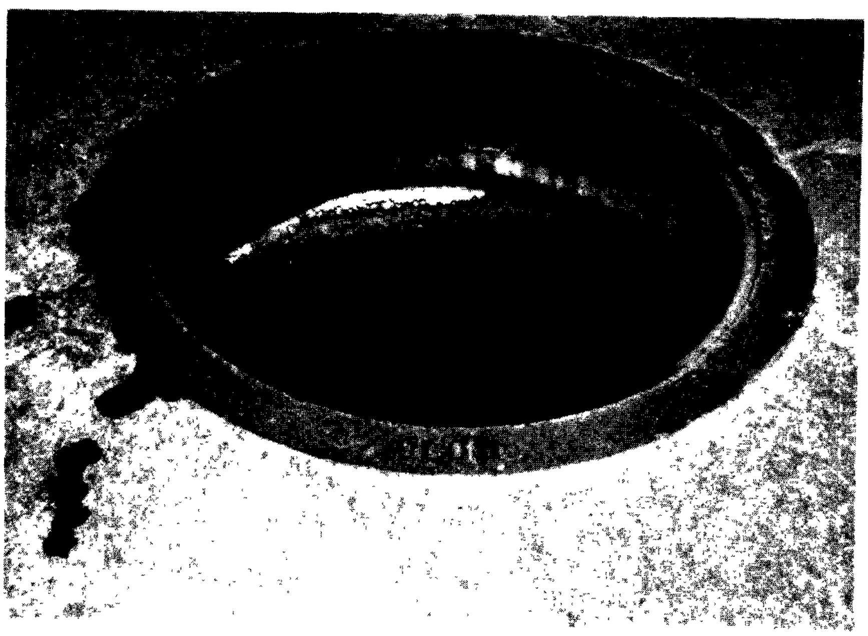


Figure B-1 (Cont'd.) Scenes at Peru Water Treatment Plant

Supply: PERU

Item: Well #5

Location: 121.9m South, 304.8m West of the NE corner of Sec. 20, T 33N, R 1E, LaSalle County

Pump: Byron Jackson Line Shaft Turbine, 63.1 ℓ/s @ 91.4m TDH, 185.3 rad/s, 6 stage, S/n 701C--37, set @ 76.2m

Motor: General Electric 89,250W, 185.3 rad/s, 3ph, 60 Hz, 460V, 144A, 60°C, 1.15 Ser. Fact, Model 5K6268 x HIA s/n DFJ 401108

Chronology: Drilled in 1931 by Sewell Well Company, St. Louis, Missouri

Notes: Casing vent, airline with gage, air relief valve

Production Data:				
Date	1947			
Static Level, m	0			
Pumping Level,m	11.9			
Pumping Rate, ℓ/s	63.1			
Specific Capacity	5.30			

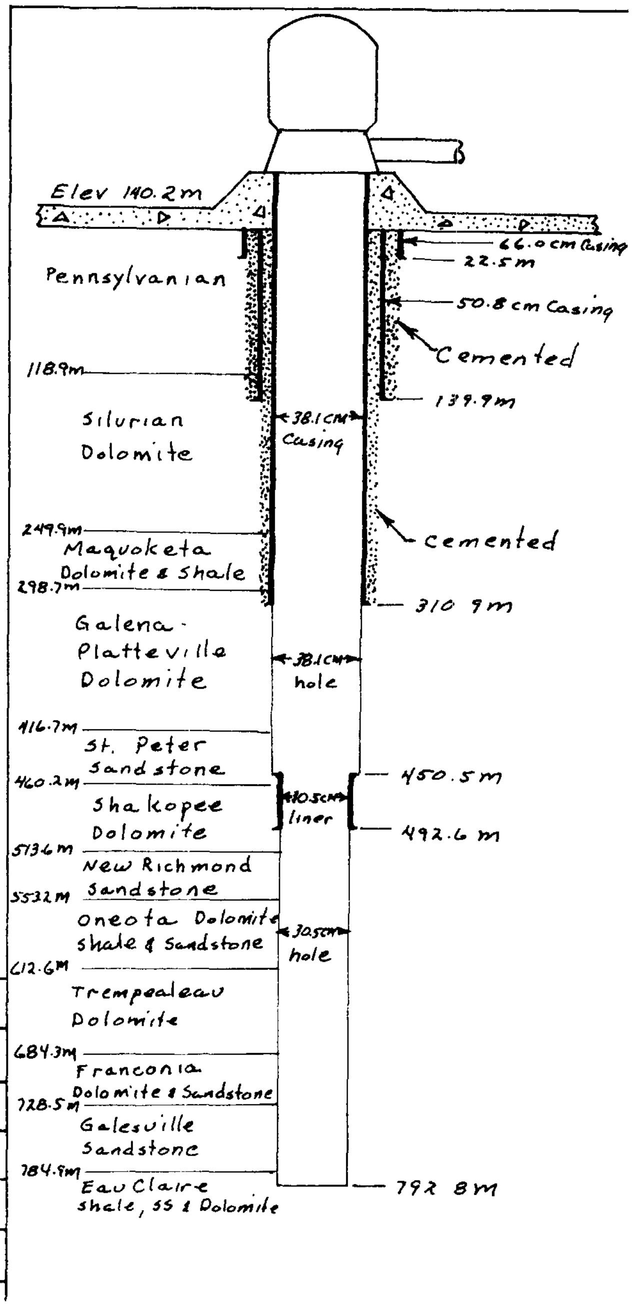


Figure B-2 Well Log-Well #5 - Peru

Supply: PERU

Item: Well #6

Location: 161.5m North, 103.6m East of the SW corner of Sec. 16, T 33N, R 1E, La Salle County

Pump: Byron Jackson Line Shaft Turbine, 75.7 ℓ/s, @ 51.8m TDH, 183.2 rad/s, 3 Stage, s/n 681C026, set @ 76.2m

Motor: General Electric 93250W, 185.3 rad/s, 3ph, 60 Hz, 460 V, 144A, 60°C, 1.15 Ser. Fact. Model 5K6268 x H 1A s/n AEJ 122,983

Chronology: Drilled in 1952

Notes: Casing vent, sample tap, airline with gage, air relief valve

Production Data:				
Date:	1952			
Static Level, m	13.4			
Pumping Level, m	45.7			
Pumping Rate, ℓ/s	96.8			
Specific Capacity	3.00			

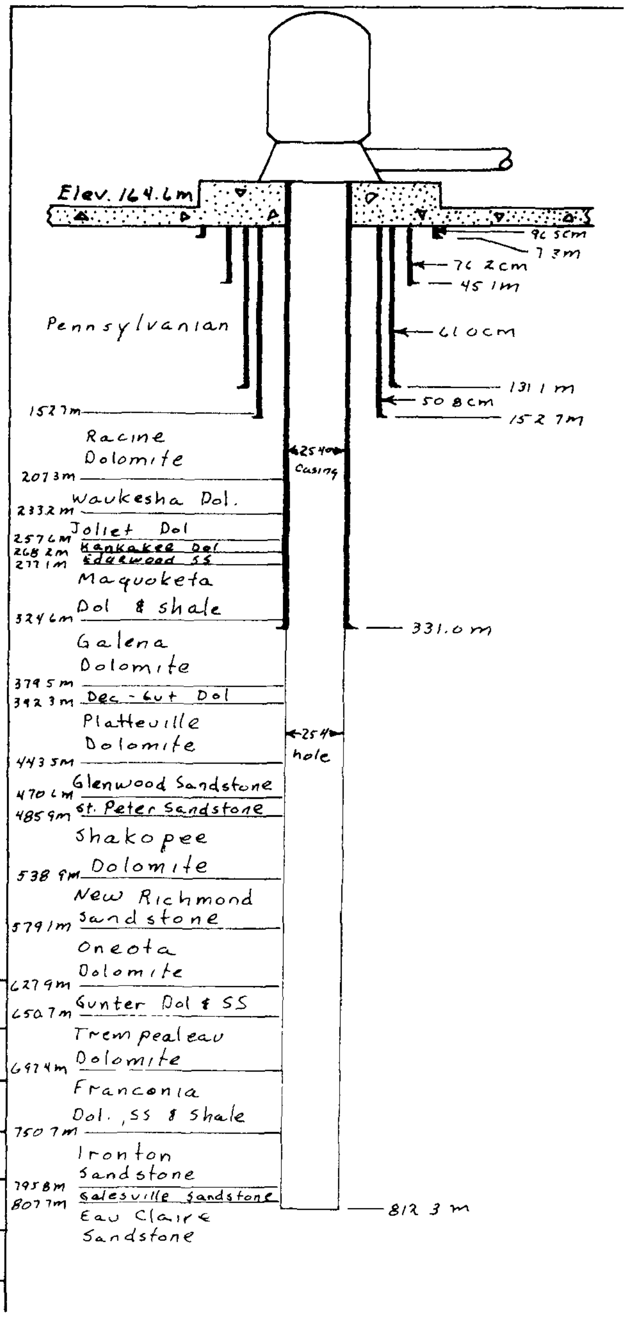


Figure B-3 Well Log-Well #6 - Peru

Supply: PERU

Item: Well #7

Location: 61.0 m South, 61.0 m East of the NW corner of Sec 21, T 33N, R 1E, La Salle County

Pump: Byron Jackson Line Shaft Turbine, 63.1 ℓ/s @ 98.5m TDH, 185.3 rad/s, Model DWT 6 stage, s/n 711Co154, Set @ 82.3m

Motor: General Electric, 93250W, 185.3 rad/s, 3ph, 60Hz, 460V, 144A, 60°C, 1.15 Ser. Fact, Model 5K 628 x H37 A, s/n KGJ 1027 100

Chronology: Drilled in 1963
Shot in 1972

Notes: Casing vent, sample tap, air line with gage, air relief valve.

Production Data:

Date:	1963			
Static Level, m	0+			
Pumping Level, m	57.6			
Pumping Rate, ℓ/s	92.2			
Specific Capacity	1.60			

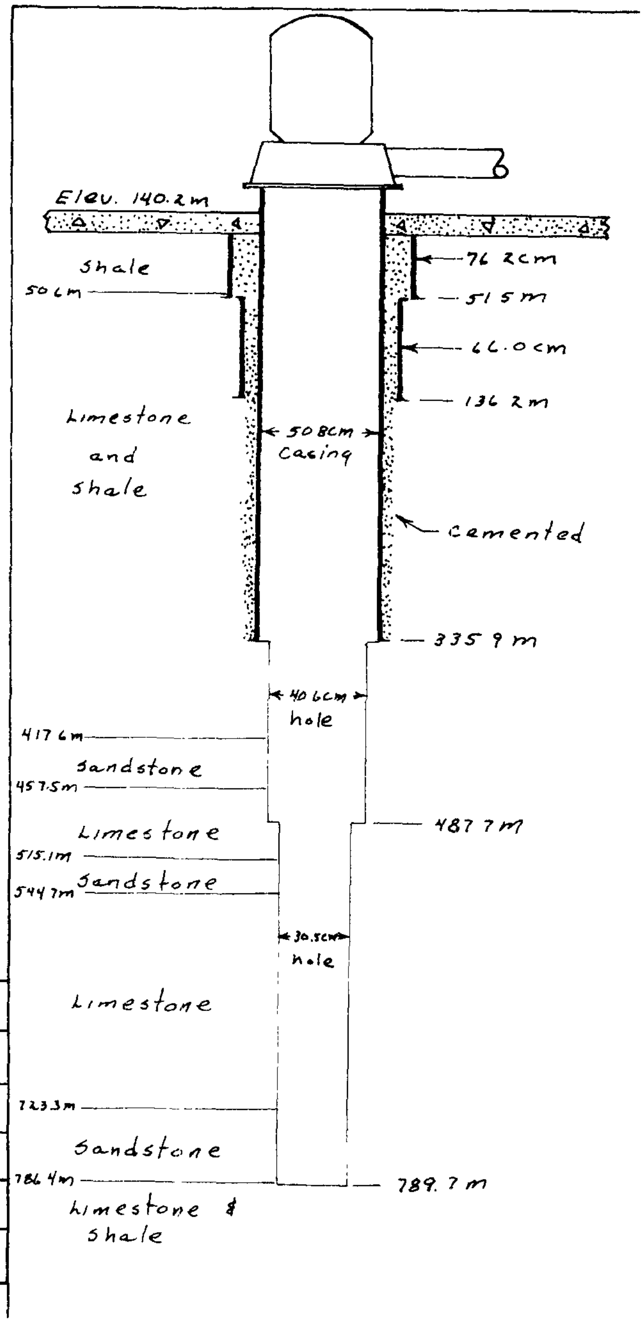
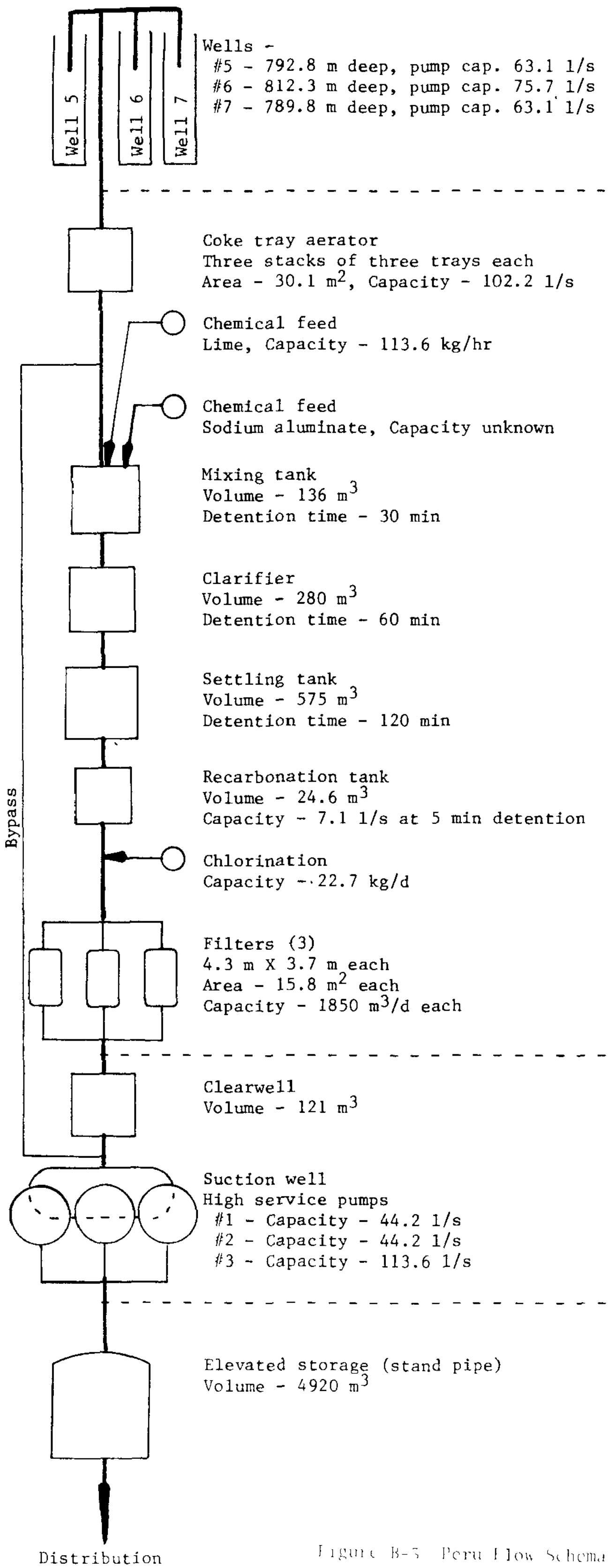


Figure B-4 Well Log-Well #7 - Peru



PARAMETER AND REMOVAL EFFICIENCY					
Ra226	%	Gross Alpha	%	Hard-ness	%
5.8		26		317	
1.15	80.1	4.93	81	117	63
3.0	48	11.4	56	181	43

Figure B-3 Peru Flow Schematic

Water Meter

Location: Well 6 house
Manufacturer: Sparling
Size: 25.4 cm (10 inch)
Measures flow in: Well 6 discharge
Records flow as: 378.5 ℓ

Booster Pump

Location: Well 6 House

Pump Data
Type: Double suction horizontal split case centrifugal
Manufacturer: American Marsh
Model: HIM
Serial: 6101197
Size: 5
Impeller: 3.43 cm
Stages: 1
Angular Velocity: 183.2 rad/s (1750 RPM)
Capacity: 75.7 L/s (1200 gpm)
Head: 48.8m (160 Ft.)
Takes suction from: Well 6 discharge
Discharges to: Distribution
Installed: Standard

Driver Data
Type: Induction motor
Manufacturer: Fairbanks-Morse
Model: QZK
Serial: F169935
Power: 44760W (60 HP)
Angular Velocity: 182.2 rad/s (1740 RPM)
Electrical Requirements: 3ph, 60 Hz, 440V, 61a
Rating: 40° C
Service factor: 1.15

Water Meter

Location: Well 7 house
Manufacturer: B.I.F.
Model: Propeloflo
Size: 20.3 cm (8 inch)
Measures flow in: Well 7 discharge
Records flow as: Hundreds of gallons (378.5 ℓ)

Aerator

Location: North side of treatment plant
Type: Coke tray with forced draft
Construction: Three stacks of three trays inside wooden housing
Dimensions: Each tray 1.83 m x 1.83 m (6' x 6')
Area: 30.1 m^2 (324 ft^2)
Capacity: 102.2 ℓ/s @ 3.4 ℓ/m^2/sec (1620 gpm @ 59pm/ft^2)
Blower: yes

Chemical Feeder

Location: Chemical room at treatment plant.
Type: Volumetric feed lime slaker
Manufacturer: Omego
Capacity: 113.6 kg/hr (250 lb/hr)
Fed from: Lime hopper
Injects to: Mixing tank

Chemical Feeder

Location: Chemical room at treatment plant
Chemical: Sodium aluminate
Type: Piston pump
Manufacturer: Warren Cook
Model No.: Crown Jewel
Fed from: Chemical drum
Injects to: Mixing tank
Anti-siphon device: None

Mixing Tank

Location: Beneath chemical room
Construction: Concrete
Dimensions: 6.1m x 6.1m x 3.7m (20' x 20' x 12')
Volume: 136,000 ℓ (36,000 gal)
Manhole: one with flush cover
Agitator: Horizontal paddles driven by vertical shaft, 1119W (1.5 hp motor)
Capacity: 6.54 x 10^6ℓ (1,728,000 gallons) per day @ 1800 second detention

Clarifier

Location: North side of treatment plant
Construction: Concrete
Dimensions: 9.1m dia. x 4.3m deep (30' dia. x 14' deep)
Volume: 280,000L (74,000 gallons)
Capacity: 6.72 x 10^6ℓ (1,776,000 gpd) at 3600 sec detention
Wier: Around circumference - 26·8m (88') long
Wier loading: 2.9 ℓ/s/m (14 gpm/ft.) @ 77.8 ℓ/s (1233 gpm)
Manhole: Two with flush lids
Manufacturer: Graver Tank and Manufacturing Company

Settling Tank

Location: Beneath aerator and lab at treatment plant
Construction: Concrete
Dimensions: 11.0m x 9.1m x 4.4m + 4.9m x 6.1m x 4.4m
(36' x 30' x 14.5' + 16' x 20' x 14.5')
Volume: 575,380ℓ (152,000 gal.)
Capacity: 6.9×10^6 L/d (1,824,000 gpd) @ 7200 sec. detention

Recarbonator

Location: Under stairs to filter room at treatment plant
Construction: Concrete
Dimensions: 4.4m x 1.5m x 3.7m deep (14.5' x 5' x 12' deep)
Volume: 24,640ℓ (6510 gal.)
Capacity: 3.55×10^6 ℓ/d (937,000 gpd) @ 600 sec. detention
7.1×10^6 ℓ/d (1,875,000 gpd) @ 300 sec. detention
CO_2 Generator: Walker Process Natural Gas burner
Serial No.: #607-2897

Gas Chlorinator

Location: Filter room at treatment plant
Manufacturer: Fischer - Porter
Type: Wall-mounted, vacuum operated, solution feed
Capacity: 22.7 kg/d (50 lbs per 24 hrs)
Chlorine Source: One 68 kg (150 lb.) cylinder
Booster Pump: None - operates off distribution pressure
Injects to: Recarbonator discharge
Chlorine room: none
Scale: yes

Filter

Location: Filter room at treatment plant
Number of Units: three
Type: Gravity rapid sand
Dimensions: 4.3m x 3.7m (14' x 12'2')
Filter Area: $15.8m^2$ (170 $ft.^2$)
Capacity: 1.85×10^6 ℓ/d @ 1.36 ℓ/m^2/s (490,000gpd @ 2 gpd/ft^2)
Filter Media: Anthracite over .76m (30") sand supported by .46m (18") gravel 5cm (2") laterals on 15.2m (6") centers
Backwash: Manual using distribution

Clear Well

Location: Beneath filters and operating floor at treatment plant
Construction: Concrete
Dimensions: 7.1m x 13.1m x 1.5m deep (20' x 43' x 5' deep)
Capacity: 121,000L (32,000 gallons)
Vents: One, turned down

Suction Well

Location: Under high service pumps on west side of power plant
Construction: Concrete
Manhole: Two, with flush covers

High Service Pump

Location: West side of power plant

PUMP DATA
Type: Single suction horizontal split case centrifugal
Manufacturer: DeLaval
Stages: Two
Capacity: 44.2 ℓ/s (700 gpm)
Head: 79.2m (260')
Takes suction from: Suction well
Discharges to: Distribution

DRIVER DATA
Type: Induction motor
Manufacturer: General Electric
Model: 5K505DG1
Power: 55,950 W (75Hp)
Angular Velocity: 185.8 rad/s (1775 rpm)
Electrical Requirements: 3ph, 60 Hz, 2200V, 17.1a
Rating: 40° C

Water Meter

Location: West side of power plant
Manufacturer: B.I.F.
Model: Venturi
Size: 20.3 cm (8")
Measures flow in: High service pump 1 discharge

High Service Pump

Location: West side of power plant

PUMP DATA
Type: Single suction horizontal split case centrifugal
Manufacturer: DeLaval
Stages: Two
Capacity: 44.2 ℓ/s (700 gpm)
Head: 79.2m (260')
Takes suction from: Suction well
Discharges to: Distribution

DRIVER DATA
Type: Induction motor
Manufacturer: General Electric
Model: 5K505DG1
Serial No.: 5380268
Power: 55950W (75 HP)
Electrical Requirements: 3ph, 60Hz, 2200V, 17.8a
Rating: 40°C

Water Meter

Location: West side of power plant
Manufacturer: B.I.F.
Model: Venturi
Size: 20.3cm (8")
Measures Flow in: High service pump 2 discharges

High Service Pump

Location: West side of power plant

PUMP DATA
Type: Double suction horizontal split case centrifugal
Manufacturer: Peerless
Model: 6A19B
Serial: 145908
Stages: One
Angular Velocity: 185.3 rad/s (1770 rpm)
Capacity: 113.6 ℓ/s (1800 gpm)
Takes Suction From: Suction well
Discharges to: Distribution

DRIVER DATA
Type: Induction motor
Manufacturer: U.S. Motors
Model: SC
Serial: 1245250
Power: 149,200W (200 HP)
Angular Velocity: 188.4 rad/s (1800 RPM)
Electrical Requirements: 3ph, 60 Hz, 440V 240a
Rating: 40°C

Water Meter

Location: West side of power plant
Manufacturer: B.I.F.
Model: Dall flow tube
Size: 25.4 cm (10")
Measures Flow in: High service pump 3 discharge

Elevated Storage

Location: Shooting Park Road and Pike Street (West)
Construction: Hemispherical bottom, vertical sides, conical top
Capacity: .757 x 10^6L (200,000 gal.)
Tower Height: 12.2m (40 ft.)
Surface Elevation: 192.0m (630 ft.) msl
Overflow: Down leg to ground surface
Maximum Surface Elevation 198.1m (650 ft.) msl
in Supply: 198.1 m (650 ft.) msl
Date Installed: 1931

Elevated Storage

Location: Shooting Park Road and Pulaski Street (East)
Construction: Hemispherical bottom, vertical sides, conical top
Capacity: .757 x 10^6ℓ (200,000 gal.)
Tower Height: 15.2m (50 ft.)
Surface Elevation: 189.0 m (620 ft.) msl
Maximum Surface Elevation in Supply: 170.7m (560 ft.) msl
Overflow: Down leg to ground surface
Data Installed: 1931

Elevated Storage

Location: Plaza booster station (North)
Construction: Steel standpipe
Tank Dimensions: 17.1m (56 ft.) dia
Capacity: 4.92 x 10^6ℓ (1,300,000 gal.)
Head Range: 21.6m (71 ft.)
Tower Height: no tower
Surface Elevation: 196.9m (645 ft.) msl
Maximum Surface Elevation in Supply: 198.1m (650 ft.) msl
Overflow: Down tank to elevation + 4 L.S.D.
Installed: General American Transportation Corporation, 1964

High Service Pump

Location: Plaza Booster Station

PUMP DATA
Type: Double suction horizontal split case centrifugal
Manufacturer: Aurora
Model: OJP
Serial: 6327077
Size: 5ℓ x 6
Stages: 1
Angular Velocity: 176.1 rad/s (1690 RPM)
Capacity: 63.1 ℓ/s (1000 gpm)
Takes Suction From: Standpipe
Discharges To: Distribution

DRIVER DATA
Type: Induction motor
Manufacturer: Marathon
Power: 37,300W (50 HP)
Angular Velocity: 186.4 rad/s (1780 rpm)
Electrical Requirements: 3ph, 60Hz, 240/480V 116/58a
Design: B
Code: F
Rating: 40°C
Auxiliary: None
Remarks: Fluid coupling to vary speed of pump

High Service Pump

Location: Plaza Booster Station

PUMP DATA
Type: Double suction horizontal spilt case centrifugal
Manufacturer: Aurora
Model: OJP
Serial No.: 6327078
Size: 5ℓ x 6ℓ
Stages: one
Angular Velocity: 183.2 rad/s (1750 rpm)
Capacity: 63.1 ℓ/s (1000 gpm)
Head: 39.6m (130 ft.)
Takes Suction From: Standpipe
Discharges To: Distribution

DRIVER DATA
Type: Induction motor
Manufacturer: Marathon
Power: 29840W (40 HP)
Angular Velocity: 186.4 rad/s (1780 rpm)
Electrical Requirements: 3ph, 61 Hz, 220/440V, 110/50a
Design: B
Code: F
Rating: 40°C
Auxiliary: 6 cylinder Waukesha natural gas engine

Water Meter

Location: Plaza Booster Station
Manufacturer: B.I.F.
Model: Dall flow tube
Size: 30.5 cm (12 inch)
Measures Flow In: Booster station discharge

Test Equipment

Chlorine & pH: Hach DR Filter Photometer
Hardness & Alkalinity: Hach Titrametric

Peru

Table B-1

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	51 / 68	52	53 / 69	54	55	56 / 70	57 / 73	58 / 72	59 / 71	60	61	62	63 / 74	64 / 97	65 / 96	66 / 98
SAMPLING POINT	Raw Comp. of Wells 5,6,7	Aerator Effluent	Blended 60% Soft 40% Filt.	Sludge Blanket	Blow-off Sludge	Filter Backwash Comp.	Well #5 Raw	Well #6 Raw	Well #7 Raw	Aerator Effluent	Sludge		Blended 60% Soft 40% Filt.	Filter Backwash Comp.	Well #5 Raw	Well #6 Raw
DATE AND TIME / PARAMETER	2/19/75 11:30A	2/19/75 11:40A	2/19/75 11:40A	2/19/75 12 OON	2/19/75 12:30P	2/20/75 6:55A	2/25/75 8 45A	2/25/75 8:55A	2/25/75 9:10A	2/25/75 9:30A	2/25/75		2/25/75 9:30A	2/25/75 10:00A	3/4/75 10:15A	3/4/75 10:05A
pH	7.7		7.9			9.0 *	7.7	7.7	7.6				7.6		7.8	7.9
IRON, mg/l	0.6		0.2			2.7 *	0.4	0.4	0.4				0.1		0.3	0.3
MANGANESE, mg/l	0.01		0.00			0.04 *	0.00	0.01	0.00				0.00		0.00	0.00
CALCIUM, mg/l	82		35			350 *	66	61	82				34		67	68
MAGNESIUM, mg/l	30		21			44 *	25	22	29				23		26	23
AMMONIUM (NH_4), mg/l	1.2		1.0			1.1 *	1.1	1.1	1.1				1.1		1.1	1.3
SODIUM, mg/l	201		190			200 *	170	190	200				190		170	190
POTASSIUM, mg/l	14.8		14.6			14.3 *	13.5	13.2	14.6				14.5		13.9	14.2
FLUORIDE, mg/l	1.0		0.8			0.7 *	0.9	1.2	1.0				0.8		0.8	1.0
CHLORIDE, mg/l	300		275			280 *	210	215	300				275		210	235
NITRATE (NO_3), mg/l	0.5		0.9			0.7 *	0.2	0.4	0.3				0.7		0.4	0.4
SULFATE, mg/l	59		50			59 *	54	76	54				54		53	64
ALKALINITY, mg/l	326		192			108 *	320	312	316				180		324	300
HARDNESS, mg/l	329		174			- -	268	243	324				180		275	265
RESIDUE, mg/l	992		716			632	784	774	908				720		734	772
T.S.byE.C., mg/l	950		790			730	800	810	950				790	7762	810	840
ARSENIC, mg/l	0.000		0.000			0.000	0.000	0.000	0.000				0.000		0.000	0.000
BARIUM, mg/l	0.2		0.1			0.8	0.2	0.2	0.2				0.1		0.1	0.0
BORON, mg/l	0.7		0.7			0.7	0.6	0.6	0.7				0.7		0.6	0.6
CADMIUM, mg/l	0.00		0.00			0.00	0.00	0.00	0.00				0.00		0.00	0.00
CHROMIUM, mg/l	0.00		0.00			0.00	0.00	0.00	0.00				0.00		0.00	0.00
COPPER, mg/l	0.00		0.00			0.01	0.01	0.00	0.00				0.00		0.01	0.01
LEAD, mg/l	0.00		0.00			0.00	0.00	0.00	0.00				0.00		0.00	0.00
MERCURY, µg/l	0.0		0.0			0.0	0.0	0.0	0.0				0.0		0.0	0.0
NICKEL, mg/l	0.0		0.0			0.0	0.0	0.0	0.0				0.0		0.0	0.0
SELENIUM, mg/l	0.00		0.00			0.00	0.00	0.00	0.00				0.00		0.00	0.00
SILVER, mg/l	0.00		0.00			0.00	0.00	0.00	0.00				0.00		0.00	0.00
ZINC, mg/l	0.02		0.00			0.07	0.00	0.03	0.00				0.00		0.00	0.02
SILICA, mg/l	10.0		10.0			9.0	10.0	10.0	10.0				10.0		10.0	10.0
CYANIDE, mg/l	0.00		0.00			0.00	0.00	0.00	0.00				0.00		0.00	0.00
GROSS ALPHA, pCi/l	19.0±7.0	15.2±6.3	10.2±4.8			2.6±3.3	21.4±6.5	11.2±5.0	26.4±7.8	17.9±6.3			9.4±4.5	38.8±40.0	29.8±7.4	8.4±4.7
GROSS BETA, pCi/l	31.5±5.4	32.2±5.5	23.2±4.4			16.9±3.7	38.2±5.0	20.4±4.0	37.7±5.6	36.9±5.0			28.0±4.5	68.3±35.4	36.4±4.9	18.4±4.0
RADIUM, pCi/l	6.49±0.14		2.90±0.09	9.31±0.17 pCi/g	9.09±0.26 pCi/g	10.04±0.26	4.57±0.16	3.73±0.10	6.07±0.18		8.86±0.16 pCi/g		3.17±0.09	13.78±0.35	4.78±0.12	3.15±0.09
RADIUM (Dup.), pCi/l	6.29±0.13		2.77±0.08			9.65±0.20		3.69±0.10			9.20±0.22 pCi/g					3.08±0.09

*Cation-Anion balance not achieved

Peru

Table B-1 (Cont'd.)

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	67 / 99	68	69	70	71 / 104	72 / 101	74 / 117
SAMPLING POINT	Well #7 Raw	Aerator Effluent	Sludge Blanket	Blow-off Sludge	Filtered Water	Filter Backwash	Filtered
DATE AND TIME / PARAMETER	3/4/75 10:20A	3/4/75 10:30A	3/4/75 11A	3/4/75 11:15A	3/4/75 2:15P	3/4/75 9:00A	3/19/75 3:10P
pH	7.7				8.6	8.3 *	8.6
IRON, mg/l	0.4				0.0	3.4 *	0.0
MANGANESE, mg/l	0.00				0.00	0.05 *	0.00
CALCIUM, mg/l	78				12	460 *	16
MAGNESIUM, mg/l	30				20	48 *	20
AMMONIUM(NH_4), mg/l	1.3				1.2	11.0 *	1.1
SODIUM, mg/l	200				200	200 *	180
POTASSIUM, mg/l	14.9				14.7	14.7 *	15.2
FLUORIDE, mg/l	0.8				0.6	0.6 *	0.7
CHLORIDE, mg/l	295				275	275 *	260
NITRATE(NO_3), mg/l	0.5				0.6	1.1 *	0.7
SULFATE, mg/l	54				54	58 *	54
ALKALINITY, mg/l	328				116	132 *	120
HARDNESS, mg/l	319				112	1350 *	122
RESIDUE, mg/l	864				532	672 *	658
T S. by E.C., mg/l	950				710	740 *	740
ARSENIC, mg/l	0.000				0.000	0.000	0.000
BARIUM, mg/l	0.0				0.0	0.2	0.1
BORON, mg/l	0.6				0.6	0.6	0.8
CADMIUM, mg/l	0.00				0.00	0.00	0.00
CHROMIUM, mg/l	0.00				0.00	0.00	0.00
COPPER, mg/l	0.01				0.01	0.02	0.00
LEAD, mg/l	0.00				0.00	0.00	0.00
MERCURY, µg/l	0.0				0.4	0.0	0.0
NICKEL, mg/l	0.0				1.0	0.0	0.0
SELENIUM, mg/l	0.00				0.00	0.00	0.00
SILVER, mg/l	0.00				0.00	0.00	0.00
ZINC, mg/l	0.01				0.00	0.08	0.00
SILICA, mg/l	10.0				10.0	10.0	10.0
CYANIDE, mg/l	0.00				0.00	0.00	0.00
GROSS ALPHA, pCi/l	42.8±9.9	30.0±8.2			4.2±3.4	5.9±4.0	2.5±2.8
GROSS BETA, pCi/l	41.3±5.8	37.8±5.1			19.2±3.6	20.6±4.1	14.7±3.6
RADIUM, pCi/l	6.07±0.14		9.11±0.18	8.84±0.15	1.21±0.05	86.3±1.20	1.44±0.06
RADIUM(Dup.), pCi/l			pCi/g	pCi/g		87.7±1.35	1.53±0.06

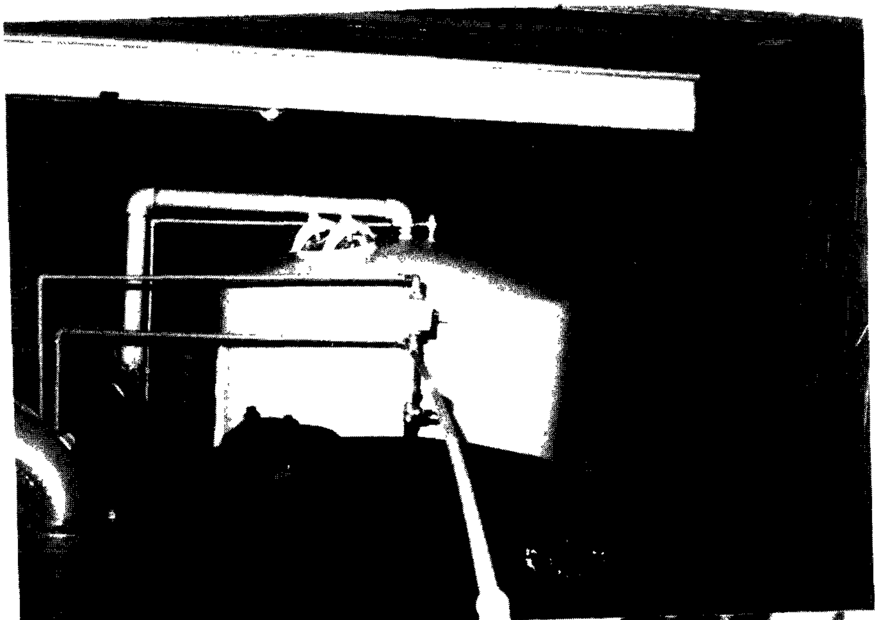
*Cation-Anion balance not achieved

APPENDIX C

HERSCHER

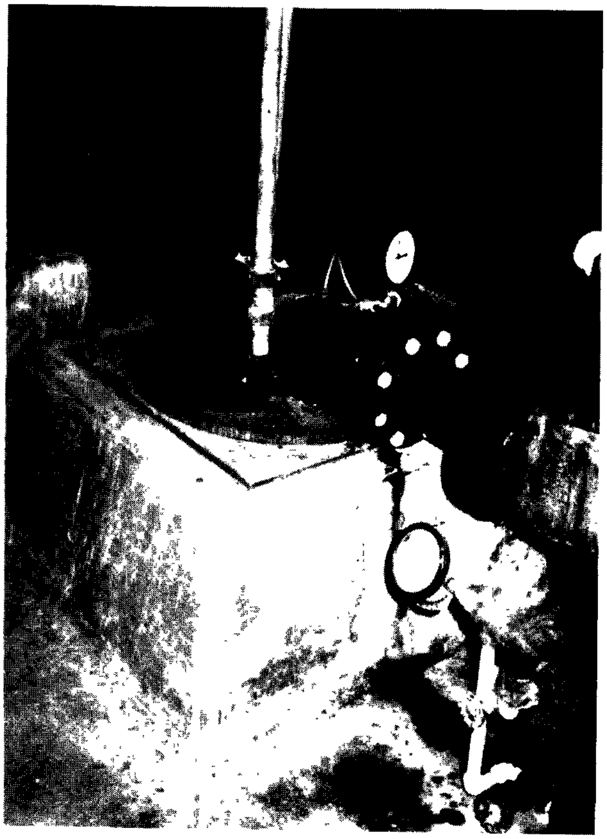
Figure C-1 Scenes at Herscher Water Treatment Plant

Herscher Water Treatment Plant

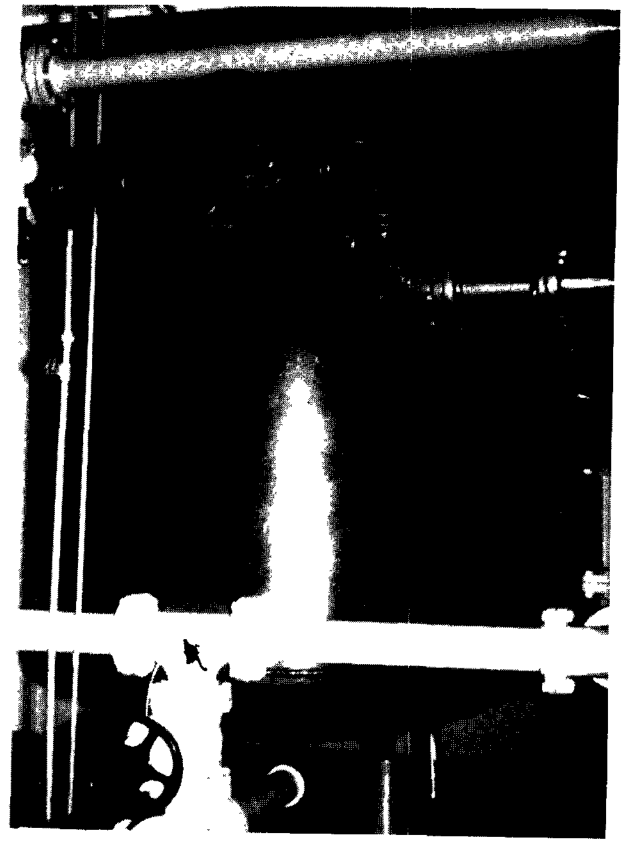


Top of Softener & West Filter---Showing Manholes Used For Sampling Anthrafilt & Resin

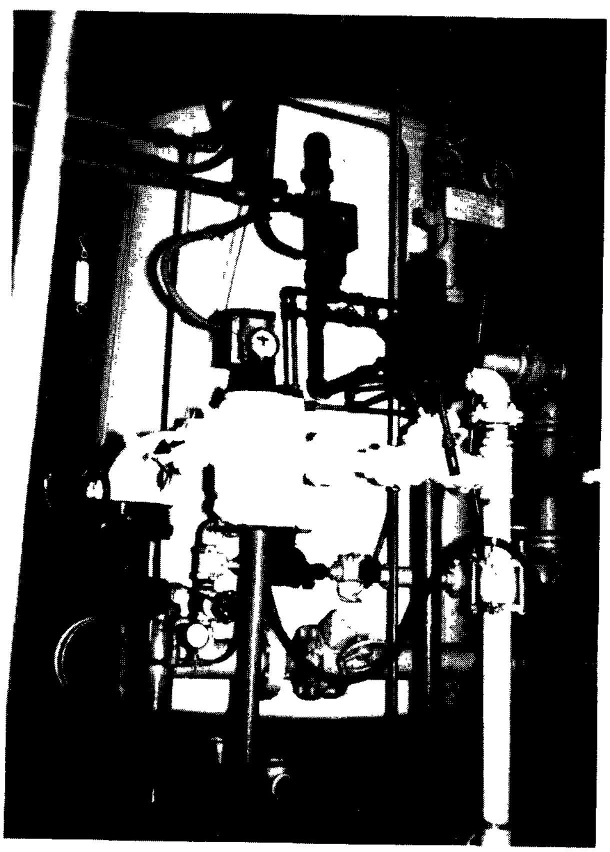
Filter Backwash Drainage Pit



Well #5



West Filter & Filter Effluent Sampling Tap (Arrow)



Softener & Sampling Tap (Arrow)

Softener Backwash Drainage Pit

Figure C-1 (Cont'd.) Scenes at Herscher Water Treatment Plant

Supply: Herscher

Item: Well #5

Location: 30.5m South, 304.8m West of the NE corner of Sec. 29, T30N, R 10E, Kankakee County

Pump: Sumo Submersible
10.09 ℓ/s, Set @ 128.0m

Motor: 18,650W

Chronology: Drilled in 1953 by an oil field contractor to 199.3m and finished by Layne-Western Co.

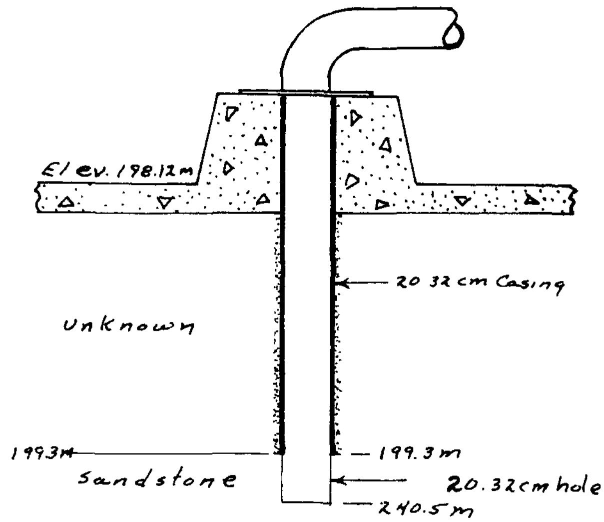
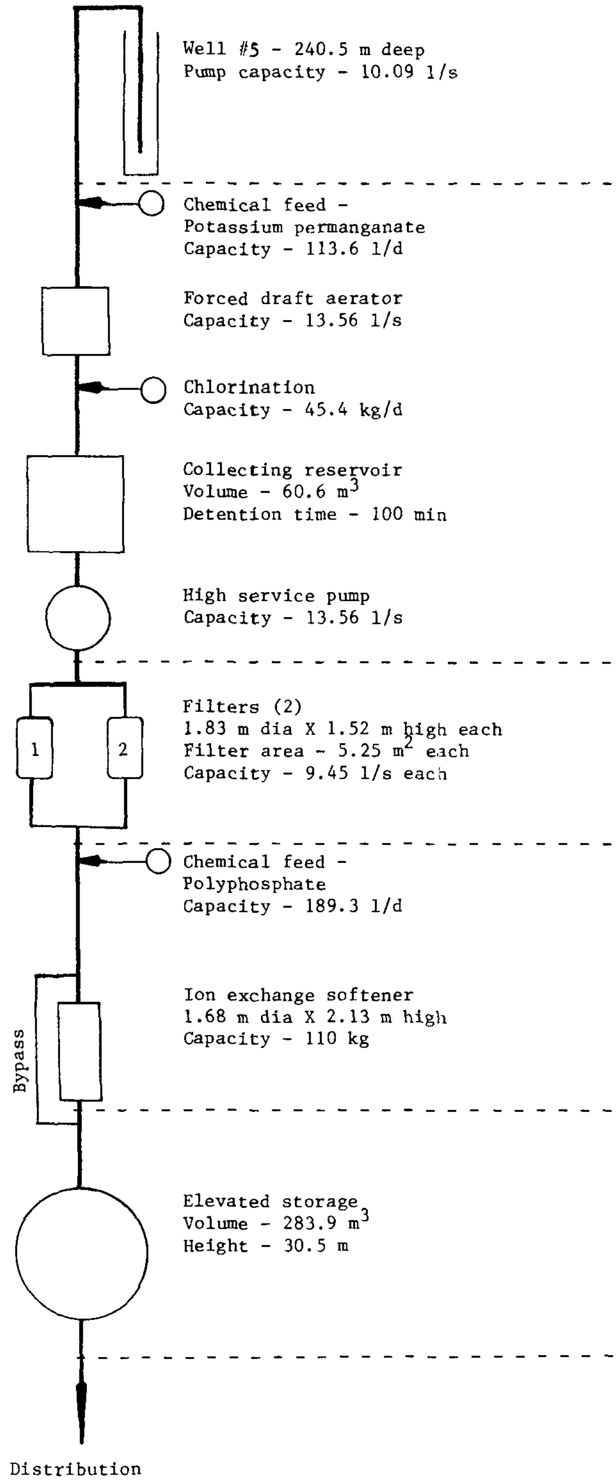


Figure C-2 Well Log-Well #5 - Herscher

Production Data:				
Date:	1975			
Static Level, m	65.5			
Pumping Level, m	118.8			
Pumping Rate, ℓ /s	10.09			
Specific Capacity	0.19			



PARAMETER AND REMOVAL EFFICIENCY					
Ra226	%	Gross Alpha	%	Hard-ness	%
14.43		56.6		404	
13.75	4.7	51.3	9.4		
6.75	50.9	19.7	61.5		
1.31	80.6	6.68	66	83.2	79.4
2.37	83.6	15.7	72	141	65

Figure C-3 Herscher Flow Schematic

Herscher

Chemical Feeder

Location: Pumphouse near aerator
Chemical: Potassium permanganate solution
Type: Piston pump
Manufacturer: Warren Cook
Capacity: 0 - 113.6 ℓ/d (0 - 30gpd)
Fed From: Plastic drum
Fed To: Raw water discharge to aerator

Aerator (Forced Draft)

Manufacturer: General Filter Company
Location: Pumphouse
Type: Square Steel (Epoxy-coated inside) with steel baffles
Size: 1.07m x 1.07m x 3.66m (42" x 42" x 12')
Inlet pipe: 12.7 cm (5")
Outlet Pipe: 15.2 cm (6")
Capacity: 13.56 ℓ/s (215 gpm)
Blower: Perrless Model 122A
Capacity: 1.47 m^3/s (950 CFM) @ ½ SP
Motor Power: 124.3W (1/6 HP)
Motor Type: Drip and Weather proof hood

Gas Chlorinator

Location: Separate room at pumphouse
Manufacturer: Wallace and Tiernan
Type: Wall mounted, "Advance" type
Model: A-741
Capacity: 45.4 kg/d (100 ppd)
Chlorine Source: Two 68kg (150 lb.) chlorine gas cylinders, platform scale mounted
Booster Pump: None. Operates from mains
Injects To: Aerator discharge

Collecting Reservoir

Location: Pumphouse
Dimensions: 4.27m x 4.88m x 3.05m (14' x 16' x 10')
Capacity: 60,566 ℓ (16,000 gal.)
Type: Concrete rectangular tank 3.05m (10')
Manholes: One with flush cover

Booster Pump

Location: Pumphouse near Aerator
Make: Layne-Bowler five stage shallow well turbine
Capacity: 13.56 ℓ/s (215 gpm)
Motor: "Hollow shaft" (U.S. Motors)
Type: H U - 3 (#3276819)
Power: 7460 W (10 HP)
Angular Velocity: 188.5 rad/s (1800 RPM)
Suction From: Holding Reservoir
Delivers To: Filters

Filters (Two Units)

Manufacturer: General Filter Corporation
Performance: Type: Pressure Type vertical
Filter Area: $5.25m^2$ (56.5 $ft.^2$)
Filtration Rate: 1.80 $ℓ/m^2/s$ (2.65 gal./$ft.^2$/min.)
Backwash Rate: 4.07 $ℓ/m^2/s$ (6 gal./$ft.^2$/min.)
Backwash Source: Mains
Specifications: Nominal Diameter: 1.83m (72")
Height: 1.52m (60")
Filter Media: #1 Antrafilt
Type of Underdrain: GFC multiplate baffle
Working Pressure: 689500 N/m^2
Filter Bed Depth: 0.61 m (24")
Gravel Support Bed: Depth - 0.38m (15")
Air relief valve: Manual
Operation: Manual
Location: Pump house

Softener

Manufacturer: General Filter Corporation
Performance:
Softening Rate: 7.38 ℓ/s (117 gpm)
Unit Capacity: 280120ℓ (74,000 gal.)
Salt Required: 232 kg (510 lbs.)
Back Wash Rate: 6.31 ℓ/s for 900s (100 gpm for 15 min.)
Brine Rate: 1.89 ℓ/s for 1200s (30 gpm for 20 min.)
Rinse Rate (slow): 1.89 ℓ/s for 1200s (30 gpm for 20 min.)
Rinse Rate (fast): 5.05 ℓ/s for 1200s (80 gpm for 20 mir.)
Operating Control: "Solomatic"
Specifications:
Nominal Diameter: 1.68 dia. (66")
Height: 2.13m high (84")
Filter Medium: 2.4 m^3 (85 ft^3) of "HCR" resin
Exchange Capacity: 110 kg (1700 Kilograins)
Operating Pressure: 689500 N/m^2 (100 psi)
Underdrain: GFC Multiple Plate
Overdrain: Standard Baffle
Location: Pump house

Brine Pump

Make: Aurora Pump
Type: Self-priming
Capacity: 1.07 ℓ/s at 15.24m TDH (17 gpm at 50 ft. TDH)
Motor Power: 559.5W (3/4 HP)
Electrical Requirements: 220V, 3ph, 60 Hz, 188.5 rad/s (1800 RPM)
Model: AA 1321-0-11
Operation: Automatic by "Solomatic" Valve Control

Chemical Feeder

Location: Pumphouse near softening unit
Chemical: Polyphosphate
Make: Milton Roy
Type: Positive displacement, three stage
Model: Simplex
Capacity: 189.3 ℓ/d (50 gpd)
Fed From: Steel tank .76m dia. x 1.22m high (30" diam x 48" high)
Injects To: Softener inlet stream

Master Meter

Location: Downstream from softener and Filtered water (bypass) discharge at Pumphouse
Make: Badger "Easy Read"
Size: 15.24 cm (6")
Reads: in 100 gallons (378.5ℓ)

Test Equipment

Chlorine & pH: Hellige Colorimetric
Hardness, Iron & Phosphate: Hach titrimetric Kit

Elevated Storage

Location: Alley between Main & Oak (100 block south)
Construction: Hemispherical top and bottom. Vertical sides
Capacity: 283,900ℓ (75,000 gal)
Height: 30.5m (100 ft.)
Installed: 1954 (S No. 7-2891)

Herscher

Table C-1

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	201 / 41	202 / 50	203 / 51	204 / 52	205 / 114	206 / 115	207 / 116	208 / 112
SAMPLING POINT	Well #5 Raw	Filter Influent	Filter Effluent	Softener Effluent	Well #5 Raw	Filter Influent	Filter Effluent	Softener Effluent
DATE AND TIME / PARAMETER	3/25/75 9 25A	3/25/75 9 30A	3/25/75 9·45A	3/25/75 10 00A	3/25/75 2 45P	3/25/75 2·50P	3/25/75 2 55P	3/25/75 3.00P
pH	8.2	8.0	8.2	8.4	8.2	8.2	8.1	8.3
IRON, mg/l	0.2	0.2	0.0	0.1	0.1	0.1 *	0.0	0.0
MANGANESE, mg/l	0.00	0.47	0.02	0.03	0.00	0.48 *	0.01	0.00
CALCIUM, mg/l	96	100	96	4	102	102 *	96	3
MAGNESIUM, mg/l	42	41	43	2	42	42 *	42	1
AMMONIUM (NH_4), mg/l	2.1	0.00	0.00	0.00	1.3	0 00 *	0.00	0.00
SODIUM, mg/l	350	380	350	560	360	380 *	360	560
POTASSIUM, mg/l	23.5	23.5	23.5	4.5	23	24 *	24	1.3
FLUORIDE, mg/l	1.9	2.2	2.1	2.0	2.1	2.1 *	2.2	2.1
CHLORIDE, mg/l	385	400	390	400	380	395 *	395	390
NITRATE (NO_3), mg/l	0.1	0.3	0.3	0.3	0.2	0.3 *	0.3	0.4
SULFATE, mg/l	405	399	408	384	411	399 *	405	411
ALKALINITY, mg/l	252	268	244	276	260	244 *	256	248
HARDNESS, mg/l	412	418	416	18	427	427 *	412	12
RESIDUE, mg/l	1466	1494	1488	1546	1476	1480 *	1468	1500
T S. by E.C., mg/l	1420	1420	1420	1560	1450	1440	1440	1520
ARSENIC, mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BARIUM, mg/l	0.2	0.2	0.2	0.0	0 2	0.2	0.2	0.0
BORON, mg/l	1.6	1.5	1 6	1 6	1.4	1.4	1.5	1.4
CADMIUM, mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHROMIUM, mg/l	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00
COPPER, mg/l	0 00	0.02	0.02	0.02	0.02	0.03	0.02	0.02
LEAD, mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MERCURY, µg/l	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
NICKEL, mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SELENIUM, mg/l	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00
SILVER, mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
ZINC, mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SILICA, mg/l	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
CYANIDE, mg/l	0 00	0.00	0.00	0.00	0 00	0.00	0.00	0.00
GROSS ALPHA, pCi/l	57.8±14.5	41.9±12.4	20.9±9.1	7.0±6.1	65.8±11.1	70.1±15.4	21.0±9.9	5.1±5.4
GROSS BETA, pCi/l	53.7±8.4	42.4±7.7	36.9±7.3	7.4±5.3	47.5±8.2	51.7±8.2	32.3±7.2	3.1±4.9
RADIUM, pCi/l	14.91±0.38	13.08±0.22	6.64±0.16	1.20±0.05	14.94±0.24	13.74±0.23	6.94±0.16	0.42±0.03
RADIUM (Dup.), pCi/l				1.30±0.05				

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	209 / 119	210 / 151	211 / 180	212 / 182	213 / 162	214 / 160	215A / 133	215B / 137
SAMPLING POINT	Well #5 Raw	Filter Influent	Filter Effluent	Softener Effluent	Filter Backwash Comp.	Soft. Bkwsh. Brine Comp.	Well #5 Raw	Well #5 Raw (Dup)
DATE AND TIME / PARAMETER	3/25/75 9 00P	3/25/75 9 10P	3/25/75 9 15P	3/25/75 9:20P	3/25/75 11 00	3/25/75 10 15P	4/1/75 9·10A	4/1/75 9:10A
pH	8.2	8.3	8.4	8.2		8.0	7.9	7.8
IRON, mg/l	0.1	0.1	0.0 *	0.0		0.2	0.1	0.1
MANGANESE, mg/l	0.00	0 39	0.00 *	0.00		0.18	0.00	0.00
CALCIUM, mg/l	98	92	98 *	21		825	98	98
MAGNESIUM, mg/l	42	41	42 *	32		400	43	43
AMMONIUM (NH_4), mg/l	1.3	1.0	0.72 *	0.19		0 79	1.4	1 4
SODIUM, mg/l	370	370	380 *	440		2950	360	370
POTASSIUM, mg/l	23 5	23.0	23.5 *	23		90	24 5	24 5
FLUORIDE, mg/l	2.1	2.1	2.1 *	2.5		2.6	2.2	2.3
CHLORIDE, mg/l	370	375	375 *	380		6750	385	385
NITRATE (NO_3), mg/l	0.2	0.1	0.4 *	[illegible]		0.5	0.8	0.7
SULFATE, mg/l	408	399	414 *	[illegible]		393	399	400
ALKALINITY, mg/l	256	256	240 *	220		224	264	260
HARDNESS, mg/l	417	398	417 *	184		3703	421	421
RESIDUE, mg/l	1466	1484	1478	1500		12742	1484	1490
T S. by E.C., mg/l	1440	1440	1440	1470		11780	1410	1410
ARSENIC, mg/l	0.000	0.000	0 000	0 000		0 000	0 000	0 000
BARIUM, mg/l	0.2	0.2	0 2	[illegible]		1.9	0.1	0.1
BORON, mg/l	1.6	1.4	1.4	[illegible]		1.4	1.4	1.4
CADMIUM, mg/l	0.00	0.00	0.00	0.00		0.02	0.00	0.00
CHROMIUM, mg/l	0.00	0.00	0.00	0.00		0.02	0.00	0.00
COPPER, mg/l	0.01	0.00	0.00	0 02		0.05	0.00	0 00
LEAD, mg/l	0.00	0 00	0.00	0 00		0.00	0.00	0 00
MERCURY, µg/l	0.0	0 0	0 0	0.0		0 0	0.3	0.0
NICKEL, mg/l	0.0	0.0	0 0	0.0		0.0	0.0	0.0
SELENIUM, mg/l	0.00	0.00	0.00	0.00		0.00	0.00	0.00
SILVER, mg/l	0.00	0 00	0 00	0 00		0.02	0.00	0.00
ZINC, mg/l	0.00	0.00	0 00	0 00		0.14	0.00	0.00
SILICA, mg/l	8.0	8.0	8.0	8 0		7.0	7.5	7.5
CYANIDE, mg/l	0.00	0.00	0.00	0.00		0.00	0.00	0.00
GROSS ALPHA, pCi/l	66.9±16 6	67 3±16.1	19.7±9.3	14 6±8 4	99.3±18 7	172±67 3	55.4±14.0	67.9±15 0
GROSS BETA, pCi/l	55.4±8.6	50.8±8.3	35.6±7.4	51 8±8 4	79 8±9.7	191.8±47 3	55.7±7.8	65.2±8.1
RADIUM, pCi/l	14.27±0.23	14.32±0.29	6 88±0.16	2.09±0 07	144.4±2.7	65.9±1.3	14.37±0.26	14.61±0.26
RADIUM (Dup.), pCi/l				2.05±0 07		63.7±1.3		

*Cation-Anion balance not achieved

Herscher

Table [illegible] (Cont'd)

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	216 148	217 139	218 140	219 144	220 168	221 171	222A 60	222B 154	223 156
SAMPLING POINT	Filter Influent	Filter Effluent	Softener Effluent	Well #5 Raw	Filter Influent	Filter Effluent	Softener Effluent	Softener Effluent (Dup)	Well 5 Raw
DATE AND TIME / PARAMETER	4/1/75 9 20A	4/1/75 9 20A	4/1/75 9 25A	4/1/75 2 20P	4/1/75 2 25P	4/1/75 2 30P	4/1/75 2 40P	4/1/75 2 40P	4/1/75 7 10P
pH	7.7	8.0	8.1	7.7	7.6	8.0	7.9	7.8	7.9
IRON, mg/1	0.4	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1
MANGANESE, mg/1	0.41	0.01	0.01	0.00	0.45	0.00	0.00	0.00	0.00
CALCIUM, mg/1	106	101	3	84	96	106	2	[illegible]	105
MAGNESIUM, mg/1	43	43	1	43	43	42	1	1	43
AMMONIUM (NH_4), mg/1	0.05	0.06	0.00	1.3	0.00	0.00	0.00	0.00	1.3
SODIUM, mg/1	350	350	560	350	350	350	560	550	350
POTASSIUM, mg/1	25.5	24	5.1	24	25.5	25	7.1	7	24
FLUORIDE, mg/1	2.2	2.2	2.1	2.2	2.3	2.3	2.3	2.3	2.3
CHLORIDE, mg/1	400	395	395	380	385	390	395	390	360
NITRATE (NO_3), mg/1	0.8	1.1	0.8	0.6	0.9	0.8	0.5	0.5	0.4
SULFATE, mg/1	393	399	408	393	417	417	405	405	414
ALKALINITY, mg/1	268	252	240	268	252	260	260	260	256
HARDNESS, mg/1	442		11.8	386	416	437	9.1	9.1	43[illegible]
RESIDUE, mg/1	1490	1440	1510	1476	1480	1492	1514	1526	1484
T S by E.C., mg/1	1430	1430	1530	1410	1410	1430	1510	1510	1410
ARSENIC, mg/1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BARIUM, mg/1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1
BORON, mg/1	1.5	1.4	1.4	1.4	1.6	1.4	1.4	1.2	1.2
CADMIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHROMIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COPPER, mg/1	0.02	0.01	0.00	0.00	0.02	0.02	0.01	0.02	0.00
LEAD, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MERCURY, µg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NICKEL, mg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SELENIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SILVER, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZINC, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SILICA, mg/1	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
CYANIDE, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GROSS ALPHA, pCi/1	50.3±13.4	27.1±10.2	4.5±5.7	50.3±14.4	35.5±11.7	19.6±9.4	6.6±6.7	0.8±5.2	31.8±11.3
GROSS BETA, pCi/1	56.1±8.1	44.2±7.2	6.8±4.0	53.5±7.7	47.5±8.0	38.1±7.4	6.0±5.1	10.6±5.5	56.7±8.4
RADIUM, pCi/1	13.38±0.26	6.37±0.13	0.68±0.03	14.04±0.28	13.92±0.28	6.94±0.16	0.48±0.03	0.37±0.03	13.96±0.28
RADIUM (Dup.), pCi/1				14.39±0.28					

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	224 181	225 [illegible]	226 147	227 143	228 152	229 157	230 149
SAMPLING POINT	Filter Influent	Filter Effluent	Softener Effluent	Filter Backwash Comp.	Softener Brine Water Rinse Comp.	Well #5 Raw	Filter Influent
DATE AND TIME / PARAMETER	4/1/75 7 10P	4/1/75 7 20P	4/1/75 7 25P	4/1/75 [illegible]	4/1/75 [illegible]	4/8/75 12 10	4/8/75 12 10A
pH	7.5	7.9	7.9		7.5	7.5	8.0
IRON, mg/1	0.1	0.0	0.0		[illegible]	[illegible]	[illegible]
MANGANESE, mg/1	0.65	0.00	0.00		[illegible]	[illegible]	0.44
CALCIUM, mg/1	104	[illegible]	26		[illegible]	[illegible]	[illegible]
MAGNESIUM, mg/1	42	[illegible]	39		[illegible]	44	43
AMMONIUM (NH_4), mg/1	0.00	0.01	0.00		[illegible]	1.5	0.00
SODIUM, mg/1	330	360	420		[illegible]	360	370
POTASSIUM, mg/1	24.5	25	44			[illegible]	[illegible]
FLUORIDE, mg/1	2.3	[illegible]	2.1		2.7	[illegible]	[illegible]
CHLORIDE, mg/1	335	400	405		[illegible]	[illegible]	445
NITRATE (NO_3), mg/1	0.5	[illegible]	0.7			[illegible]	0.9
SULFATE, mg/1	[illegible]	40[illegible]	416		[illegible]	[illegible]	350
ALKALINITY, mg/1	264	248	260			[illegible]	[illegible]
HARDNESS, mg/1	43[illegible]	43[illegible]			5443	[illegible]	401
RESIDUE, mg/1	1496	148[illegible]	1496		[illegible]	[illegible]	1474
T S by E.C., mg/1	1430	1430	1460		[illegible]	1430	1430
ARSENIC, mg/1	0.000	0.000	0.000		[illegible]	0.000	0.000
BARIUM, mg/1	0.1	0.1	0.1		[illegible]	0.0	0.0
BORON, mg/1	1.4	1.2	1.2		[illegible]	1.4	1.4
CADMIUM, mg/1	0.00	0.00	0.00		0.00	0.00	0.00
CHROMIUM, mg/1	0.00	0.00	0.00		0.00	0.00	0.00
COPPER, mg/1	0.02	0.02	0.03		0.06	0.00	0.03
LEAD, mg/1	0.00	0.00	0.00		0.00	0.00	0.00
MERCURY, µg/1	0.0	0.0	0.0		0.0	0.0	0.0
NICKEL, mg/1	0.0	0.0	0.0		0.0	0.0	0.0
SELENIUM, mg/1	0.00	0.00	0.00		0.00	0.00	0.00
SILVER, mg/1	0.00	0.00	0.00		0.00	0.00	0.00
ZINC, mg/1	0.00	0.00	0.02		0.15	0.00	0.03
SILICA, mg/1	8.0	8.0	8.0		7.0	[illegible]	8.0
CYANIDE, mg/1	0.00	0.00	0.00		0.00	0.00	0.00
GROSS ALPHA, pCi/1	45.7±13.2	8.6±7.4	[illegible]±5.8	32.7±11.7	216.5±98.9	66.[illegible]±15.1	[illegible]5.6±14.3
GROSS BETA, pCi/1	47.5±8.0	33.0±7.1	47.5±8.0	40.8±7.1	279.3±55.8	20.2±6.3	54.4±8.4
RADIUM, pCi/1	13.94±0.28	6.84±0.16	2.16±0.06	158.99±2.93	94.16±1.81	13.95±0.28	13.84±0.30
RADIUM (Dup.), pCi/1				154.21±1.99			

*Cation-Anion balance not achieved

Herscher

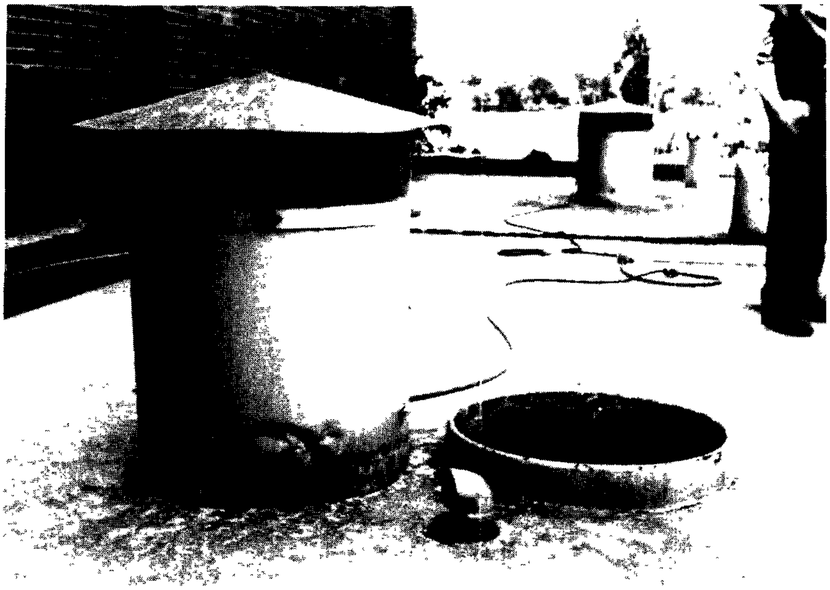
Table C-1 (Cont'd.)

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	231 146	232 150	233 159	234 145	235A 179	235B 153	236 164	237 157	238 202	239 206	240A 186	240B 203	241 161	242 155
SAMPLING POINT	Filter Effluent	Softener Effluent	Well #5 Raw	Filter Influent	Filter Effluent	Filter Effluent	Softener Effluent	Well #5 Raw	Filter Influent	Filter Effluent	Softener Effluent	Softener Effluent	Filter Backwash Comp.	Soft. Bkwsh Brine Water Rinse Comp.
DATE AND TIME / PARAMETER	4/8/75 12:10A	4/8/75 12:20A	4/8/75 8:10A	4/8/75 8:10A	4/8/75 8 15A	4/8/75 8·15A	4/8/75 8:30A	4/8/75 2:40P	4/8/75 2 40P	4/8/75 2 45P	4/8/75 2·50P	4/8/75 2:50P	4/8/75 4:30P	4/8/75 3:10P
pH	8.1	8.3	8.0	8.1	8.2	8.1	8.3	8.0	8.0	8.0	8.0	7.9		7.7
IRON,mg/1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0		0.3
MANGANESE,mg/1	0.13	0.05	0.00	0.53	0.02	0.02	0.00	0.00	0.50	0.00	0.00	0.00		0.12
CALCIUM,mg/1	80	4	84	82	82	82	2	76	82	80	32	35		1150
MAGNESIUM,mg/1	40	2	43	43	39	42	1	43	43	43	44	44		500
AMMONIUM(NH_4),mg/1	0.00	0.00	1.4	0.00	0.00	0.00	0.00	1.5	0.00	0.00	0.00	0.00		0.10
SODIUM,mg/1	370	560	360	360	360	350	550	370	360	360	400	400		4200
POTASSIUM,mg/1	25.5	4	24	25	25	25	10.9	24	25.5	25	43	44		75
FLUORIDE,mg/1	2.4	2.2	2.3	2.2	2.4	2.2	2.2	2.4	2.2	2.3	2.3	2.3		2.8
CHLORIDE,mg/1	390	400	380	395	395	390	390	380	390	400	395	400		9500
NITRATE(NO_3),mg/1	0.6	0.4	0.4	0.6	0.7	0.5	0.6	0.6	0.4	0.6	0.7	0.5		1.5
SULFATE,mg/1	390	369	384	372	369	278	381	372	387	374	384	378		460
ALKALINITY, mg/1	256	260	252	264	260	244	252	256	256	268	240	248		264
HARDNESS,mg/1	364	19	386	382	365	377	9	366	382	376	261	268		4925
RESIDUE,mg/1	1482	1546	1482	1482	1472	1482	1514	1472	1488	1486	1488	1490		17868
T S.byE.C.,mg/1	1430	1540	1430	1430	1430	1430	1540	1430	1430	1430	1470	1470		15370
ARSENIC,mg/1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
BARIUM,mg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.5
BORON,mg/1	1.6	1.4	1.4	1.4	1.4	1.6	1.4	1.4	1.4	1.4	1.4	1.4		1.2
CADMIUM,mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
CHROMIUM,mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
COPPER,mg/1	0.02	0.00	0.00	0.02	0.01	0.01	0.01	0.00	0.11	0.01	0.00	0.00		0.05
LEAD,mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
MERCURY,μg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
NICKEL,mg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
SELENIUM,mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
SILVER,mg/1	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
ZINC,mg/1	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.10	0.00	0.00	0.00		0.15
SILICA,mg/1	8.0	8.0	8.0	8.0	8.0	8 0	8.0	8.0	8.0	8.0	8.0	8.0		7.5
CYANIDE,mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
GROSS ALPHA,pCi/1	27.3±10.5	8.3±6.7	46.2±11.8	50.2±13.5	17.7±8.1	15.4±8.0	3.2±4.9	47.8±13.4	45.3±12.9	20.2±8.6	10.9±6.9	10.0±6.6	83.8±17.4	259.4±95.8
GROSS BETA,pCi/1	30.1±7.0	8.2±5.5	44.1±7.6	58.4±8.6	42.6±7.7	34.7±7.2	14.2±5.9	47.9±8.1	64.5±8.9	38.9±7.5	39.4±7.5	44.7±7.8	65.4±9.0	246.4±53.2
RADIUM,pCi/1	7.26±0.14	1.93 ±0.06	14.06±0.30	14.24±0.23	6.66±0.13	6.13±0.14	0.59±0.04	14.29±0.23	13.30±0.22	6.51±0.15	2.24±0.07	2.30±0.07	149.8±2.23	79.30±1.53
RADIUM(Dup.),pCi/1					6.62±0.12	6.19±0.12	0.61±0.03				2.38±0.07		144.0±3.43	

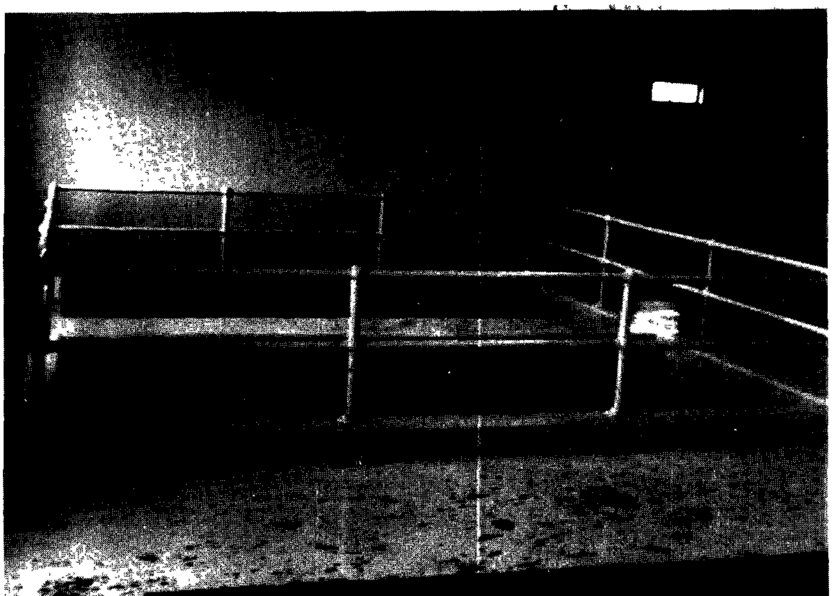
*Cation-Anion balance not achieved

APPENDIX D

ELGIN



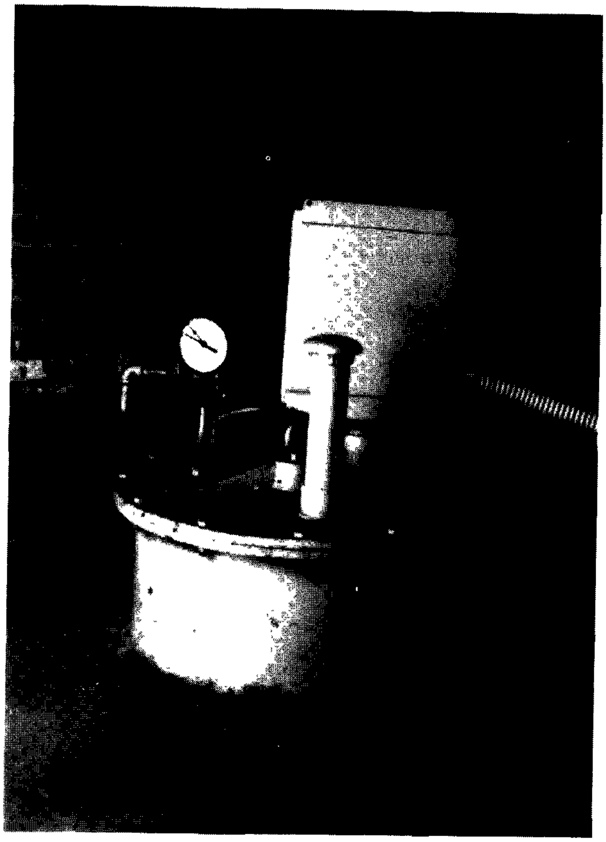
Aeration Tank Vent
(With Exhaust Fan on Top)



Filter #6

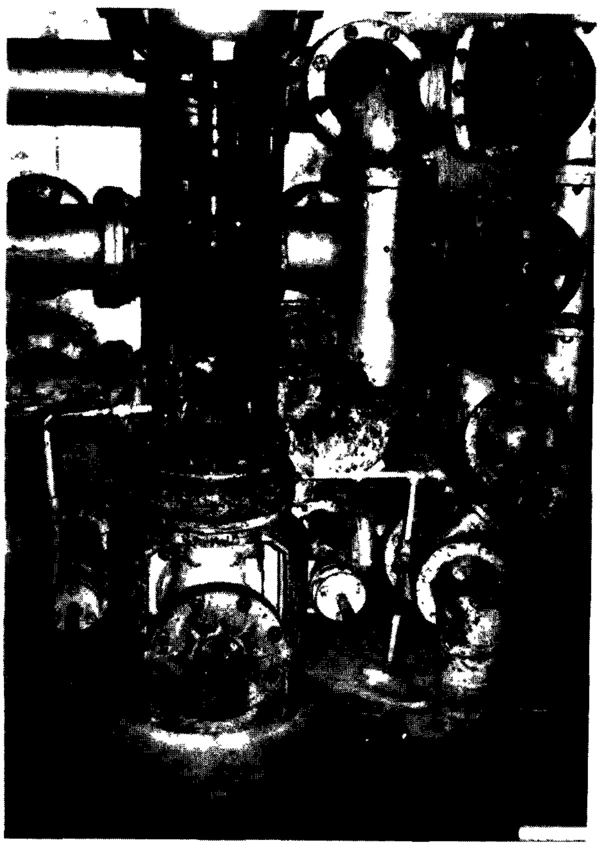
View of Lagoon

Figure D-1 Scenes at Elgin Water Treatment Plant



Well #5

Filter #3 Filter Beds & Drain Channels



Slush Pump-Sampling Tap for Fresh Sludge (Arrow)

Slush Pump-Locations of Intake Valves Manifold (partial view)

Figure D-1 (Cont'd.) Scenes at Elgin Water Treatment Plant

Supply: ELGIN (Slade Avenue Plant)

Item: Well #1

Location: 381 m South, 396.2m West of the NE corner of Sec. 11, T 41N, R8E, Kane County

Pump: KSB Submersible
63.1ℓ/s set at 182.9m

Motor: 149200W, 480 Volt

Chronology: Drilled in 1904 by Frank M. Gray, Milwaukee, Wisconsin. Rehabilitated in 1960-61 by S. B. Geiger & Co., Chicago

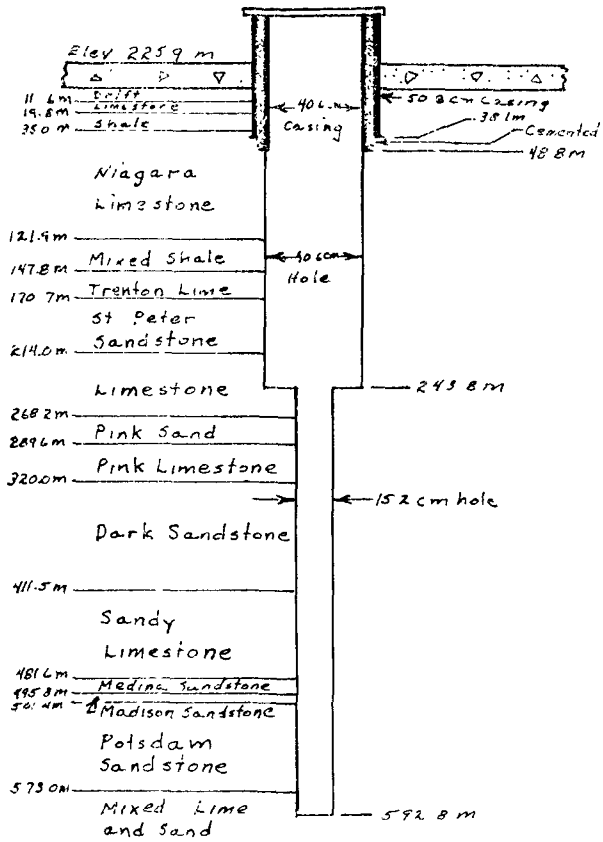


Figure D-2 Well Log-Well #1 - Elgin

Production Data:				
Date	1931			
Static Level, m	26.5			
Pumping Level, m	37.5			
Pumping Rate, ℓ/s	22.7			
Specific Capacity	2.06			

Supply: ELGIN (Slade Avenue Plant)

Item: Well #2

Location: 335, 3m South, 365.8m West of the NE corner of Sec. 11, T41N, R8E, Kane County

Pump: B-J Submersible
63.1 ℓ/s

Motor: 149200 W

Chronology: Drilled in 1904 by Frank M. Gray, Milwaukee, Wisconsin
Rehabilitated in 1959 by S. B. Geiger and Co. Chicago

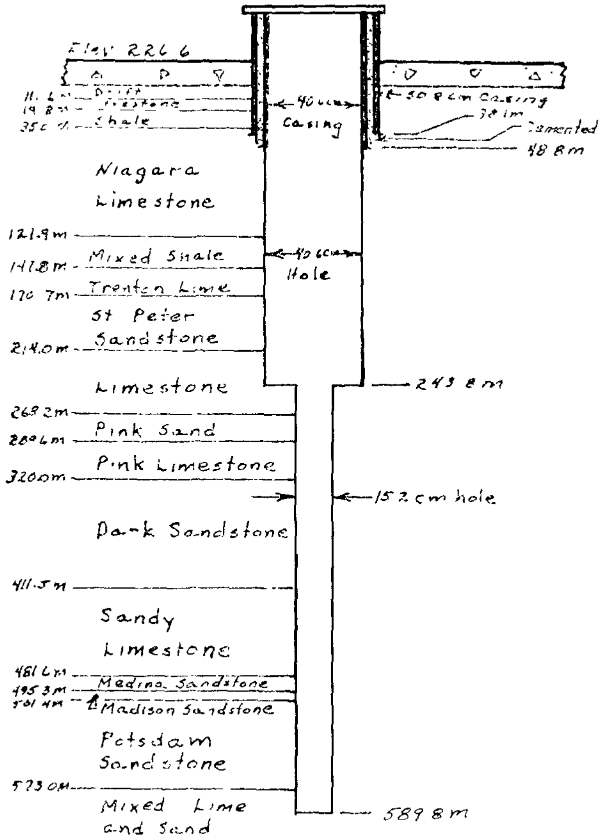


Figure D-3 Well Log-Well #2 - Elgin

Production Data:				
Date	1960			
Static Level, m	100			
Pumping Level, m	118.3			
Pumping Rate, ℓ/s	49.8			
Specific Capacity	2.72			

Supply: ELGIN (Slade Avenue Plant)

Item: Well #3

Location: 304.8m South, 335.3m West of the NE corner of Sec. 11 T4IN, R8E, Kane County. (Well house approximately 90m north of Slade Avenue Treatment Plant)

Pump: B-J Submersible
56.8 ℓ/s

Motor: 111,900W. 480V

Chronology: Drilled in 1904 by Frank M. Gray, Milwaukee, Wisconsin

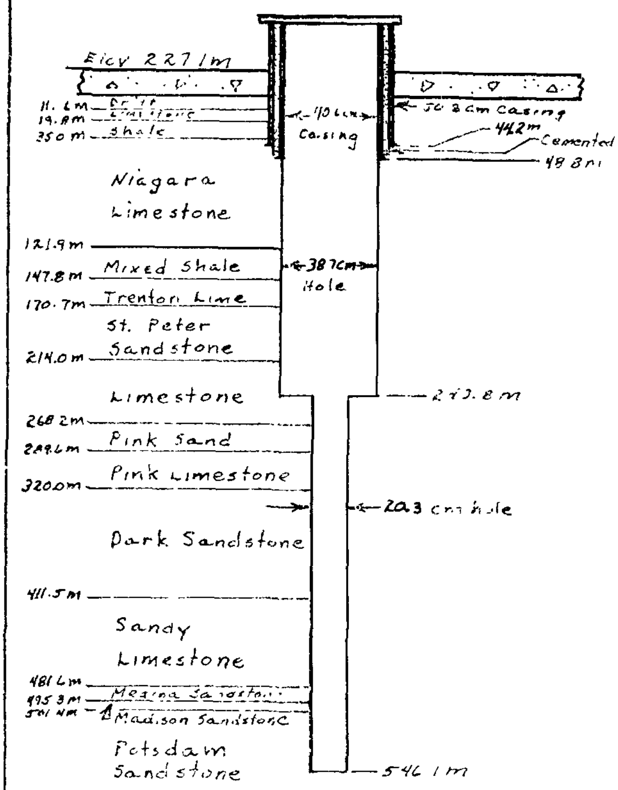


Figure D-4 Well Log-Well #4 - Elgin

Production Data:				
Date	1960	1961		
Static Level, m	97.5	107.3		
Pumping Level, m		131.4		
Pumping Rate, ℓ/s		23.7		
Specific Capacity		1.02		

Supply: ELGIN (Slade Avenue Plant)

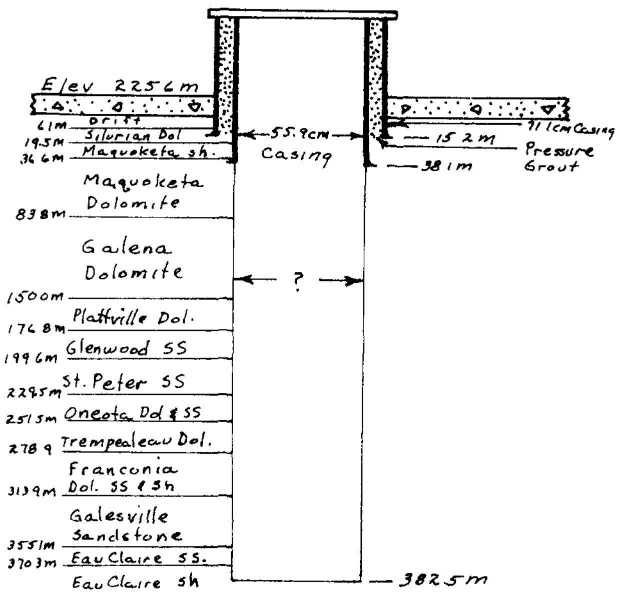
Item: Well #5

Location: 457.2m South, 442.0m West of the NE corner of Sec. 11 T41N, R8E, Kane County. (Well house 152.4m South of Slade Avenue Treatment Plant)

Pump: B-J Submersible
63.1ℓ/s set at 182.9m

Motor: B-J Electric
149200W

Chronology: Drilled in 1949 by Layne-Western Company



Production Data:				
Date	1949			
Static Level, m	30.5			
Pumping Level, m	97.6			
Pumping Rate, ℓ/s	82.0			
Specific Capacity	1.22			

Figure D-5 Well Log-Well #5 - Elgin

Supply: ELGIN (Slade Avenue Plant)

Item: Well #6

Location: 518.m South, 457.2m West of NE corner of Sec. 11, T4IN, R8E, Kane County (152.4m south of Slade Avenue Treatment Plant)

Pump: B-J submersible

Motor: 186,500 W

Chronology: Drilled in 1958 by L. C. Neely, Batavia

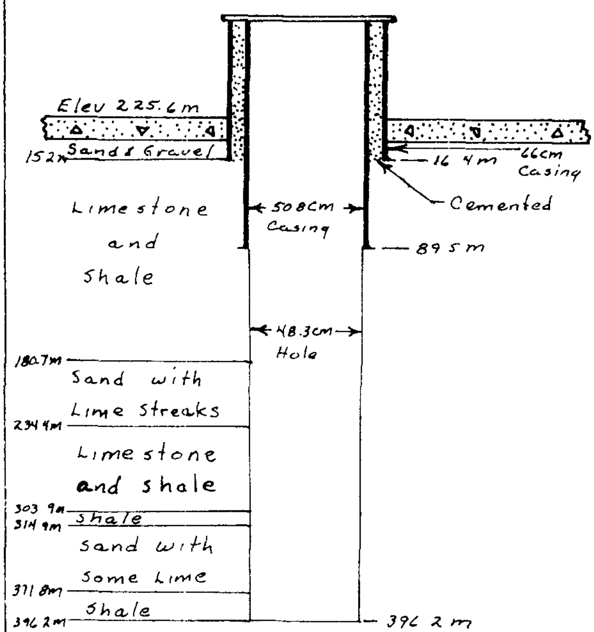
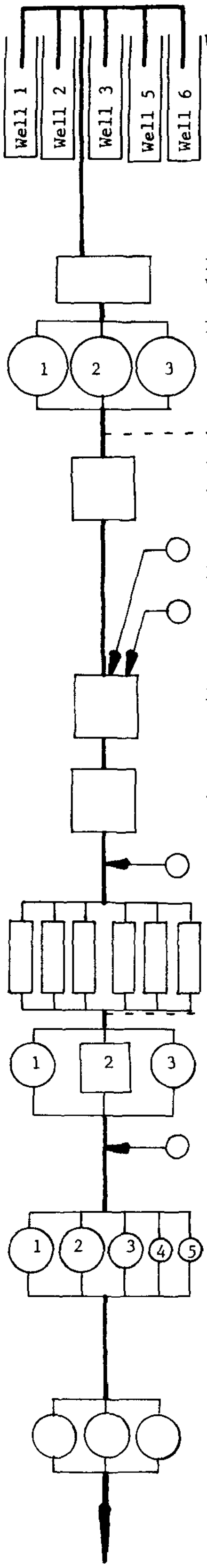


Figure D-6 Well Log-Well #6 - Elgin

Production Data:				
Date	1958	1958	1975	
Static Level, m	124.0	124.0	118.6	
Pumping Level, m	135.3			
Pumping Rate, ℓ/s	94.8			
Specific Capacity	8.39			



Wells-
#1 - 592.8 m deep, pump cap. 63.1 l/s
#2 - 589.8 m deep, pump cap. 63.1 l/s
#3 - 546.1 m deep, pump cap. 56.8 l/s
#5 - 382.5 m deep, pump cap. 63.1 l/s
#6 - 396.2 m deep, pump cap. 94.8 l/s

Raw water reservoir
Volume - 934 m^3

Low service pumps (3)
#1 - 113.6 l/s at 10 m head
#2 - 132.5 l/s at 12.2 m head
#3 - 72.5 l/s at 12.2 m head

Forced draft aerators (2)
4.57 m X 13.41 m X 2.44 m each
Capacity - unknown

Chemical feed (2)
Lime, Capacity unknown

Chemical feed (3)
Ferrous sulfate, Capacity unknown

Mixing basins (2)
Volume - 190 m^3 each
Detention time - 30 min

Recarbonation chamber (2)
Volume - 62 m^3 each

Chlorination
Capacity - 68.2 kg/d

Filters (6)
6.10 m X 5.49 m X 2.44 m each
Area - 33.4 m^2 each
Capacity - 3920 m^3/d each

Clearwells -
#1 - Volume - 3780 m^3
#2 - Volume - 7570 m^3
#3 - Volume - 3780 m^3

Chlorination
Capacity - 68.2 kg/d

High service pumps (5)
#1 - Capacity - 176.6 l/s
#2 - Capacity - 176.6 l/s
#3 - Capacity - 88.3 l/s
#4 - Capacity - 50.5 l/s
#5 (Auxiliary) - Capacity unknown

Elevated storage
Volume - 1890 m^3 each

PARAMETER AND REMOVAL EFFICIENCY

Sampling point	Ra226	%	Gross Alpha	%	Hard-ness	%
Well #1	6.61		21.9		254	
Well #2	6.15		14.3		238	
Well #3	4.78		15.7		253	
Well #5	4.91		15.9		248	
Well #6	12.97		54.5		236	
After low service pumps	5.57		17		242	
After filters	0.75	86.5	10.9	35.9	102	57.8

Figure D-7 Elgin Flow Schematic

Elgin (Slade Avenue Plant)

Raw Water Reservoir

Location: Slade Avenue Plant, under building
Construction: Concrete
Dimensions: 15.24m x 18.29m x 3.35m (50' x 60' x 11')
Capacity: 934 388 ℓ (.25MG)
Vents: 2 Vents - North
1 Vent - East side

Water Meters

Raw Water Meters
Quantity: 2
Manufacturer: Simplex Valve and Meter Company
Model: Venturi MT
Size: 40.6 cm tube x 24.1 cm throat (16" x 9.5")
Serial Numbers: #16-264-4339 and #16-309-5084 MT
Measures flow in MGD, 0 to 8.0 MGD (0 to 30.283 x 10^6L)
Records flow as gallons
Circular disc belt
Floor-mounted

Low Service Pumps

PUMP DATA
Type: Vertical turbine
Quantity: 3
Manufacturer: Aurora pump
Serial Number: #83923, #83924
Capacity: 113.56ℓ/c @ 10.06m, 132.49ℓ/s @ 12.19m & 72.55 @ 12.19m
(1800 gpm @ 33', 2100 gpm @ 40', 1150gpm @ 40' respective)
Takes Suction From: Raw water reservoir
Discharges To: Aerators

DRIVER DATA
Type: Electric motor
Manufacturer: U.S. motors
Model: Type CFU
Serial Numbers: #155320, #975157, #971239
Power: 18659W, 29840W, 29840W (25hp, 40hp, 40hp)
Angular velocity: 188.5 rad/s (1800RPM), 125.6 rad/s (1200 RPM),
125.6 rad/s (1200 RPM)
Electrical Requirements: 3ph, 60Hz

Aerators

Location: Base of aerators are on second floor of plant over the settling basin
Type: Root blowers with nozzles to diffuse
Quantity: two
Construction: Concrete
Dimensions: 4.57m x 13.41m x 2.44m (15' x 44' x 8' depth)
Area:
Capacity:
Blower: Rotary Lobe Blower, Serial No. 708055
Dresser Industries, Vacuum Pump Division

Chemical Feeder

Location: Chemical room at Slade Avenue Treatment Plant
Quantity: Two
Chemical: Lime
Type: Lime slaker
Serial Number: #83644-1, #83644-2, Model No. 41-02
Manufacturer: B.I.F. Omega
Fed From: Overhead hopper
Injects To: Mixing basin

Chemical Feeder

Location: Chemical room at Slade Avenue Treatment Plant
Quantity: three
Type: Omega Universal Volumetric Feeder
Model #UF-3, Serial # U-3864
dry feeder injects ferrous sulfate
Manufacturer: Omega
Capacity:
Fed From:
Injects To: Mixing basin
1 - out of service
2 - feed a mixture of ferrous sulfate and aluminum sulfate hand-mixed

Mixing Basin

Location: Under the aerator
Quantity: Two
Construction: Concrete
Dimensions: 6.71m x 6.71m x 4.27m (22' x 22' x 14')
Volume: 190,000ℓ (50,000 gal.)
Manhole:
Agitator:
Capacity:
Detention Time: 1800S
Sludge Removal: Walker Process continuous sludge removal equipment

Recarbonator

Location: Chemical room
Quantity: Two
Type: Carbal unit; Manufactures CO_2 from city gas
Serial Number: #20/2161, #20/1603
Manufacturer: Walker Process
Capacity:
Fed From: City gas line
Injects To: Recarbonation chamber

Recarbonation Chamber

Location: North end of clariflow
Quantity: Two
Construction: Concrete
Dimensions: 1.98m x 6.71, x 4.72m (6½' x 22' x 15½')
Volume: 62,000L (16,000 gal.) each
Manhole:

Filters

Location: Second floor filter room
Quantity: Four
Type: Rapid sand filters, gravity
Dimensions: 6.10m x 5.49m x 2.44m (20' x 18' x 8')
Filter Area: 33.44m^2 (360 $ft.^2$) each
Capacity: 4.73 x 10^6ℓ/d each @ 1.358 ℓ/m^2/s (1.25 MGD each @ 2gpm/ft^2)
Filter Media: Sand and gravel
Backwash: Manual using finished water
Waste Water: To sludge lagoon

Filters

Location: Second floor filter room
Quantity: Two
Type: Rapid sand filters, gravity
Dimensions: 6.10m x 5.49m x 2.44m (20' x 18' x 8')
Filter Area: 33.44m^2 (360 $ft.^2$) each
Capacity: 3.03 x 10^6 ℓ/d each @ 1.358 ℓ/m^2/s (0.8 MGD each @ 2gpm/$ft.^2$)
Filter Media: Sand and gravel
Backwash: Manual using finished water
Waste Water: To sludge lagoon. Clean water discharged to the Fox River

Wash Water Pump

Location: First floor, pump room

PUMP DATA
Type: Single stage, horizontal drive, centrifugal
Manufacturer: Aurora pump
Capacity: 378.5 ℓ/s (6000 gpm)
Head:
Takes Suction From: Clear water reservoir

DRIVER
Type: Induction motor
Style: 50N417
Serial: 1S50N417
Power: 55,950W (75 HP)
Angular Velocity: 12,145 rad/s (1160 RPM)
Electrical Requirements: 3ph, 60Hz

Clear Water Reservoirs

Location: South of Slade Avenue Treatment Plant
Quantity: Two round, one square, interconnected
Construction: Concrete
Round:
- Dimensions: 27.43m dia x 6.40m deep (90' diameter x 21')
- Capacity: 3.78×10^6 ℓ (1 MG) each
- Vents: One each

Square:
- Dimensions:
- Capacity: 7.57×10^6 ℓ (2 MG)
- Vents: One

High Service Pump

Location: First floor pump room

PUMP DATA
Type: Single state, horizontal drive, centrifugal pump
Manufacturer: American Well Works, Aurora Pump
Capacity: 176.6 ℓ/s (2800 gpm)
Head:
Takes Suction From: Clear water reservoirs
Discharges To: Distribution

DRIVER DATA
Type: Induction motor
Manufacturer: General Electric
Model No. 95#587G1
Serial No. 5286770
Power: 149,200W (200 HP)
Angular Velocity: 186.9 rad/s (1785 RPM)
Electrical Requirements: 3ph, 60Hz

High Service Pump

Location: First floor, pump room

PUMP DATA
Type: Single stage, horizontal drive, centrifugal
Manufacturer: American Well Works, Aurora
Capacity: 176.6 ℓ/s (2800 gpm)
Head: 60.96m (200')
Takes Suction From: Clear water reservoirs
Discharges To: Distribution

DRIVER
Type: Induction motor
Manufacturer: General Electric
Model No: 95E587G1
Serial No: 5286769
Power: 149,200W (200 HP)
Angular Velocity: 186.9 rad/s (1785 RPM)
Electrical Requirements: 3ph, 60Hz

High Service Pump

Location: First floor, pump room

PUMP DATA
Type: Single stage, horizontal drive, centrifugal
Manufacturer: American Well Works, Aurora, Illinois
Capacity: 88.3ℓ/s (1400 gpm)
Head:
Takes Suction From: Clear water reservoirs
Discharges To: Distribution

DRIVER
Type: Induction Motor
Manufacturer: General Electric
Model: 943350G1
Serial: 5311356
Power: 74600W (100 HP)
Angular Velocity: 186.4 rad/s (1780 RPM)
Electrical Requirements: 3ph, 60Hz

High Service Pump

Location: First floor, pump room

PUMP DATA
Type: Single stage, horizontal drive, centrifugal
Manufacturer: American Well Works, Aurora, Illinois
Capacity: 50.5 ℓ/s (800 gpm)
Head:
Takes Suction From: Clear water reservoirs
Discharge To: Distribution

DRIVER
Type: Induction Motor
Manufacturer: General Electric
Model: 5 KF505CG1
Serial: 5311371
Power: 44760W (60 HP)
Angular Velocity: 185.8 rad/s (1775 RPM)
Electrical Requirements: 3ph, 60Hz

Auxiliary High Service Pump

Location: First floor pump room

PUMP DATA
Type: Single stage, horizontal drive, centrifugal
Manufacturer: American Well Works, Aurora, Illinois
Model: 8071
Capacity:
Head:
Takes Suction From: Clear water reservoirs
Discharge To: Distribution

DRIVER
Type: Six cylinder gasoline engine
Manufacturer: Climax

Auxiliary Power, Engine - Generator Set

Location: First floor, pump room

GENERATOR DATA
Type:
Manufacturer: E - M
Power: Can operate one well and one booster pump, and chemcial feeders.

DRIVER
Type: 8 cylinder gasoline engine
Manufacturer: Climax
Model: R81
Number: 18033

Gas Chlorinator

Location: First floor chlorinator room on west side of building
Manufacturer: Wallace & Tiernan
Type: V-notch variable-orifice, free-standing, vacuum operated, solution feed.
Model: A-751
Serial: #DD-15798
Capacity: 181.8 kg/d (400 ppd)
Chlorine Source: Five 68Kg (150 lb.) cylinders on a platform scale
Booster Pump: None - operates off water main pressure
Injects To: Prechlorination

Gas Chlorinator

Location: First floor chlorinator room on west side of building
Manufacturer: Wallace & Tiernan
Type: V-notch, variable-orifice
Model: A7331132
Serial No.: #JJ3098
Capacity: 68.2 kg/d (150ppd)
Chlorine Source: Five 68kg (150 lb.) cylinders on a platform scale
Booster Pump:
Injects To: Post-chlorination

Chemical Feeder

Location: Room on first floor on east side
Quantity: One
Chemical: Hydrofluosilicic acid
Type: Proportional displacement chemical feed pump
Model: No. 12101-11
Serial No.: #6705305
Electrical Requirements: 115 volt, 20 amp. 50/60 Hz frequency
Manufacturer: Precision Control Products, Inc.,
Capacity:
Fed From: Plastic tank
Injects To: Filter effluent

Water Meters - Finished Water Meters

Quantity: Two
Manufacturers: Builders - Providence, Inc.
Model:
Size:
Measures Flow in 1000 gal. (3785 ℓ)
Records flow as gallons
Round flat chart and counter
Records flow as gallons
Wall-mounted

Elgin

Table D-1

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	101 / 102	102 / 103	103 / 105	104 / 106	105 / 107	106	107	108 / 108	109 / 109	110 / 111	111	112 / 113	113	114	115	116 / 118
SAMPLING POINT	Well #1 Raw	Well #5 Raw	Well #2 Raw	Well #3 Raw	Well #6 Raw	Aerator Effluent	Sludge	Filter Effluent	Filter Backwash Rinse Comp.	Aerator Inlet Wells 1,2, 3 and 5	Aerator Effluent	Filter Effluent	Sludge	Sludge Lagoon	Filter Backwash	Aerator Influent
DATE AND TIME / PARAMETER	3/7/75 1:55P	3/7/75 2:05P	3/7/75 2 15P	3/7/75 2 20P	3/7/75 3 00P	3/7/75 3·30P	3/7/75 3 45P	3/7/75 4:00P	3/7/75 3 15P	3/14/75 11:30A	3/14/75 12:10P	3/14/75 1:45P	3/14/75 2P	3/14/75 2:30P	3/14/75 1·30P	3/21/75 9:00A
pH	8.0	8.0	8.0	8.0	8.4			9.5	9.0 *	8 5		8.9				8.5
IRON,mg/1	0.0	0.0	0.1	0.1	0.0			0.0	13.0 *	0.0		0.0				0.00
MANGANESE,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.23 *	0.00		0.00				0.00
CALCIUM,mg/1	59	56	60	58	55			10	1350 *	58		12				59
MAGNESIUM,mg/1	26	24	25	25	24			18	53 *	24		20				23
AMMONIUM(NH_4),mg/1	0.72	0 59	0.63	0.6	0.59			0.51	0.57 *	0.62		0.54				0.58
SODIUM,mg/1	23	28	25	22	19			23	24 *	25		24				25
POTASSIUM,mg/1	10.2	9.6	10.1	10.1	9.4			10	9.7 *	10.3		10.4				10.5
FLUORIDE,mg/1	0.6	0 6	0.7	0.7	0.5			0.5	0.7 *	0.6		1.4				0.7
CHLORIDE,mg/1	8	4	18	8	5			15	19 *	12		16				11
NITRATE(NO_3),mg/1	0.2	0.1	0.2	0.2	0.1			0 2	1 0 *	0 3		0 4				0 1
SULFATE,mg/1	9	5	8	8	3			10	13 *	8		14				11
ALKALINITY, mg/1	312	312	300	300	292			128	136 *	300		138				296
HARDNESS,mg/1	254	238	253	248	236			99		243		112				242
RESIDUE,mg/1	352	340	356	350	278			182	190 *	336		184				338
T S.byE.C.,mg/1	360	350	360	340	340			220	230 *	360		220				370
ARSENIC,mg/1	0.000	0.000	0.000	0.000	0.000			0.000	0.000	0.000		0.000				0.000
BARIUM,mg/1	6.6	10 3	6.0	6.1	18.0			0.6	50	7.0		0 8				7.0
BORON,mg/1	0.2	0.2	0.2	0.2	0.2			0.2	0.2	0.2		0.3				0.3
CADMIUM,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00		0.00				0.00
CHROMIUM,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00		0 00				0.00
COPPER,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.03	0.00		0.10				0 03
LEAD,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00		0.00				0.00
MERCURY,µg/1	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0		0.0				0.0
NICKEL,mg/1	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0		0.0				0.0
SELENIUM,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00		0.00				0.00
SILVER,mg/1	0.00	0.00	0.00	0.00	0.00			0 00	0.02	0.00		0.00				0 00
ZINC,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.02	0.00		0.00				0.01
SILICA,mg/1	7.5	7.0	7.5	7.5	7.5			8.5	7.0	7.5		8.0				7.5
CYANIDE,mg/1	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00		0.00				0.00
GROSS ALPHA,pCi/1	21.9±4.6	14.3±3.9	15.7±4.0	15.9±4.0	54.5±7.3	28.9±5 4		1.6±1.0	2.9±1.4	19.0±4.5	15.1±4.0	2.9±1.4			4.1±1.7	15.0±4.0
GROSS BETA,pCi/1	23.2±3.0	20.8±2.9	24.3±3.1	23.5±3.1	46.2±4.0	33.3±3.5		11.1±1.7	13.0±1.9	21.7±3.0	23.9±3 1	9.9±1.9			12.7±2.0	25.4±3.2
RADIUM,pCi/1	6.61±0.32	6.15±0.30	4.78±0.17	4.91±0.11	13.25±0.22		12.53±0.19	0.75±0.04	21.91±0.49	5.70±0.12		0.80±0.04	1.26±0.04	30.±2	11.53±0.26	5.64±0.12
RADIUM(Dup.),pCi/1					12.69±0.22		pCi/g		21.02±0.51				pCi/g	pCi/g		5.38±0.12

*Cation-Anion balance not achieved

Elgin

Table D-1 (Cont'd.)

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	117	118 / 120	119	120	121 / 141
SAMPLING POINT	Aerator Effluent	Filter	Sludge	Sludge	Filter Backwash Comp.
DATE AND TIME / PARAMETER	3/21/75 9:30A	3/21/75 2:30P	3/21/75 10:30A	3/21/75 11A	3/21/75 1:30P
pH		9.6			8.8
IRON, mg/1		0.0			11.3 *
MANGANESE, mg/1		0.00			0.30 *
CALCIUM, mg/1		10			1800 *
MAGNESIUM, mg/1		17			86 *
AMMONIUM (NH_4), mg/1		0.39			0.44 *
SODIUM, mg/1		25			26 *
POTASSIUM, mg/1		10.6			10.4 *
FLUORIDE, mg/1		1.0			0.8 *
CHLORIDE, mg/1		17			17 *
NITRATE (NO_3), mg/1		0.1			0.2 *
SULFATE, mg/1		13			24 *
ALKALINITY, mg/1		116			114 *
HARDNESS, mg/1		95			
RESIDUE, mg/1		168			182 *
T.S. by E.C., mg/1		210			210 *
ARSENIC, mg/1		0.000			0.000
BARIUM, mg/1		0.5			60
BORON, mg/1		0.3			0.3
CADMIUM, mg/1		0.00			0.00
CHROMIUM, mg/1		0.00			0.04
COPPER, mg/1		0.03			0.04
LEAD, mg/1		0.00			0.00
MERCURY, µg/1		0.0			0.0
NICKEL, mg/1		0.0			0.0
SELENIUM, mg/1		0.00			0.00
SILVER, mg/1		0.00			0.02
ZINC, mg/1		0.00			0.03
SILICA, mg/1		8.5			7.5
CYANIDE, mg/1		0.00			0.00
GROSS ALPHA, pCi/1	20.4±4.6	1.4±1.0			2.1±1.2
GROSS BETA, pCi/1	27.4±3.3	11.6±1.5			12.6±1.6
RADIUM, pCi/1		0.71±0.04	3.15±0.09 pCi/g	6.01±0.18 pCi/g	21.89±0.32
RADIUM (Dup.), pCi/1					

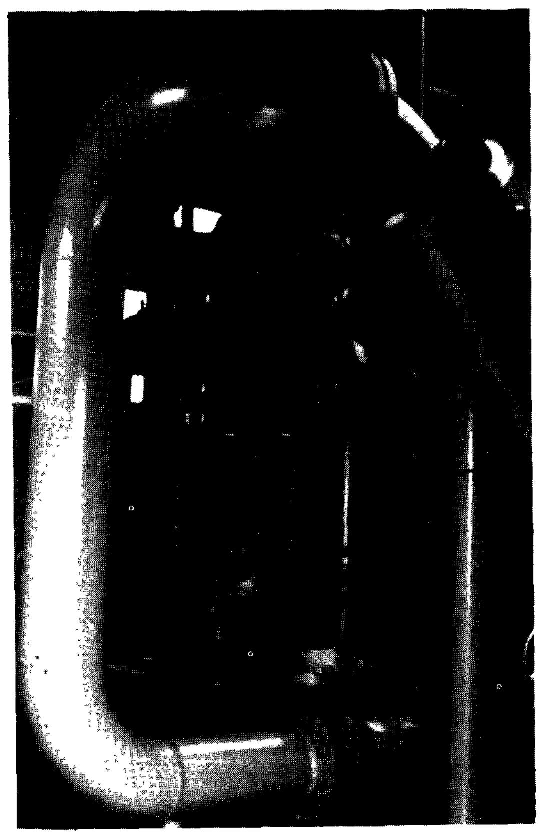
*Cation-Anion balance not achieved

APPENDIX E

LYNWOOD

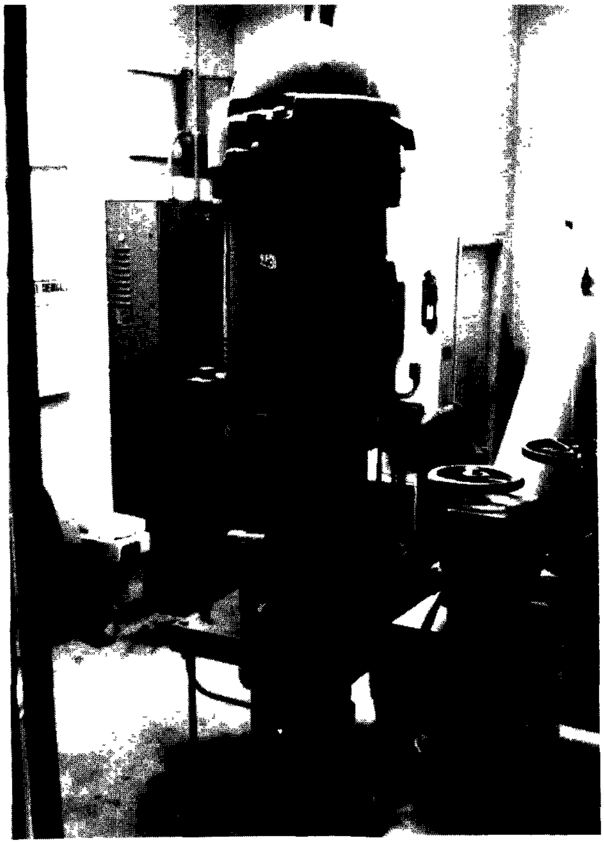
Lynwood - Water Treatment Plant

Top of Unit #1 - Used for collecting resin sample

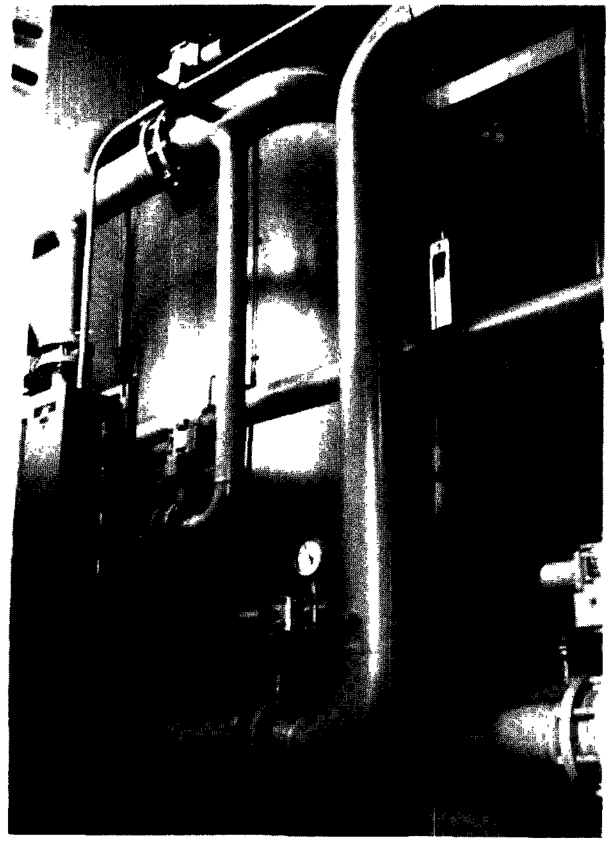


Well discharge to softening units

Figure E-1 Scenes at Lynwood Water Treatment Plant

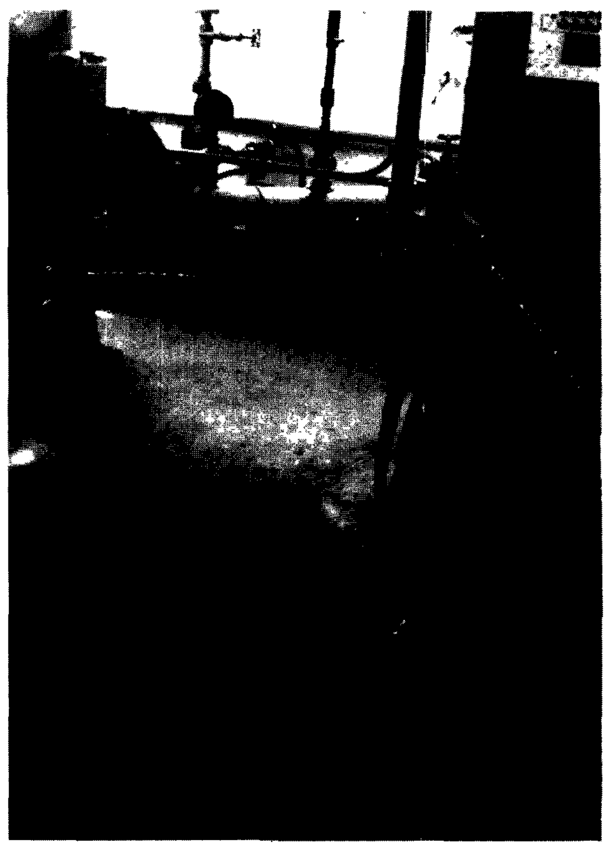


Well



Softener-Unit #1 & Sampling Point (Arrow)

Side view of Softener Units - Front



Back wash discharge & drain

Figure E-1 Scenes at Lynwood Water Treatment Plant

Supply: Lynwood

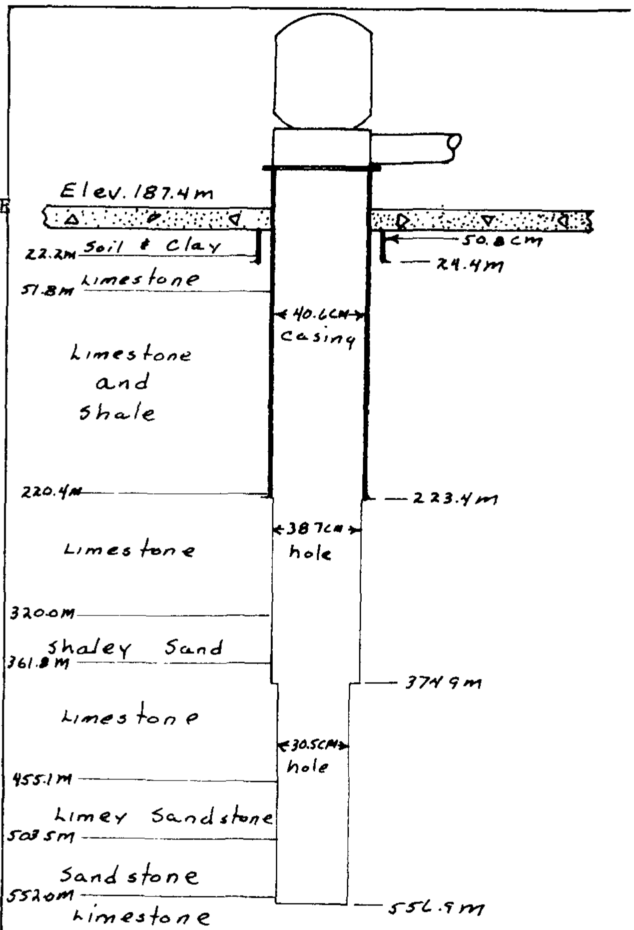
Item: Well #2

Location: 782.7m North, 762.0m East of the SW Corner of Sec. 7, T 35N, R 15E Cook County

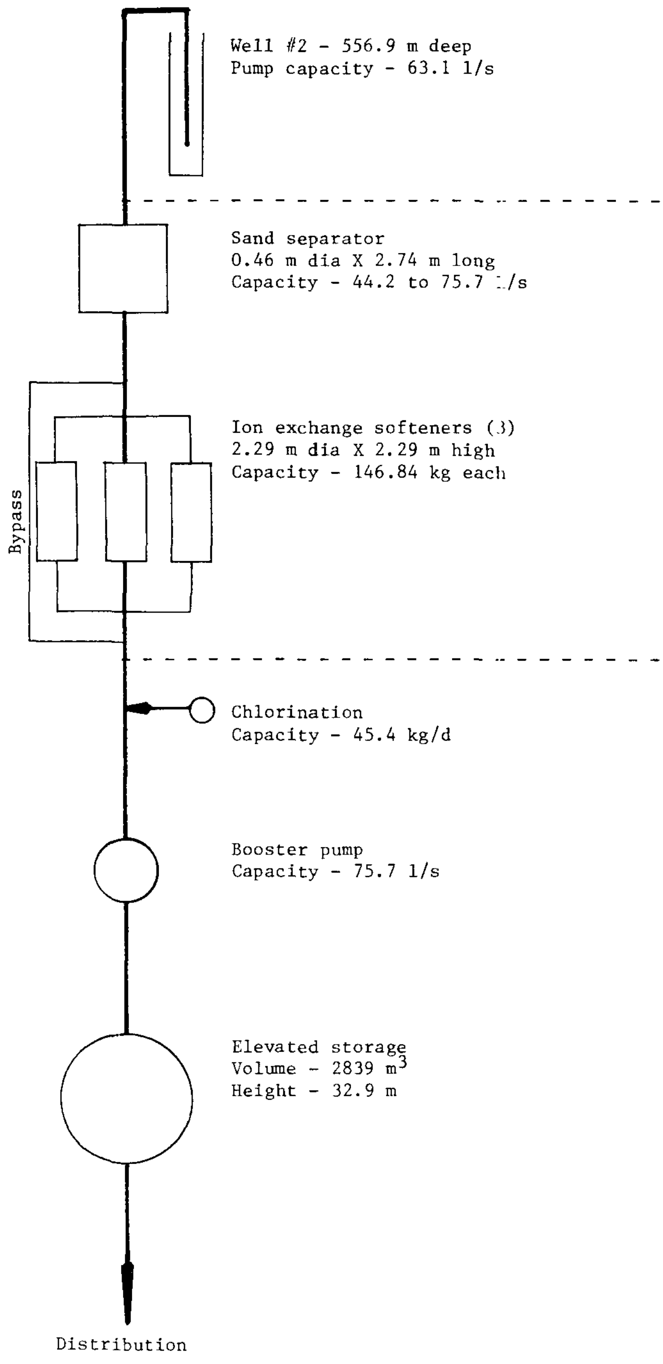
Pump: Johnson Turbine
63.1 L/s @ 249.9m,
Set at 228.6m

Motor: U. S. Motors Holloshaft
223,800W

Chronology: Drilled in 1972 by
Wehling Well Works



Production Data				
Date	1972			
Static Level, m	120.4			
Pumping Level, m	153.9			
Pumping Rate, ℓ/s	62.4			
Specific Capacity	1.86			



PARAMETER AND REMOVAL EFFICIENCY					
Ra226	%	Gross Alpha	%	Hard-ness	%
14.7		111.8		848	
1.8	87.7	11.7	89.5	78	90.8

Figure L-5 Lynwood Flow Schematic

Sand Separator (Desander)

Location: Pumphouse. Near Well #2
Manufacturer: Laval Separator Corporation, Fresno, California
Type: Industrial Separator
Model No.: 1S87012
Capacity: 44.2 ℓ/s to 75.7 ℓ/s (700 - 1200 gpm)
Dimensions: .46m dia x 2.74m long (18" dia x 9' long)
Function: Separation of sand from the water

Air Compressor

Location: Pumphouse East of Well #2
Make: Quincy
Model: HKF - 81114L
Size: 8.89 cm x 7.62 cm (3½" x 3")
Pressure: 1.379×10^6 N/m^2 (200 psig)
Tank: 227.1ℓ (60 gal.) Horizontal
Motor Manufacturer: General Electric
Motor Power: 2238W (3 HP)
Angular Velocity: 183.75 rad/s (1755 RPM)
Electrical Requirements: 3 ph, 60 Hz, 230-460V
Function: Pneumatic Valve Control for Softening Unit

Softening Unit

Location: Pumphouse
Manufacturer: Permutit Company, Paramus, New Jersey
Type: "Progressive Mode Ion Exhange"
No. of Components: Three (3) sub units
Dimensions: 2.29m (90") diameter x 2.29m (7'6") straight shellheight
Under Drain: Double dish
Softening Medium: Permutit Q-102
Volume: 3 at 5.83m^3 (206 ft^3)
Bed Depth: 1.35m (53")
Rising Space: .94m (37")
Capacity Rating: 25.19 kg/m^3 (11 Kgrains/ft^3)
Total Capacity: 3 x 146.84 kg (2266 Kgrains)

Brine Pump

Number: Two (one spare)
Make: Marlow
Model: 14HEL-9 / 14HEL-9
Serial: 523664/523667
Capacity: 1.26 ℓ/s (20 gpm)
Operation: Automatic
Pumps From: Brine pit
Discharges To: Softener (during regeneration)

Brine Tank (pit)

Location: Southwest of pumphouse
Construction: Concrete
Dimensions: 4.57m x 3.96m x 3.05m (15 ft. x 13 ft. x 10 ft.)

Master Meter

Manufacturer: Badger
Type: "Easy Read"
Serial No.: 12019567
Operation: Electrical
Read Out: Visual (digital) and recorded on chart. (Recorder not operating)

Booster Pump

Manufacturer: Weinman Pump, Columbus, Ohio
Type: Split Case - Centrifugal - Double Suction
Model No.: 6638U 5L1
Capacity: 75.7 ℓ/s (1200 gpm)
Motor: Lincoln
Motor Power: 55.95 kw
Electrical Requirements: 3ph, 60Hz
Serial No.: 022401
Suction From: Softener Discharge
Discharges To: Elevated tower and distribution system

Elevated Tank

Location: West edge of subdivision
Manufacturer: Chicago Bridge and Iron Company
Type: Fluted pedestal tank
Material: Steel
Capacity: 2.839×10^6 ℓ (750,000 gal.)
Working Waterhead: 32.92m - 42.67m (108 ft. to 140 ft.)

Gas Chlorinator

Location: Separate room southeast corner of pumphouse
Manufacturer: Wallace and Tiernan
Type: V-notch - pneumatic feed (U-22341)
Capacity: 45.4 kg/d (100 ppd)
Serial: TT-1359
Booster Pump: Aurora turbine
Pump Capacity:
Maximum Pressure: 896350N/m^2 (130 psi)
Scales: Wallace & Tiernan (Platform-dual)
Chlorine Cylinders: (2) 68kg (150 lb.)
Ventilation: Fan near floor

Testing Equipment

Location: At pumphouse
Chlorine: Wallace & Tiernan colorimeter
Hardness: Hach Titrimetric
Fe, pH: Hach Spectrophotometer

Lynwood

Table E-1

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	315 136	316 128	317 121	318A 129	318B 123	319 124	320 185	321 122
SAMPLING POINT	Well #2 Raw	Softener Effluent	Well #2 Raw	Softener Effluent	Softener Effluent	Well #2 Raw	Softener Effluent	Soft.Bkwsh Brine Water Rinse Comp.
DATE AND TIME / PARAMETER	4/10/75 10 25A	4/10/75 10:30A	4/10/75 10:55A	4/10/75 11.00A	4/10/75 11:00A	4/10/75 11.35A	4/10/75 11 40A	4/10/75 2:00P
pH	8.4	8.6	8.5	8.7	8.6	8.6	8.7	8.2
IRON, mg/1	0.6	0.1	0.7	0.1	0.1	0.7	0.1	3.1
MANGANESE, mg/1	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.11
CALCIUM, mg/1	260	29	260	25	26	240	23	1100
MAGNESIUM, mg/1	52	4	54	3	3	53	3	275
AMMONIUM (NH_4), mg/1	1.0	0.64	1.0	0.24	0.23	1.0	0.50	4.6
SODIUM, mg/1	330	700	340	700	700	340	720*	1650
POTASSIUM, mg/1	27	19.5	27	12.4	12.4	27.5	7.6	93
FLUORIDE, mg/1	1.4	1.6	1.6	1.4	1.6	1.5	1.5	1.5
CHLORIDE, mg/1	*340*	*355*	*350*	*350*	*350*	*355*	*345*	4500
NITRATE (NO_3), mg/1	0.2	0.9	0.5	0.2	0.2	0.2	0.2	0.9
SULFATE, mg/1	904	896	904	904	896	888	888	880
ALKALINITY, mg/1	204	204	204	208	204	204	196	204
HARDNESS, mg/1	863	89	872	75	77	818	70	3880
RESIDUE, mg/1	2140	2146	2143	2178	2178	2146	2136	9608
T.S.byE.C., mg/1	1750	1970	1750	1970	1970	1750	1970	8290
ARSENIC, mg/1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BARIUM, mg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
BORON, mg/1	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2
CADMIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHROMIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COPPER, mg/1	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.03
LEAD, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MERCURY, µg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NICKEL, mg/1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SELENIUM, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SILVER, mg/1	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00
ZINC, mg/1	0.05	0.00	0.06	0.01	0.00	0.07	0.00	0.04
SILICA, mg/1	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0
CYANIDE, mg/1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GROSS ALPHA, pCi/1	85.2±20.2	8.1±8.2	58.4±16.4	14.2±9.8	0.0±5.6	78.5±19.0	22.6±11.6	185.1±62.2
GROSS BETA, pCi/1	71.5±9.5	21.8±6.6	64.3±9.1	18.9±6.4	15.2±6.1	67.5±9.3	408.6±20.7	258.5±51.4
RADIUM, pCi/1	14.49±0.24	2.15±0.06	14.90±0.24	1.79±0.06	1.67±0.06	15.19±0.25	1.62±0.05	64.04±0.77
RADIUM(Dup.), pCi/1								

*Cation-Anion balance not achieved

Lynwood

Table F-1 (Cont'd)

IEPA SAMPLE NUMBER / ARGONNE LAB NUMBER	301 130	302 127	303 135	304 126	305 132	306 138	307 131	308A 169	308B 178	309 172	310 176	311 175	312 177	313A 125	313B 170	314 173
SAMPLING POINT	Well #2 Raw	Softener Effluent	Well #2 Raw	Softener Effluent	Well #2 Raw	Softener Effluent	Soft.Bkwsh Brine Water Rinse.Comp.	Well #2 Raw	Well #2 Raw	Softener Effluent Unit #1	Well #2 Raw	Softener Effluent Unit #1	Well #2 Raw	Softener Effluent Unit #1	Softener Effluent Unit #1	Softener Backwash Comp.
DATE AND TIME / PARAMETER	3/27/75 3:30P	3/27/75 3·40P	3/27/75 4:05P	3/27/75 4·15P	3/27/75 4:35P	3/27/75 4:40P	3/27/75 6:30P	4/2/75 10:15A	4/2/75 10 15A	4/2/75 10:30A	4/2/75 11 15A	4/2/75 11 20A	4/2/75 12:15P	4/2/75 12:20P	4/2/75 12 20P	4/2/75 3P
pH	7.7	7.8	7.6	7.8	7.6	7.6	7.2	7.9	8.0	8.3	8.0	8.3	8 0	8.2	8.2	7.7
IRON,mg/l	0.6	0.1	0.6	0.1	0.6	0.1	3.5	0.6	0.6	0.1	0.6	0.1	0.6	0.0	0.0	4.3
MANGANESE,mg/l	0.03	0.00	0.03	0.00	0.03	0.00	0.10	0.02	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.11
CALCIUM,mg/l	260	27	240	25	250	23	1150	240	250	29	250	26	250	25	25	1325
MAGNESIUM,mg/l	52	4	54	4	54	3	290	56	60	4	55	3	54	3	3	325
AMMONIUM(NH_4),mg/l	1.0	0.41	1.0	0.33	1.0	0.58	4.1	0.98	1.1	0.22	1.1	0.22	1.1	1.1	1.2	5 1
SODIUM,mg/l	340	720	350	700	340	700	1650	360	360	725	350	725	360	725	725	1950
POTASSIUM,mg/l	27	16.4	28	12.9	27	7.8	92.5	28.5	29	11.2	28.5	9 4	29.5	11	10.8	104
FLUORIDE,mg/l	1.6	1.6	1.6	1.8	1.7	0.7	1.8	1.8	1.7	1.7	1.7	1.8	1.8	1.8	1.7	1.8
CHLORIDE,mg/l	360	360	355	360	360	360	4800	355	360	360	360	365	360	365	365	5700
NITRATE(NO_3),mg/l	0.3	0.3	0.2	0.2	0.4	0.5	0.4	0 5	0.4	0.4	0.3	0.5	0.4	0.5	0 7	0.4
SULFATE,mg/l	845	875	860	845	850	864	840	903	900	930	868	903	950	920	896	880
ALKALINITY, mg/l	232	212	208	212	228	212	200	216	216	216	216	216	216	216	216	216
HARDNESS,mg/l	863	84	822	79	847	70	4067	830	871	89	851	77	847	75	75	4649
RESIDUE,mg/l	2142	2154	2134	2166	2142	2232	10466	2134	2130	2144	2142	2148	2142	2168	2178	11944
T.S.byE C.,mg/l	1770	1980	1770	1980	1770	2010	8730	1780	1760	1980	1760	1980	1780	2010	2010	10070
ARSENIC,mg/l	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BARIUM,mg/l	0.3	0.1	0.3	0.0	0.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
BORON,mg/l	1.4	1.2	1.2	1.4	1 3	1.2	1.1	1.3	1.0	1.1	1.2	1 1	1 0	1.1	1.0	1.1
CADMIUM,mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
CHROMIUM,mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00
COPPER,mg/l	0.02	0.01	0.02	0.02	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.04
LEAD,mg/l	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00
MERCURY,μg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0
NICKEL,mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SELENIUM,mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SILVER,mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZINC,mg/l	0.04	0.00	0.07	0.01	0.05	0.00	0.04	0.04	0.04	0.00	0.06	0.01	0 01	0.01	0.01	0.08
SILICA,mg/l	8.5	8.5	8.5	8.5	8.5	8.5	8 0	8.5	9.0	9.0	8.5	9 0	9 0	9.0	9.0	8.0
CYANIDE,mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GROSS ALPHA,pCi/l	178.4±28.7	16.6±10.9	104.6±21.8	7.0±8.0	148.6 ±27.0	11.1±9.4	197.1±64.6	109.4±22.9	88.5±20.6	13.0±10.2	110.3±23.2	9.4±9.3	155.9±25.7	7.6±9.3	7.3±8 9	181.3±71.0
GROSS BETA,pCi/l	112.9±10.1	13.2±6.6	99.3±9.5	26.9±5.9	103.0±9.8	15.7±5.2	263.6±50.9	87.5±10.3	73.7±9.6	14.7±6.1	74.5±9.7	15.6±6.2	83.5±10.2	22.5±6.8	20.6±6.6	264.1±51.4
RADIUM,pCi/l	14.69±0.30	.82±0.06	14.80±0.23	1.71±0.05	14.73±0.24	1.55±0.05	70.07±1.11	14.58±0.24	14.43±0.23	1.84±0.06	14.70±0.24	1.80±0.06	14.38±0.23	1.70±0.06	1.81±0.06	82.94±1.52
RADIUM(Dup.),pCi/l												1.78±0.05				

*Cation-Anion balance not achieved

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16. ABSTRACT

Five water supplies which were known to have radium-226 in the raw water (ranging from 3.3 to 14.7 pCi/l) and which have existing water softening equipment were chosen to determine the efficiency of radium removal. Plants using ion exchange and lime water softening processes were investigated.

At the plants using ion exchange softening, samples of raw, aerated, and softened water were collected, analyzed for radium-226 and mineral content, and the radium removal efficiency was calculated. At the plants using lime softening, samples of raw and filtered water were analyzed. All plants were operated in a normal manner during sampling.

In general, the ion exchange softening removed the radium-226 more efficiently with 70.2 to 98.2% being removed as compared to 70 to 92% for lime softening. Although the removal efficiency was somewhat lower using lime softening, it was more consistent since the problem of breakthrough at the end of a softener run was not experienced and little or no blend water is required to produce a stable produect.

17. KEY WORDS AND DOCUMENT ANALYSIS		
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