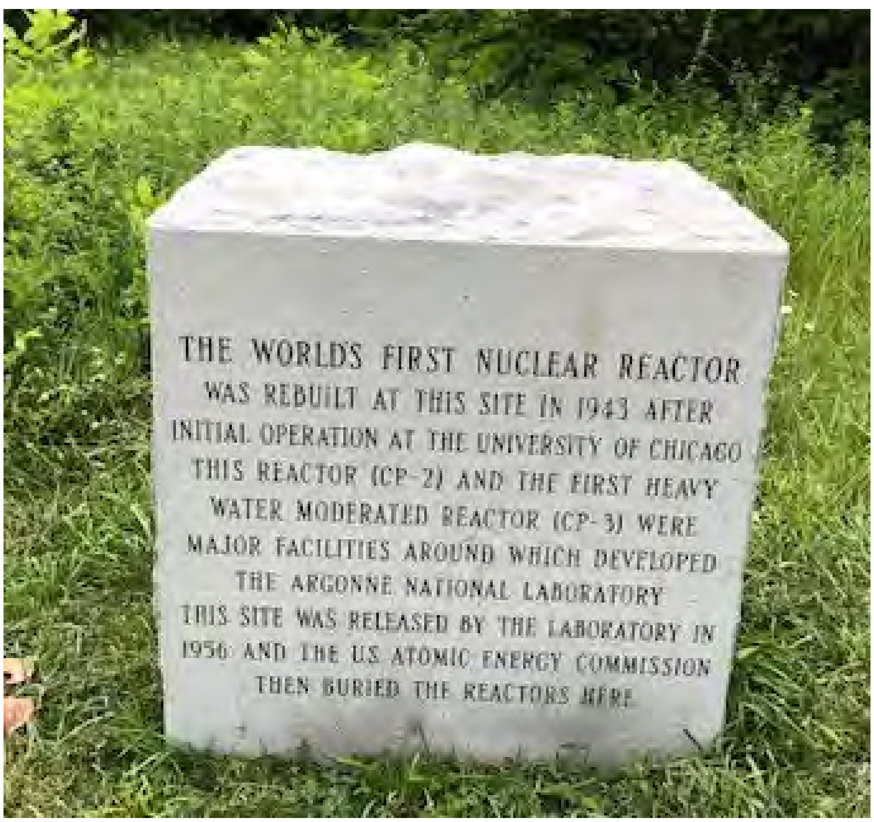
ANL-23/01

Surveillance of Site A and Plot M

Report for 2022

Environment, Safety, and Health Directorate



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ANL-23/01

Surveillance of Site A and Plot M Report for 2022

by

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PREFACE

This report is prepared for the U. S. Department of Energy (DOE) by the Worker Safety & Environment (WSE) Division at Argonne National Laboratory (Argonne). The results of the environmental monitoring program at Site A and Plot M and an assessment of the impact of the site on the environment and the public are presented in this publication. Funding to support this program was provided by the DOE Office of Legacy Management (DOE-LM).

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1.0 SUMMARY

The results of the environmental surveillance program conducted at Site A/Plot M for calendar year (CY) 2022 are presented within this document. Site A/Plot M is in the Palos Area Preserves, operated by the Forest Preserve District of Cook County. The surveillance program consists of the collection and analysis of surface and groundwater samples to determine the amount of hydrogen-3 and strontium-90 present in the environment within and surrounding the site of the former research facility (Site A) and waste burial site (Plot M).

The surveillance program was modified in 2015 by the removal of eight groundwater monitoring wells at Site A and Red Gate Woods, and the reduction in the sampling frequency, for all but the Plot M wells, from quarterly to annual. The changes were based on a review of monitoring results compiled over many years. These results indicated that the concentrations of hydrogen-3 and strontium-90 in the wells that were closed were low and consistently trending downward, and further monitoring of these wells was not required.

The CY2022 results indicate that, with a few exceptions, the amounts of hydrogen-3 and strontium-90 are slowly decreasing as a result of decay and dilution. The maximum potential radiation dose to a hypothetical resident near Plot M resulting from residual radioactivity in this area was estimated to be 0.673 mrem/y, based upon very conservative assumptions. A more realistic estimate of potential dose is 0.00098 mrem per visit for an occasional park visitor. The maximum potential dose is far below the DOE’s allowable dose to the public of 100 mrem/y.

Hydrogen-3 concentrations in surface water in two small intermittent streams that pass by Plot M were below the detection limit of 0.1 nCi/L upstream of Plot M, and appeared at a maximum of 12.8 nCi/L downstream of Plot M. Five samples of surface water were collected from ponds in the vicinity of Site A. None of these ponds contained hydrogen-3 above the detection limit of 0.1 nCi/L.

Hydrogen-3 continued to be detected during CY2022 in nine wells surrounding Plot M. The results were found to be slowly decreasing and consistent with previous results in seven of the nine monitoring wells. Monitoring wells BH06 and BH35 had the highest concentrations of hydrogen-3. In recent years, the hydrogen-3 concentration in BH06 has increased compared to concentrations found prior to 2009 as seen in Figure 4-6. As seen in Figure 4-7, hydrogen-3 concentration in BH35 decreased in CY2022 compared to previous years. Low levels of strontium-90 were found in groundwater from three of the nine Plot M wells sampled. Since 2010, the strontium-90 results in well BH06 appear to be slightly increasing. The other strontium-90 results are consistent with those measured in the past. All concentrations were below the State of Illinois' Class I Groundwater Quality Standard of 8 pCi/L for strontium-90.

The two wells in the vicinity of Site A were found to contain much lower amounts of hydrogen-3 than the Plot M wells. The amounts present were found to be slowly decreasing and were consistent with past observations. Low levels of strontium-90 were also found in the two Site A wells. All results were below groundwater quality standards. The six deep wells at Red Gate Woods that were constructed in the dolomite bedrock downgradient of Plot M were found to contain low levels of hydrogen-3, all below the State of Illinois' Class I Groundwater Quality Standard of 20 nCi/L. The CY2022 results were consistent with past findings and demonstrate that hydrogen-3 concentrations in these wells are slowly decreasing.

Two unused former picnic wells were also sampled at Red Gate Woods. Both wells had low levels of hydrogen-3, similar to last year's results. The hydrogen-3 levels in the former picnic well at Red Gate Woods North increased from 2010 to 2014, followed by a downward trend from 2014 to the CY2022 sampling event. All results were below the State of Illinois' Class I Groundwater Quality Standard of 20 nCi/L for hydrogen-3.

At the request of DOE-LM during a previous annual inspection, the Site A and Plot M monuments were replaced in May of 2021. Figures 1.1 and 1.2 show views of the monuments.

The results of the surveillance program indicate that the radioactivity remaining at Site A/Plot M does not endanger the health or safety of the public visiting the site, using the picnic areas, or living in the vicinity.

Figure 1-1 View of Site A Monument

Figure 1-2 View of Plot M Monument

2.0 INTRODUCTION

2.1 Site History

The environmental surveillance program discussed in this report is an ongoing activity that resulted from the 1976-1978 radiological characterization of the former site of Argonne National Laboratory and its predecessor, the University of Chicago's Metallurgical Laboratory. This site was part of the World War II Manhattan Engineer District Project and was located in a forested area southwest of Chicago, IL, owned by the Forest Preserve District of Cook County, now known as the Palos Area Preserves. Research was conducted at two locations in the Palos Area Preserves: Site A, a 19-acre parcel that contained experimental laboratories and nuclear reactor facilities; and Plot M, a 150 ft x 140 ft area used for the burial of radioactive waste. The location of the Palos Area Preserves is shown in Figure 2.1. The locations of Site A and Plot M are shown in Figure 2.2 along with the Site A surface water sample locations and Red Gate Woods picnic well locations. Previous comprehensive reports on this subject[1,2] provide additional detail and illustrations on sampling locations and provide descriptive material along with the results through 1981. Annual reports are available for 1982 through 2021.[3-36,50-55] While earlier data will not be repeated in this report, reference is made to some of the results.

Operations at Site A began in 1943 and ceased in 1954. Among the research programs carried out at Site A were reactor physics studies, fission product separations, hydrogen-3 recovery from irradiated lithium, and work related to the metabolism of radionuclides in laboratory animals. Radioactive waste and radioactively contaminated laboratory articles from these studies were buried at Plot M. At the termination of the programs, the reactor fuel and heavy water, used for neutron moderation and reactor cooling, were removed, and shipped to Oak Ridge National Laboratory. The biological shield for the CP-3 reactor located at Site A, together with various pipes, valves, and building debris, was buried in place in 1956.

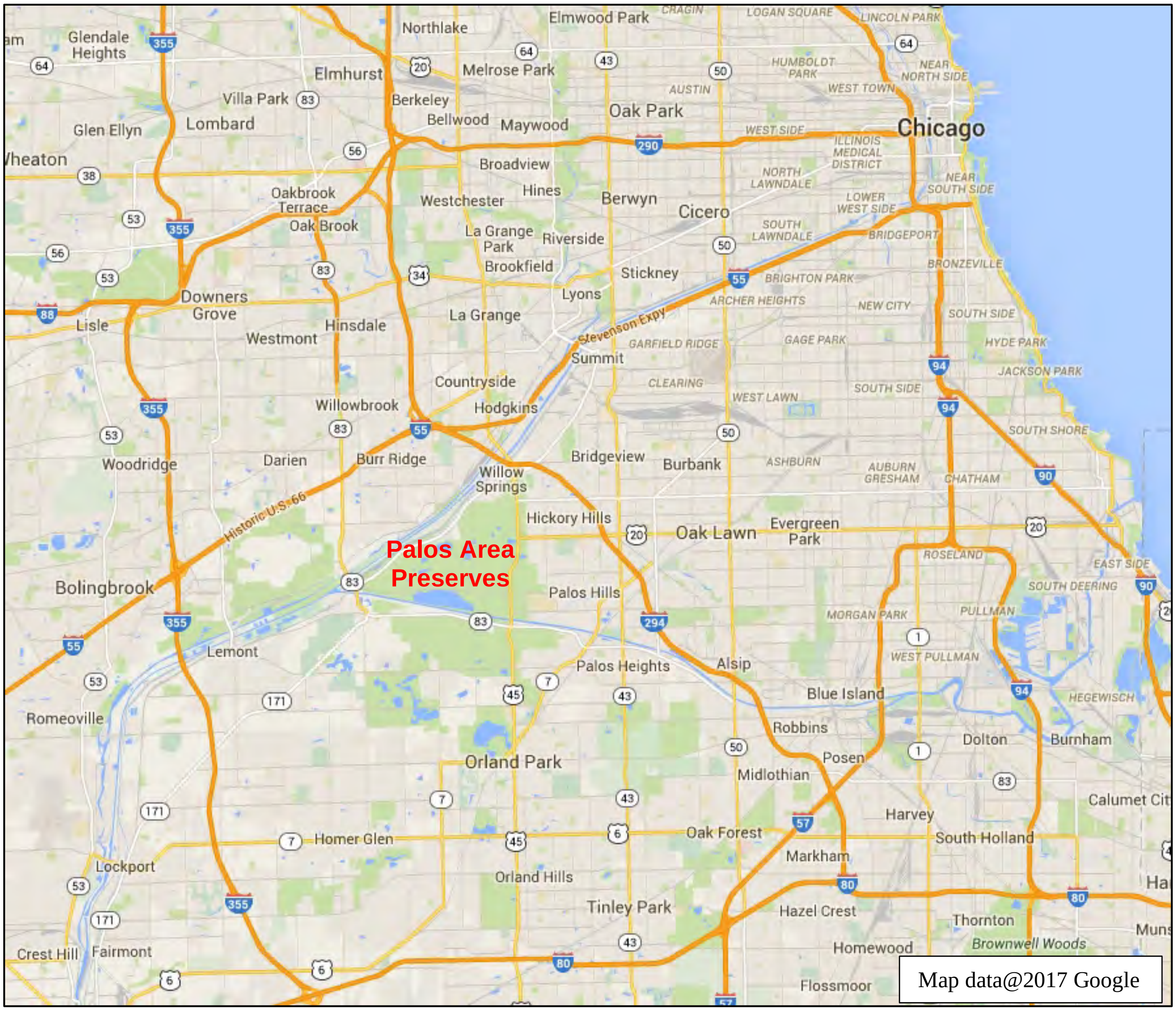

Figure 2-1 Location of Palos Area Preserves

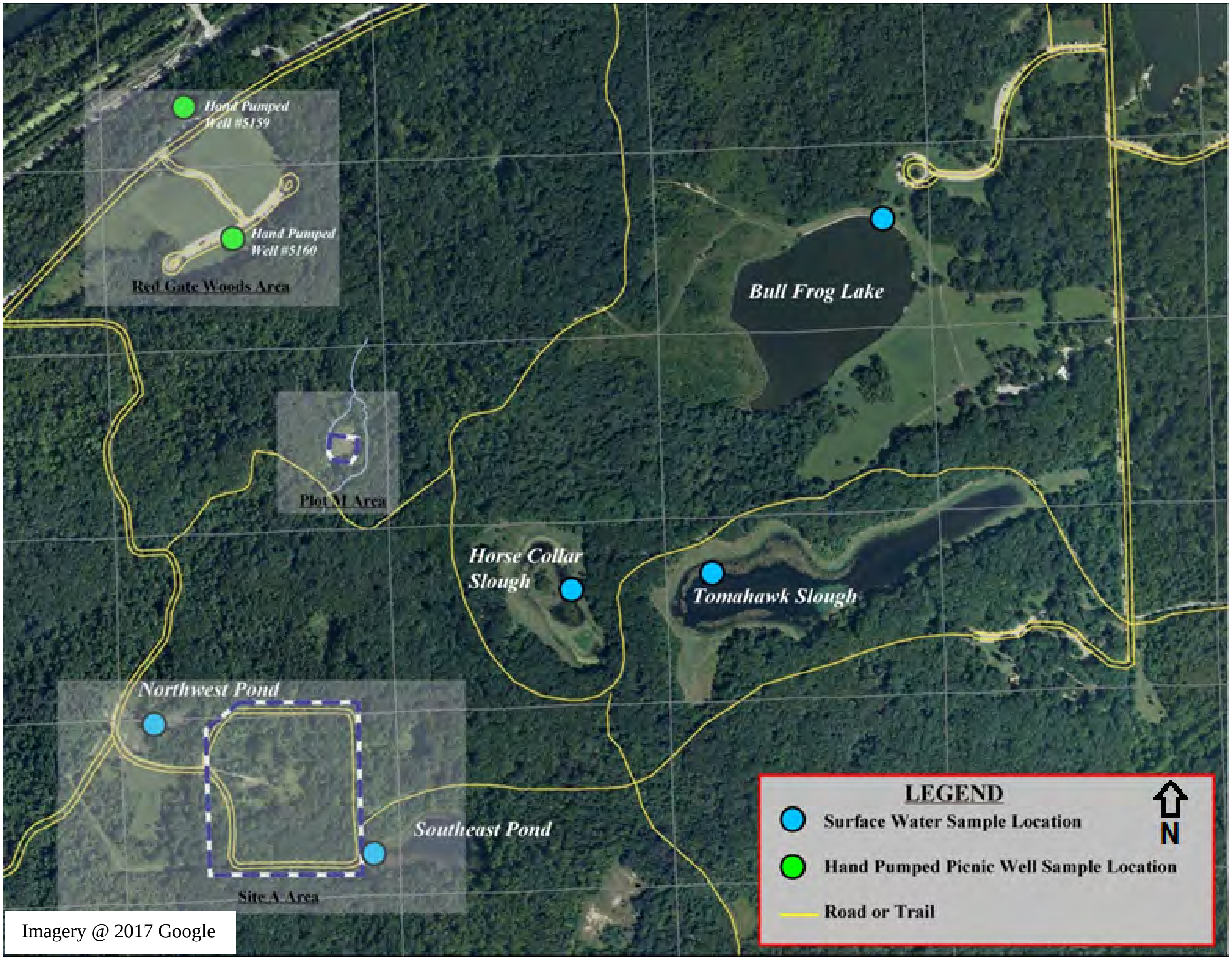

Figure 2-2 Site A/Plot M Area Map

Burial of radioactive waste at Plot M began in 1944 and was discontinued in 1949. Waste was buried in six-foot deep trenches and covered with soil until 1948, after which burial took place in steel bins. The steel bins were removed in 1949 and sent to Oak Ridge National Laboratory for disposal; however, the waste, buried in trenches, was allowed to remain in place. Concrete sidewalls, eight feet deep, were poured around the perimeter of the burial area and a one-foot-thick reinforced concrete slab was poured over the top. The concrete slab was covered with soil and seeded with grass. Both the Site A and Plot M areas were decommissioned in 1956.

In 1973, elevated levels of hydrogen-3 (as tritiated water) were detected by Argonne in two nearby hand-pumped picnic wells (#5160 and #5159). Later investigations found the hydrogen-3 to be migrating from the Plot M burial plot into the surrounding soil and aquifers. As a result, a radiological survey of the area surrounding the site was conducted by Argonne in 1976 with special emphasis on the Site A and Plot M areas.[1]

In 1990, elevated levels of radioactivity were discovered outside the original developed area. By 1997, additional characterization and remediation had been completed by DOE to remove residual radioactivity and document the remediation of the area.

The terminology used in previous reports is continued in this report. A hole drilled and well installed into the glacial drift is called a borehole (BH). Water from such wells is called groundwater. Monitoring wells drilled into the dolomite bedrock are called deep holes (DH). The former hand-pumped drinking water wells, which are completed into or close to the dolomite bedrock, are called picnic wells. They are identified by a location name and well number.

The results of radioactivity measurements are expressed in this report in terms of picocuries per liter (pCi/L) for strontium-90 and nanocuries per liter (nCi/L) for hydrogen-3 in water samples. The use of the term dose throughout this report refers to effective dose equivalent. Radiation effective dose equivalent calculations are reported in units of millirem (mrem) or millirem per year (mrem/y). Other abbreviations of units are defined within the text of this report.

2.2 Site Characteristics

Geologically, Plot M is constructed on a moraine upland which is dissected by two valleys, the Des Plaines River valley to the north and the Calumet Sag valley to the south. The upland is characterized by rolling terrain with poorly developed drainage. Streams are intermittent and either drain internally or flow to one of the valleys. The area is underlain by glacial drift, dolomite, and other sedimentary rocks. The uppermost bedrock is Silurian dolomite, into which both the picnic wells and some of the monitoring wells are placed. The dolomite bedrock is about 200 feet thick. The overlying glacial drift has a thickness that ranges from 165 feet at Site A to zero at the Des Plaines River and Calumet Sag Canal. The boreholes terminate in this layer of overlying glacial drift. The depth to bedrock at Plot M is about 130 feet.

Hydrologically, the surface water consists of ponds and intermittent streams. When there is enough precipitation, an intermittent stream flows past Plot M, continues near the Red Gate Woods picnic well (#5160 in Figure 2.2), and discharges into the Illinois and Michigan (I&M) Canal. The groundwater in the glacial drift and dolomite bedrock forms two distinct flow systems. The flow of groundwater in the drift is controlled principally by topography. The groundwater in the dolomite, which is recharged by groundwater migrating downward through the glacial drift, flows toward two discharge areas, the Des Plaines River to the north and the Calumet Sag Canal to the south. There is no groundwater usage downgradient of Site A/Plot M. The former hand-pumped picnic wells have been disabled by removing the handles. These wells are currently used only for groundwater monitoring.

The climate is that of the upper Mississippi valley, as moderated by Lake Michigan, and is characterized by cold winters and hot summers. Precipitation averages about 37 inches annually. The largest rainfalls occur between April and September. The average monthly temperature ranges from 21°F in January to 73°F in July. Approximately 8.9 million people reside within 50 miles of the site; the population within a five-mile radius is about 150,000. The only portion of the Palos Area Preserves in the immediate area of Plot M and Site A that is developed for public use is the Red Gate Woods picnic area (Figure 2.2), although small numbers of individuals use the hiking and biking trails that pass through more remote areas of the Preserve.

3.0 MONITORING PROGRAM

3.1 Purpose of the Monitoring Program

The monitoring program at Site A/Plot M was conducted in accordance with the “Long-Term Surveillance and Maintenance Plan for Site A and Plot M, Palos Forest Preserve, Cook County, Illinois”, issued in January 2015[37]. DOE-LM conducts stewardship activities at Site A and Plot M to protect human health and the environment, facilitate stakeholder involvement, and to comply with applicable regulations. DOE-LM carries out its stewardship responsibilities through a combination of government ownership, conducting regular inspections, maintaining institutional controls, facilitating public awareness, and monitoring environmental media.

The monitoring program is assessed by DOE-LM every three to five years to determine if the goals are being met. At each review, changes to the monitoring program may be recommended. The current monitoring program was put in place by DOE-LM in 2015 following reviews conducted in 2011 (DOE 2011) [38] and 2014 (DOE 2014)[39]. These reviews found that, except for hydrogen-3 at Plot M, past monitoring results indicated that concentrations of radionuclides were low, and trends were decreasing and consistent. The low concentrations, coupled with the consistent trends, indicated that, with the exception of sampling for hydrogen-3 at Plot M, the major monitoring objectives could be met through annual rather than quarterly sampling. It was found that eight groundwater monitoring wells could be plugged and abandoned without jeopardizing monitoring objectives. These wells were sealed and abandoned, in accordance with Illinois Environmental Protection Agency requirements, in 2015. Four wells were closed at Site A (BH41, BH51, BH52 and BH54). Four deep dolomite wells at Red Gate Woods were also closed (DH09, DH10, DH13, and DH17). The sampling frequency for the remaining wells at Site A and Red Gate Woods and including the two picnic wells and five ponds near Site A and Plot M, were reduced from quarterly to annual in 2015. The sampling program for Plot M was not changed in 2015 and remains on a quarterly schedule. The constituents of concern in groundwater and surface water continued to be limited to hydrogen-3 and strontium-90.

3.2 Structure of the Monitoring Program

The Site A/Plot M monitoring program follows the guidance for monitoring at DOE facilities.[40] Although Site A/Plot M is not an active DOE facility, the same monitoring principles are applicable. The monitoring program is designed to assess the concentration of hydrogen-3 and strontium-90 in groundwater near these sites, and to monitor hydrogen-3 in two of the former picnic wells in Red Gate Woods and several surface waters in the vicinity. This is accomplished by analyzing water samples collected from groundwater wells and surface water. Sampling locations are described in the following sections of this report. Samples collected, analyses performed, and the sampling frequency are shown in Table 3-1.

The samples were analyzed by the Argonne Radiological Protection Division Analytical Services Radiochemistry laboratories using DOE-approved methods. The detection limit for hydrogen-3 in water is 0.1 nCi/L. The detection limit for strontium-90 is 0.25 pCi/L in water. The uncertainties associated with individual concentrations for strontium-90 shown in the tables are the statistical counting errors at the 95% confidence level. Because of the amount of hydrogen-3 data presented in many of the tables, the uncertainty values are not included. In such cases, the following typical uncertainties apply:

Hydrogen-3 Concentration (nCi/L)	Uncertainty (% of Conc.)
0.1-1.0	40-5%
1-10	5-1%
> 10	1%

Table 3-1 Environmental Monitoring Program for Site A and Plot M

Location name	Frequency – Hydrogen-3	Frequency – Strontium-90
Site A – Groundwater from monitoring wells in glacial drift		
BH55	Annual	Annual
BH56	Annual	Annual
Site A region – surface water ponds		
Northwest Pond	Annual	NSR
Southeast Pond	Annual	NSR
Bull Frog Lake	Annual	NSR
Horse Collar Slough	Annual	NSR
Tomahawk Slough	Annual	NSR
Plot M - Groundwater from monitor wells in glacial drift		
BH02	Quarterly	Annual
BH03	Quarterly	Annual
BH04	Quarterly	Annual
BH06	Quarterly	Annual
BH09	Quarterly	Annual
BH10	Quarterly	Annual
BH11	Quarterly	Annual
BH26	Quarterly	Annual
BH35	Quarterly	Annual
Red Gate Woods – Groundwater from monitor wells in dolomite		
DH03	Annual	NSR
DH04	Annual	NSR
DH11	Annual	NSR
DH12	Annual	NSR
DH14	Annual	NSR
DH15	Annual	NSR
Red Gate Woods - Groundwater from former picnic wells in dolomite		
5159	Annual	NSR
5160	Annual	NSR
Plot M - Surface Water		
Location 1	Quarterly	NSR
Location 6	Quarterly	NSR
Location 7	Quarterly	NSR
Location 8	Quarterly	NSR

NSR = No Sample Required

4.0 RESULTS OF THE MONITORING PROGRAM

Unless otherwise noted in the appropriate table, during CY2022, all planned samples were collected. Results of the environmental surveillance program conducted during CY2022 are presented in the following sections of this report.

4.1 Plot M Surface Water

Surface water samples were attempted to be collected quarterly from four sampling locations along the two streams that flow around Plot M, shown in Figure 4.1. Location 1 is upstream of the Plot M area. Location 6 is immediately north and downstream of Plot M, with Locations 7 and 8 slightly further north. No water was present in the stream beds during the third and fourth quarters of CY2022, thus no surface water samples were collected from these locations. During the 2017 DOE-LM site visit, it was decided that because the stream flow is intermittent, the Location 6 sample would only be collected when flowing water is present. During the four quarters of CY2022, attempts were made to collect stream samples from Plot M after significant precipitation events.

The stream samples were analyzed for hydrogen-3 and the results are shown in Table 4.1. The same concentration pattern in the water flowing around Plot M was observed this year as in the past. Concentrations were below the detection limit upstream of Plot M (Location 1); hydrogen-3 was the highest at Location 6 during the first quarter. The amount of hydrogen-3 at Location 6 in the February of CY2022 sample was 12.8 nCi/L.

Historically, Surface Water Location #6 was identified as a seep. Over time, erosion patterns in the shallow streambed near Location #6 created low spots for water to remain in-between precipitation events. Quarterly samples were then subsequently collected from these low spots. It was determined that the integrity of the seep be distinguished as flowing or non-flowing. In January 2017, a site visit to Plot M was performed after several days of below freezing conditions to verify flow at Surface Water Location #6 (seep #6). No ice/water mounding was observed along the slope wall in the vicinity of Location #6 (seep #6). Due to the lack of flow at the vicinity of the seep, it was determined to reclassify the location as Surface Water Location #6 and remove the seep designation.

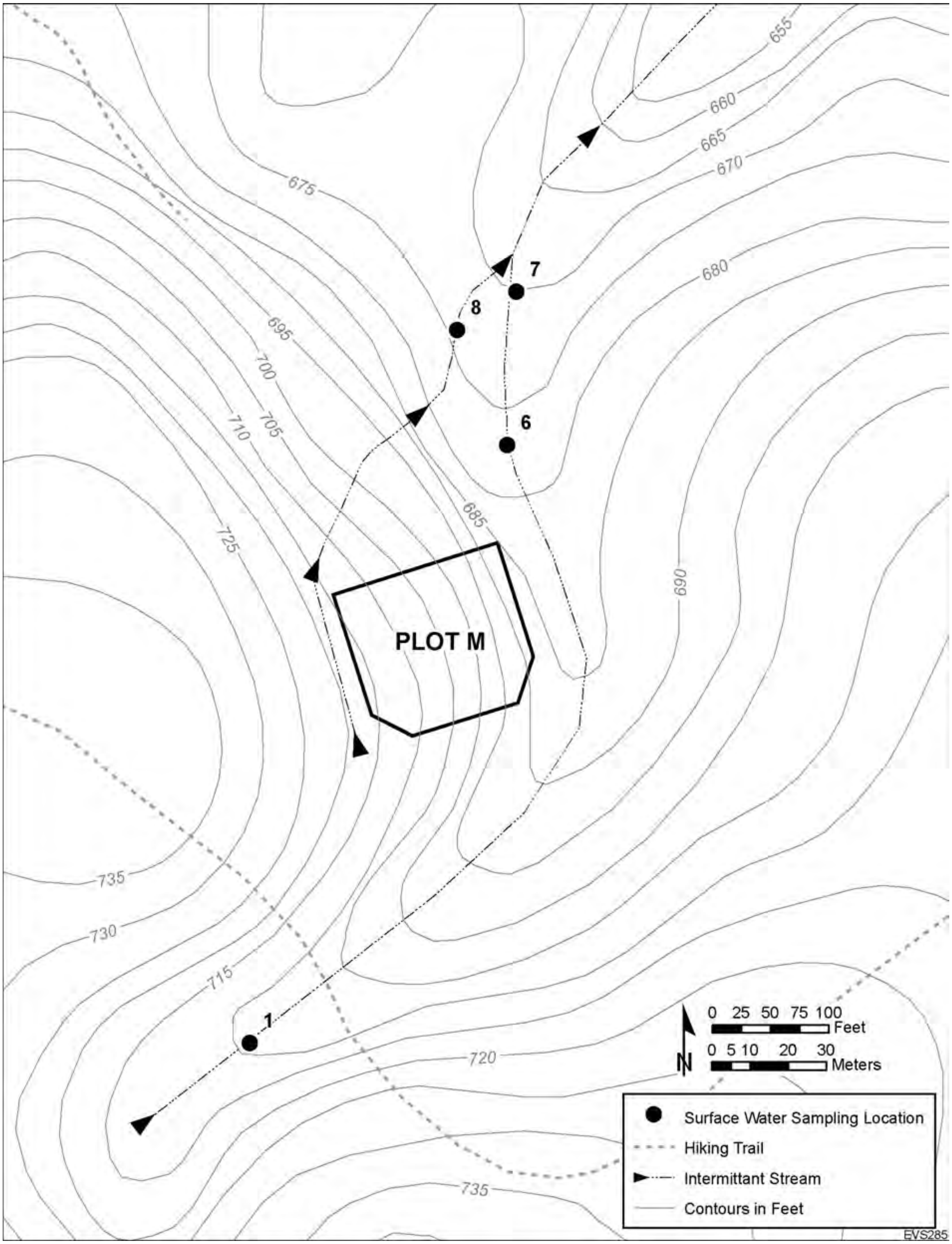

Figure 4-1 Stream Sampling Locations near Plot M

Table 4-1 Hydrogen-3 Content of Streams Next to Plot M, 2022

Location Number[1]	Date Collected (Concentrations in nCi/L)			
	February 22	May 3	August 16	November 2
1	< 0.1	< 0.1	DRY	DRY
6	12.8	4.0	DRY	DRY
7	0.7	4.4	DRY	DRY
8	0.2	0.6	DRY	DRY

[1] See Figure 4.1

Hydrogen-3 concentrations in the streams vary greatly, depending in part on the amount of precipitation prior to sample collection. Figure 4.2 illustrates how some of the previous years' samples from Locations 7 and 8 had higher than normal hydrogen-3 concentrations. In previous years, samples were collected during times of very low flow in the streams due to dry weather prior to the sampling event. The low flow conditions could have resulted in surface water with higher contribution of groundwater emanating from the Plot M area, resulting in higher-than-normal hydrogen-3 concentrations. This also allows for a more conservative risk assessment of human health and the environment.

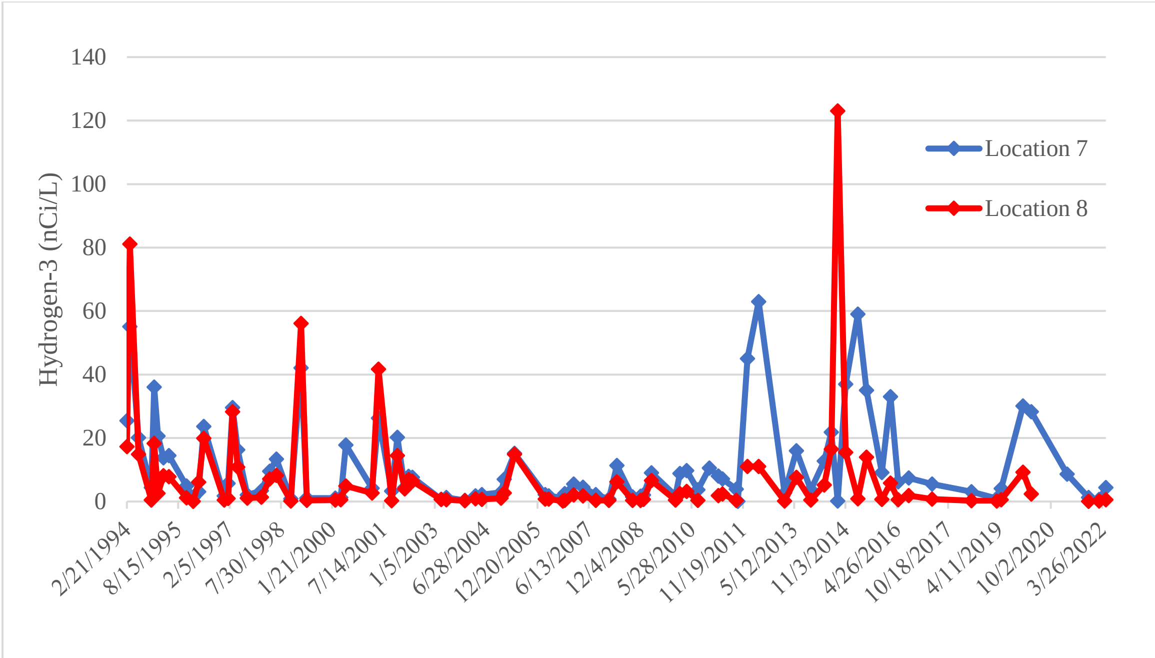

Figure 4-2 Hydrogen-3 in Plot M Streams Locations 7 and 8

One set of samples from five surface water bodies in the vicinity of Site A was collected in June of CY2022. These surface water bodies are the pond northwest of Site A, the pond southeast of Site A, Horse Collar Slough, Tomahawk Slough, and Bull Frog Lake. These locations are identified in Figure 2.2. The samples were analyzed for hydrogen-3 and the results are presented in Table 4.2. All the hydrogen-3 results were below the detection limit of 0.1 nCi/L.

Table 4-2 Hydrogen 3 Content of Site A Area Ponds, 2022

Location	June 7 (Concentrations in nCi/L)
NW Site A	< 0.1
SE Site A	< 0.1
Bull Frog Lake	< 0.1
Horse Collar Slough	< 0.1
Tomahawk Slough	< 0.1 (< 0.1)[1]

[1] Duplicate QC sample results are denoted in parentheses.

4.2 Plot M Groundwater

Nine boreholes screened within the glacial drift are present in and around Plot M (Figure 4.3). Two of these wells (BH09 and BH10) were drilled at a 45° angle to intercept groundwater under the waste. Water samples were collected in all nine wells and water level measurements were recorded quarterly in seven wells. The water levels for the angle wells were not measured. During the fourth quarter of CY2022, BH06 was dry. During the third and fourth quarters of CY2022, BH09 was dry, and in the fourth quarter, BH10 was dry.

All the water samples were analyzed for hydrogen-3; the results are shown in Table 4.3. Duplicate quality control sample results are shown in parentheses. The hydrogen-3 concentrations varied widely from well to well and, in some cases, from quarter to quarter. The hydrogen-3 concentrations follow similar trends over the past several years. Most of the results indicate that hydrogen-3 concentrations are slowly decreasing in these wells.

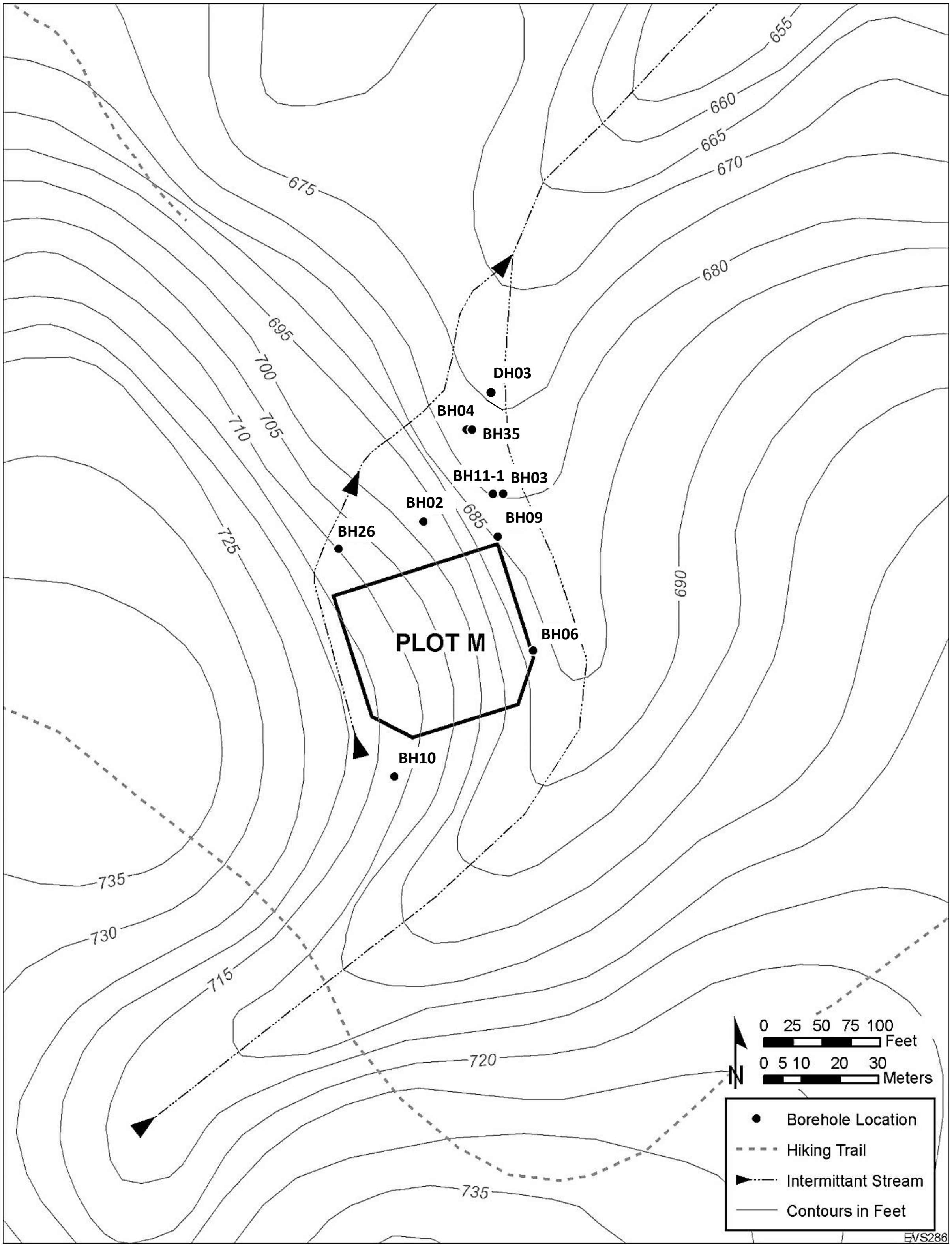

Figure 4-3 Map of Plot M Site

Table 4-3 Hydrogen-3 Content of Plot M Monitoring Well Water, 2022

Borehole Number	Well Depth (ft)	Date Collected (Concentrations in nCi/L)			
		March 15	June 9	September 14	December 8
BH02	39.41	3.0	2.9	3.3	17.9
BH03	40.00	72	38	52	70
BH04	36.05	256	219	248	265
BH06	40.30	297 (296)[1]	3,255	2,056	DRY
BH09[2]	40.00	205	388	DRY	DRY
BH10[2]	40.00	14.2	12.9	59 (59)[1]	DRY
BH11	39.30	49	48	50	50 (49)[1]
BH26	60.65	41	1.9	6.6	8.4
BH35	105.50	575	633	619	614

[1] Duplicate QC sample results are denoted in parentheses.

[2] Slant well drilled at 45º to a depth of 40 ft. below the surface.

The highest hydrogen-3 concentrations near Plot M during CY2022 were found in BH04, BH06, BH35, and the slant well BH09. Figure 4.4 shows the trend in hydrogen-3 concentrations in BH03 and BH04. Since 1989, there has been a steady decrease in hydrogen-3 concentration in these wells. Figure 4.5 shows the trend of hydrogen-3 concentrations in BH09, a slant well with the well screen located directly under Plot M. This well had very high levels of hydrogen-3 during the 1990s and have since significantly decreased since 1999.

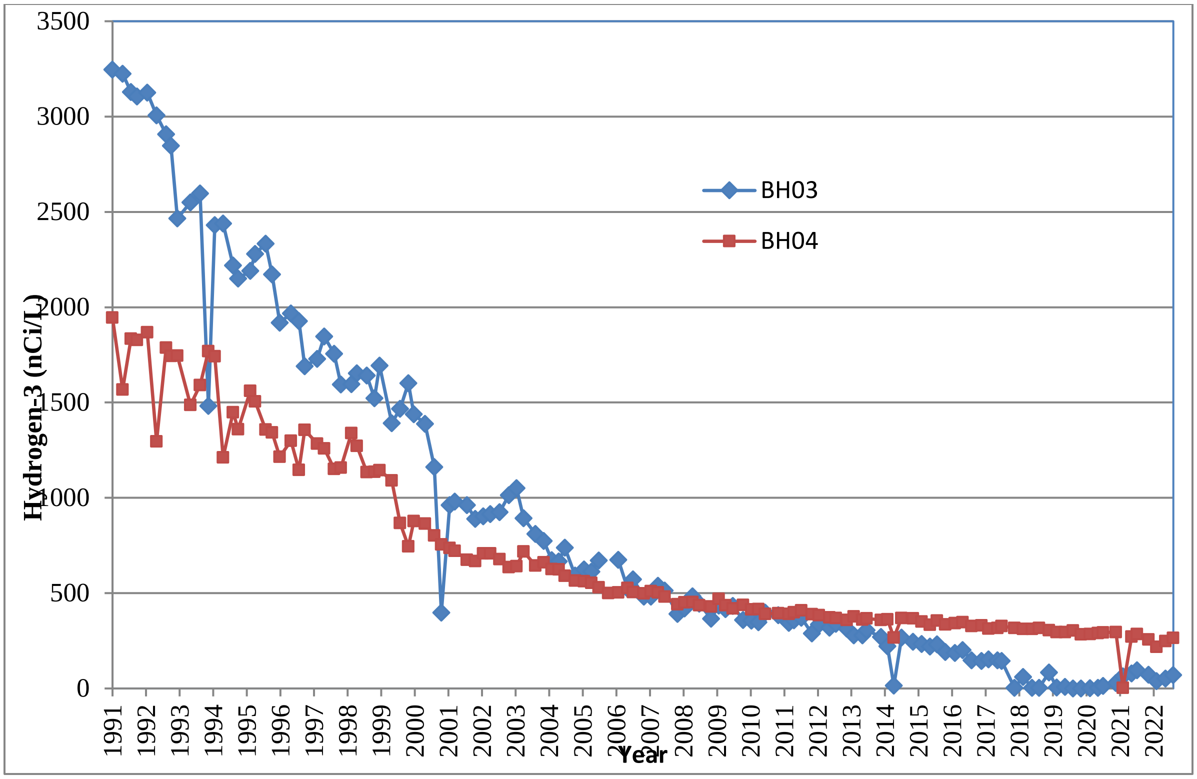

Figure 4-4 Hydrogen-3 in Plot M Wells BH03 and BH04

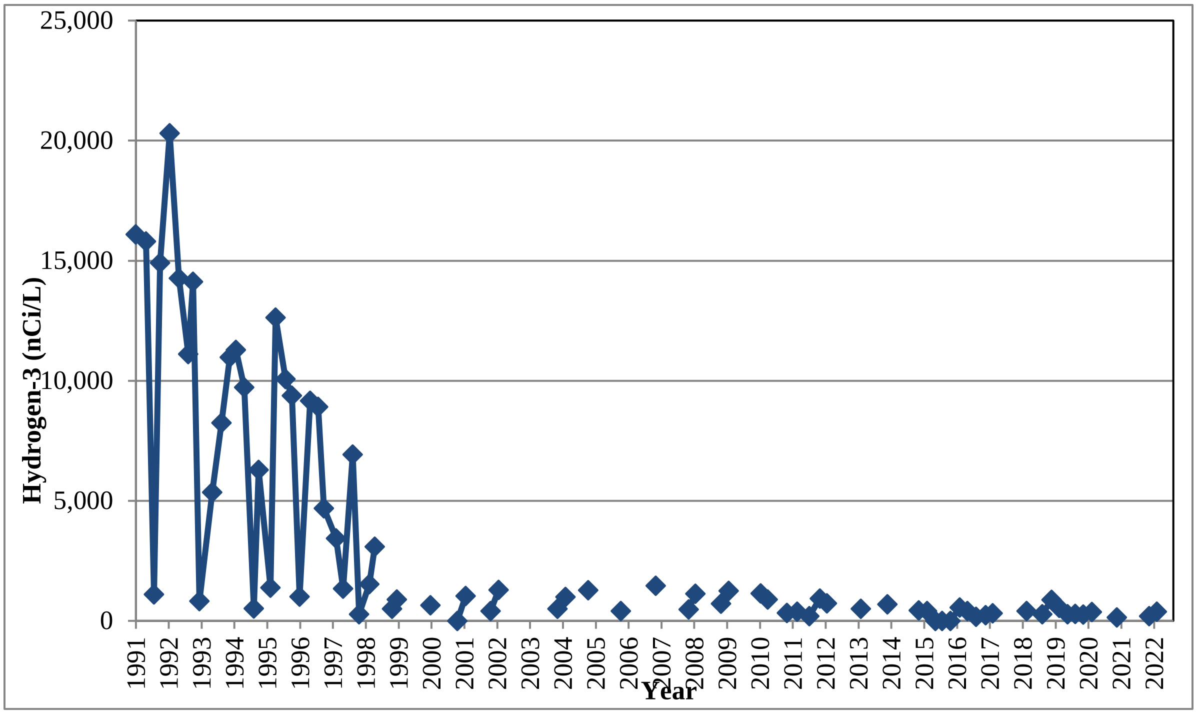

Figure 4-5 Hydrogen-3 in Plot M Well BH09

As shown in Table 4.3, Well BH06 contained high hydrogen-3 concentrations during three of the four quarters of CY2022, with the second quarter of CY2022 being the highest. In the fourth quarter of CY2022, BH06 was dry. The trend in hydrogen-3 concentrations in BH06 since CY1991 is shown in Figure 4.6, which also depicts groundwater elevations in this well. From CY1994 through the first half of CY2009, the hydrogen-3 concentrations ranged from 50 to 150 nCi/L. Since CY2009, the highest concentration of hydrogen-3 was seen in CY2019 at 5,693 nCi/L and the lowest in CY2012 at 488 nCi/L. In CY2022, the highest concentration was 3,255 nCi/L (June 2022). During this time period, groundwater elevations were found to have fluctuated more than during the period between 1994 and 2009. The changing groundwater elevations could be responsible for the recent increase in hydrogen-3 concentrations and the wide variability between sample results.

The hydrogen-3 concentrations in Well BH35, shown in Figure 4.7, have been steadily increasing since 2003. The cause of the increase is related to downward movement of the hydrogen-3 plume beneath Plot M to the northeast towards the Des Plaines River. Well BH35 is the deepest at 105 feet and is located downgradient of Plot M. A slight decrease in hydrogen-3 concentrations has occurred since CY2021.

Figure 4.8 shows hydrogen-3 concentrations in Well BH02 since 1991. The hydrogen-3 concentrations in this well remained at low levels during CY2022, as compared to 2012 and 2013, which had several samples with relatively high levels of hydrogen-3. This figure also shows the groundwater elevation in the well. Figure 4.8 indicates that the spikes in hydrogen-3 concentration that occurred in previous years happened during periods when the groundwater elevation was lower than normal. Lower groundwater elevations could change the way groundwater moves and interacts with contaminated soil under Plot M, causing the hydrogen-3 concentrations to vary widely.

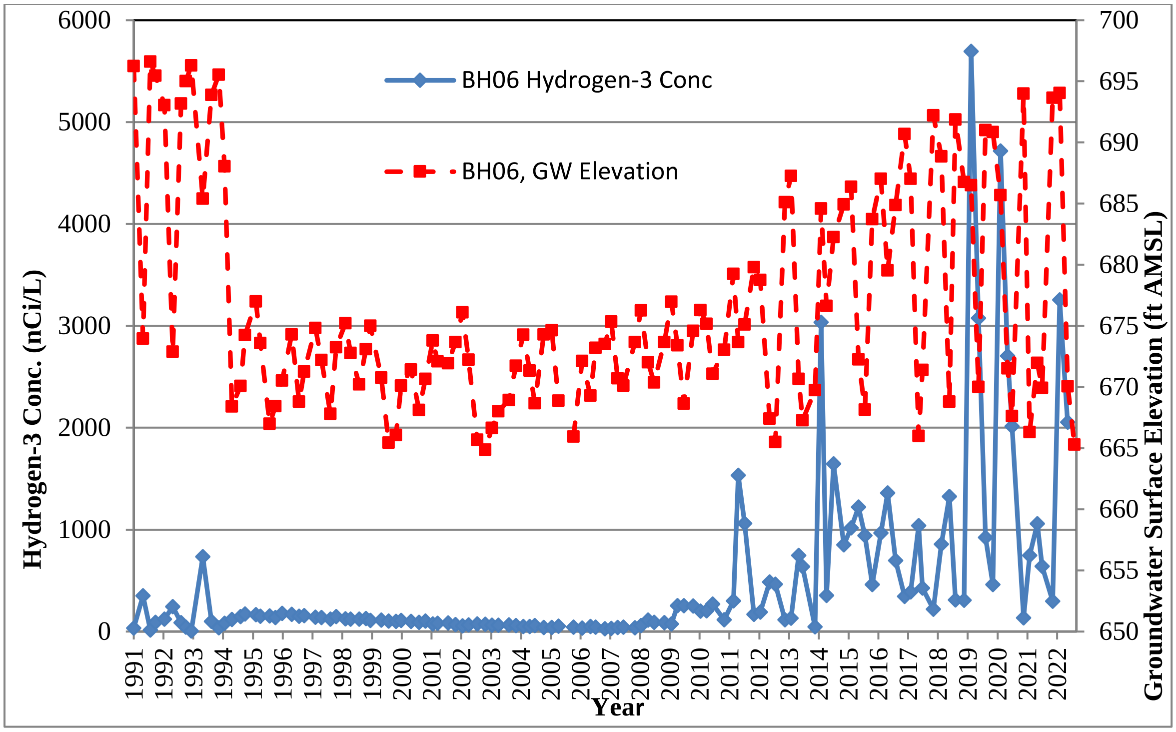

Figure 4-6 Hydrogen-3 and Groundwater Elevation in Well BH06

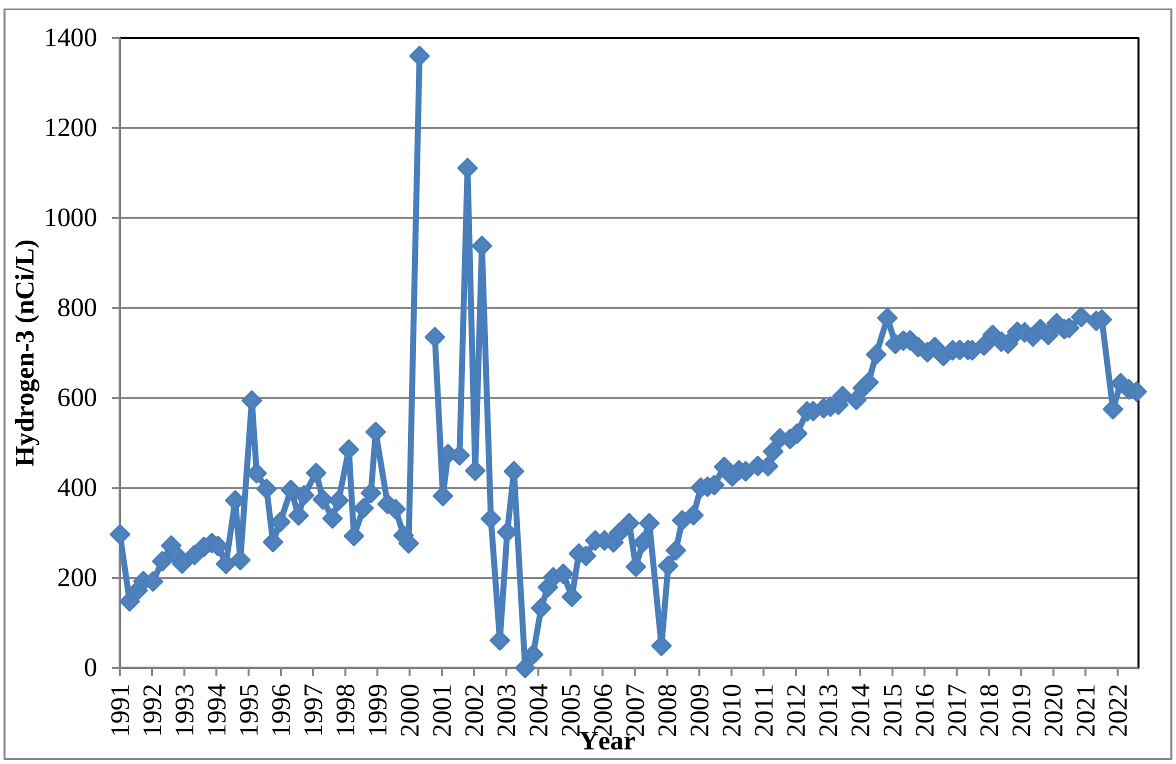

Figure 4-7 Hydrogen-3 in Well BH35

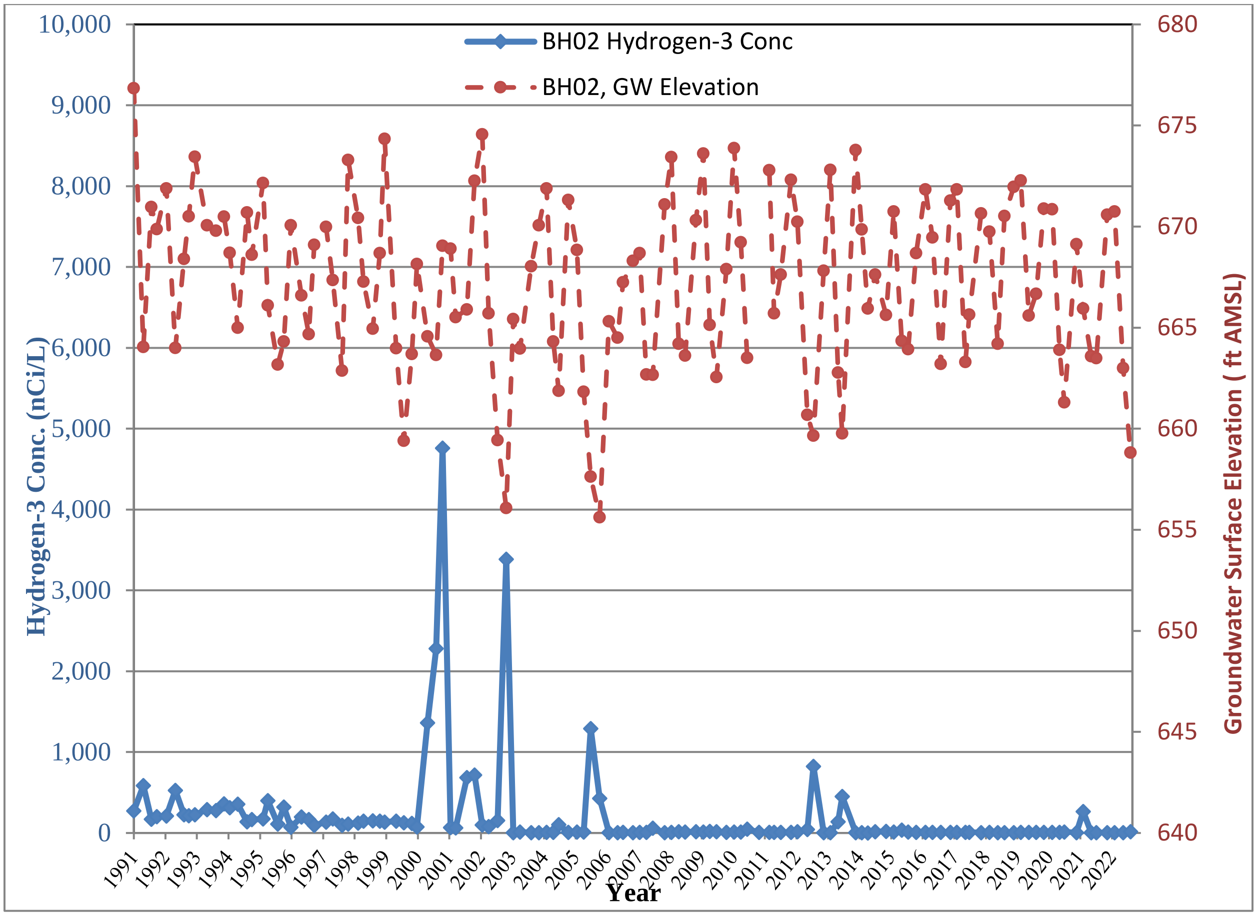

Figure 4-8 Hydrogen-3 and Groundwater Elevation in Well BH02

Groundwater samples from the Plot M monitoring wells were analyzed once for strontium-90 during CY2022. The results are shown in Table 4.4. Strontium-90 concentrations greater than the detection limit of 0.25 pCi/L were found in three (BH06, BH09, and BH11) of the nine wells sampled. The highest strontium-90 concentration in CY2022 was 4.50 pCi/L in water collected from BH09. Strontium-90 concentrations in BH06 were also elevated, at 1.88 pCi/L, in addition to BH11, at 1.12 pCi/L. Figure 4.9 illustrates the historical trend of strontium-90 results in BH06 and 11. BH09 strontium results cannot be illustrated due to the well frequently being dry. With a few exceptions, the amount of strontium-90 in BH11 is decreasing over time. Strontium-90 in BH06, which have been relatively consistent since 2010, have since been exhibiting an unpredictable behavior to date. All results were less than the State of Illinois Class 1 Ground Water Quality Standard of 8 pCi/L for strontium-90.

Table 4-4 Strontium-90 Content of Monitoring Well Water Samples Near Plot M, 2022

Well Number[1]	Well Depth (ft.)	June 9 (Concentrations in pCi/L)
BH02	39.41	<0.25
BH03	40.00	<0.25
BH04	36.05	<0.25[3]
BH06	40.30	1.88 ± 0.154
BH09[2]	40.00	4.50 ± 0.358
BH10[2]	40.00	<0.25[4]
BH11	39.30	1.12 ± 0.096
BH26	60.65	<0.25
BH35	105.50	<0.25

[1] See Figure 4.2 for map of Plot M site

[2] BH09 and BH10 are slant wells drilled at 45° to a depth of 40 ft. below the surface.

[3] BH04 was analyzed each quarter for Sr-90 and Cs-137 as part of the intercomparison program with the IEMA laboratory. All samples collected during 2022 were <0.25 pCi/L.

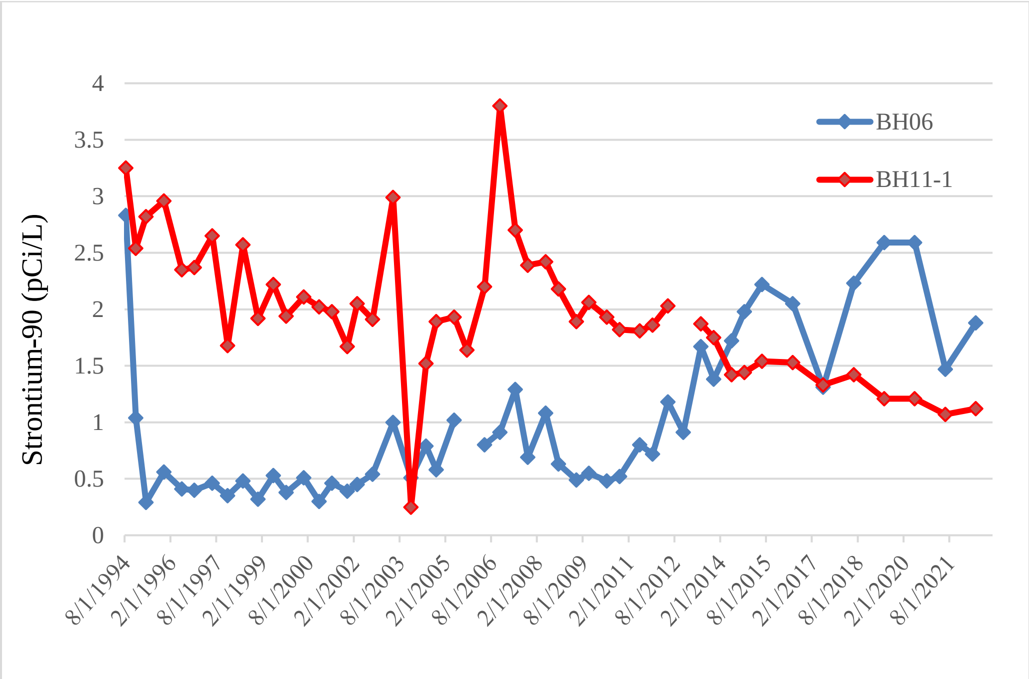

Figure 4-9 Strontium-90 in Plot M Wells BH06 and BH11

The depth-to-groundwater and groundwater elevations in the vertical wells at Plot M are shown in Table 4.5. Groundwater elevations measured during CY2022 in most of the shallow wells were consistent with typical groundwater elevations in these wells. Groundwater elevations for the two slant wells are not included in this table. Due to the difference in the screen depth of these wells, data cannot be used to develop potentiometric surface maps of the Plot M area. The differing well depths, in addition to the groundwater elevation differences between nearby wells, indicate that a hydraulic connection between the wells cannot be assumed. In general, Plot M groundwater flows downward and downgradient to the northeast, toward the Des Plaines River.

Table 4-5 Water Level Measurements in Monitoring Wells Near Plot M, 2022

			Date Measured							
			March 15		June 9		September 14		December 8	
Well Number[1]	Depth (ft.)	Top of Casing Elevation (ft AMSL)[2]	Depth to water (ft.)	Water Surface Elevation (ft AMSL)	Depth to water (ft.)	Water Surface Elevation (ft AMSL)	Depth to water (ft.)	Water Surface Elevation (ft AMSL)	Depth to water (ft.)	Water Surface Elevation (ft AMSL)
BH2	39.41	692.70	22.12	670.58	21.96	670.74	29.70	663.00	33.88	658.82
BH3	40.00	693.30	31.72	661.58	31.18	662.12	34.16	659.14	37.64	655.66
BH4	36.05	682.20	17.35	664.85	16.97	665.23	21.97	660.23	26.66	655.54
BH6	40.30	704.90	11.25	693.65	10.86	694.04	34.85	670.05	39.60	665.30
BH11	39.30	693.00	20.73	672.27	19.54	673.46	29.16	663.84	33.45	659.55
BH26	60.65	692.30	48.60	643.70	47.81	644.49	47.48	644.82	50.37	641.93
BH35	105.5	682.40	93.30	589.10	92.94	589.46	94.72	587.68	93.69	588.71

[1] Water depth for wells 09 and 10 are not shown since these are slant wells.

[2] From 1994 IT Study report. AMSL = Above Mean Sea Level.

4.3 Site A Groundwater

The locations of the two Site A monitoring wells are shown in Figure 4.10. Hydrogen-3 monitoring results are shown in Table 4.6. The results of duplicate QC samples are shown in parentheses. The results found in water from wells BH55 and BH56 are most likely originating from the buried CP-3 biological shield. The hydrogen-3 concentrations at Site A are several orders of magnitude lower than those found at Plot M and are trending downward. Figure 4.11 shows the decreasing hydrogen-3 concentrations in these two wells. Figure 4.12 shows the decreasing strontium-90 concentrations in these two wells. The results of the strontium-90 analyses are shown in Table 4.7. Groundwater levels were measured in these monitoring wells, and the values appear in Table 4.8.

Table 4-6 Hydrogen-3 Content of Monitoring Well Water Samples Near Site A, 2022

Well Number	Depth (ft.)	June 10 (Concentrations in nCi/L)
BH55	87.20	0.68
BH56	102.40	0.70 (0.78)[1]

[1] Duplicate QC sample results are denoted in parentheses.

Table 4-7 Strontium-90 Content of Monitoring Well Water Samples Near Site A, 2022

Borehole Number	Depth (ft.)	June 10 (Concentrations in pCi/L)
BH55	87.20	0.70 ± 0.077
BH56	102.40	0.86 ± 0.093 (0.72 ± 0.072)[1]

[1] Duplicate QC sample results are denoted in parentheses.

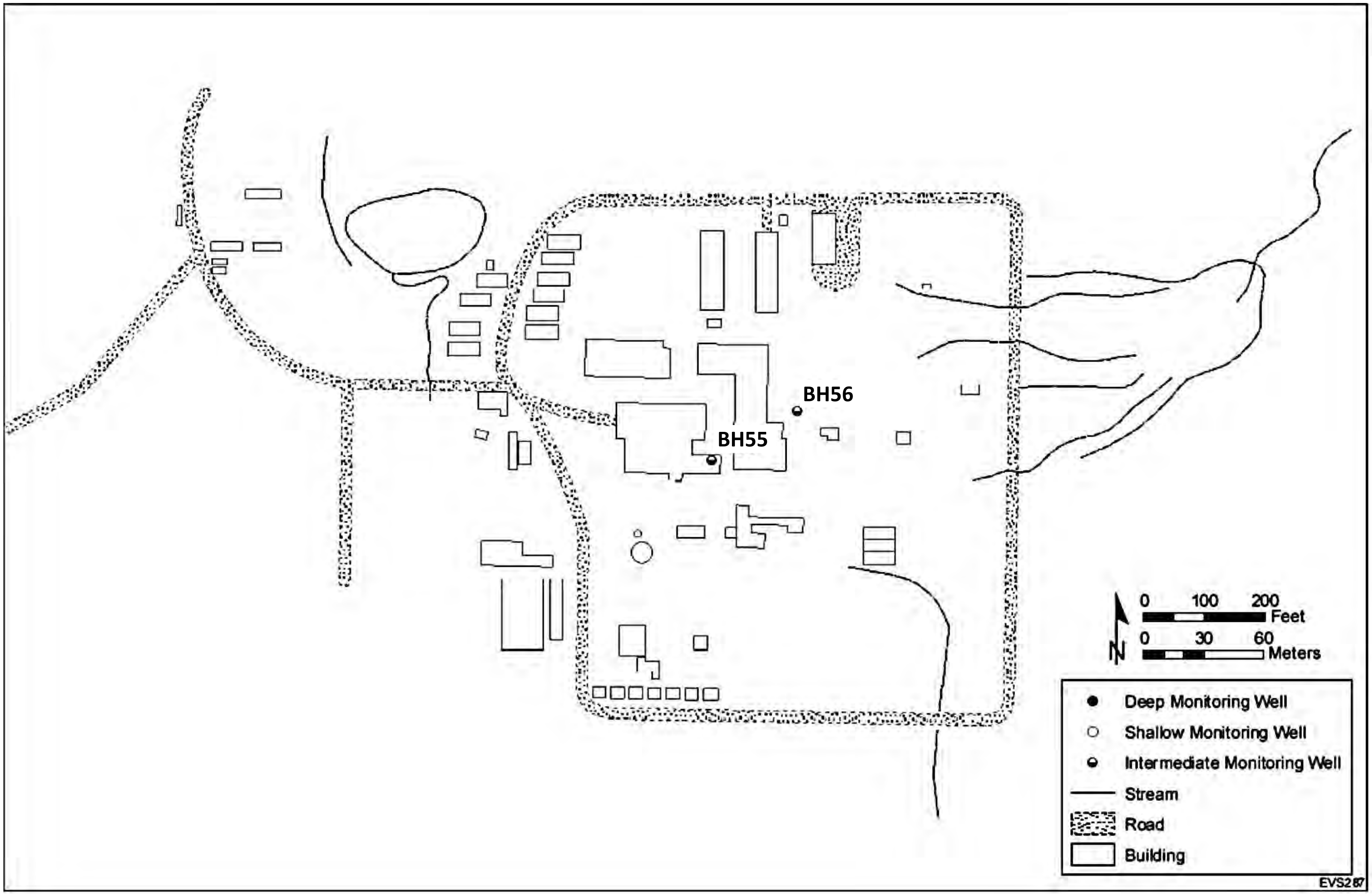

Figure 4-10 Monitoring Wells at Site A

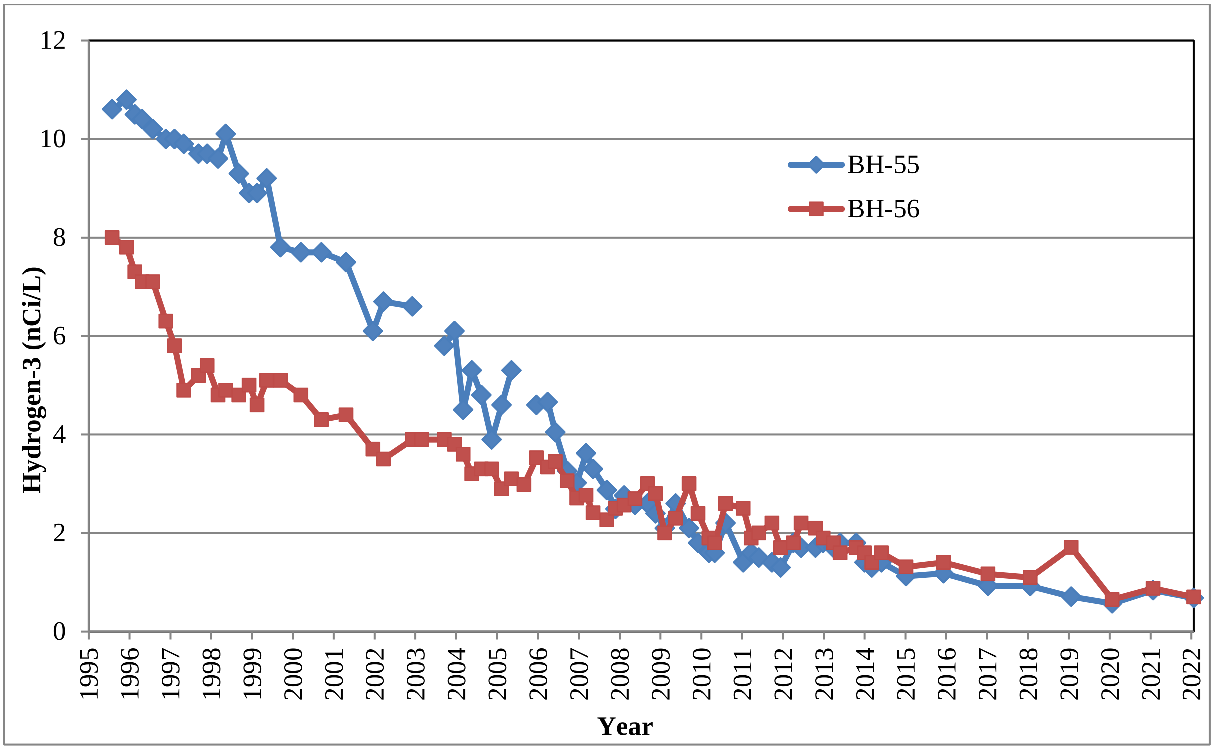

Figure 4-11 Hydrogen-3 in Site A Wells BH55 and BH56

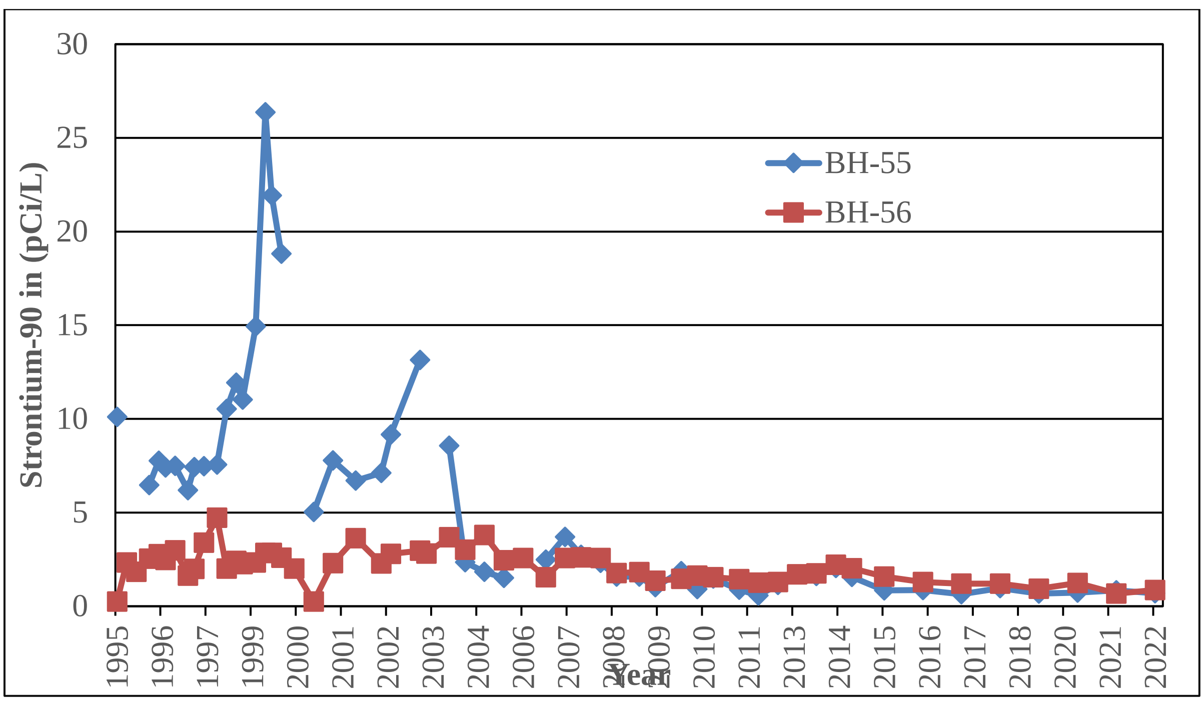

Figure 4-12 Strontium-90 in Site A Wells BH55 and BH56

Table 4-8 Water Level Measurements in Monitoring Wells Near Site A, 2022

Well Number	Depth to Bottom (ft.)	Top of Casing Elevation (ft AMSL)[1]	June 10	
			Depth to water (ft.)	Water Surface Elevation (ft AMSL)[1]
BH55	87.2	743.78	75.27	668.51
BH56	102.4	742.23	88.65	653.58

[1] From 1996 Advanced Surveying and Mapping topo map.
AMSL = Above Mean Sea Level.

4.4 Dolomite Well Water

Six wells cased into the dolomite bedrock were sampled once in CY2022 to monitor the movement of hydrogen-3 within this aquifer located downgradient of Plot M. One of the dolomite wells (DH03) is located near Plot M, and five dolomite wells that are located north of Plot M in the Red Gate Woods area are shown in Figure 4.12. All samples were analyzed for hydrogen-3. The results are shown in Table 4.9. All the dolomite wells exhibited low but measurable hydrogen-3 concentrations, and all the results are consistent with concentrations measured in the past. The well with the consistently highest hydrogen-3 results is DH15. Figure 4.13 shows the hydrogen-3 concentrations in DH15 since 1990. The hydrogen-3 results have been relatively stable in this well since 1998. All the dolomite well samples were below the State of Illinois Class 1 Groundwater Quality Standard of 20 nCi/L. The presence of hydrogen-3 in these wells is explained by the 1988 USGS investigation[41], which indicated a hydrogen-3 plume underlies the stream which flows from Plot M and passes to the northeast of these wells. The plume has spread downward and downgradient, resulting in small amounts of hydrogen-3 in the dolomite aquifer in this area.

Other dolomite wells, DH03 and DH04, are located close to and downgradient of Plot M. The CY2022 hydrogen-3 result for DH03 was 0.61 nCi/L, and 0.83 nCi/L for DH04 which are slightly lower than previous samples. The hydrogen-3 concentration in all dolomite wells were below 2.0 nCi/L. Previous analyses of soil core samples[42] indicated the presence of hydrogen-3 as deep as the drift-dolomite interface in the vicinity of these wells.

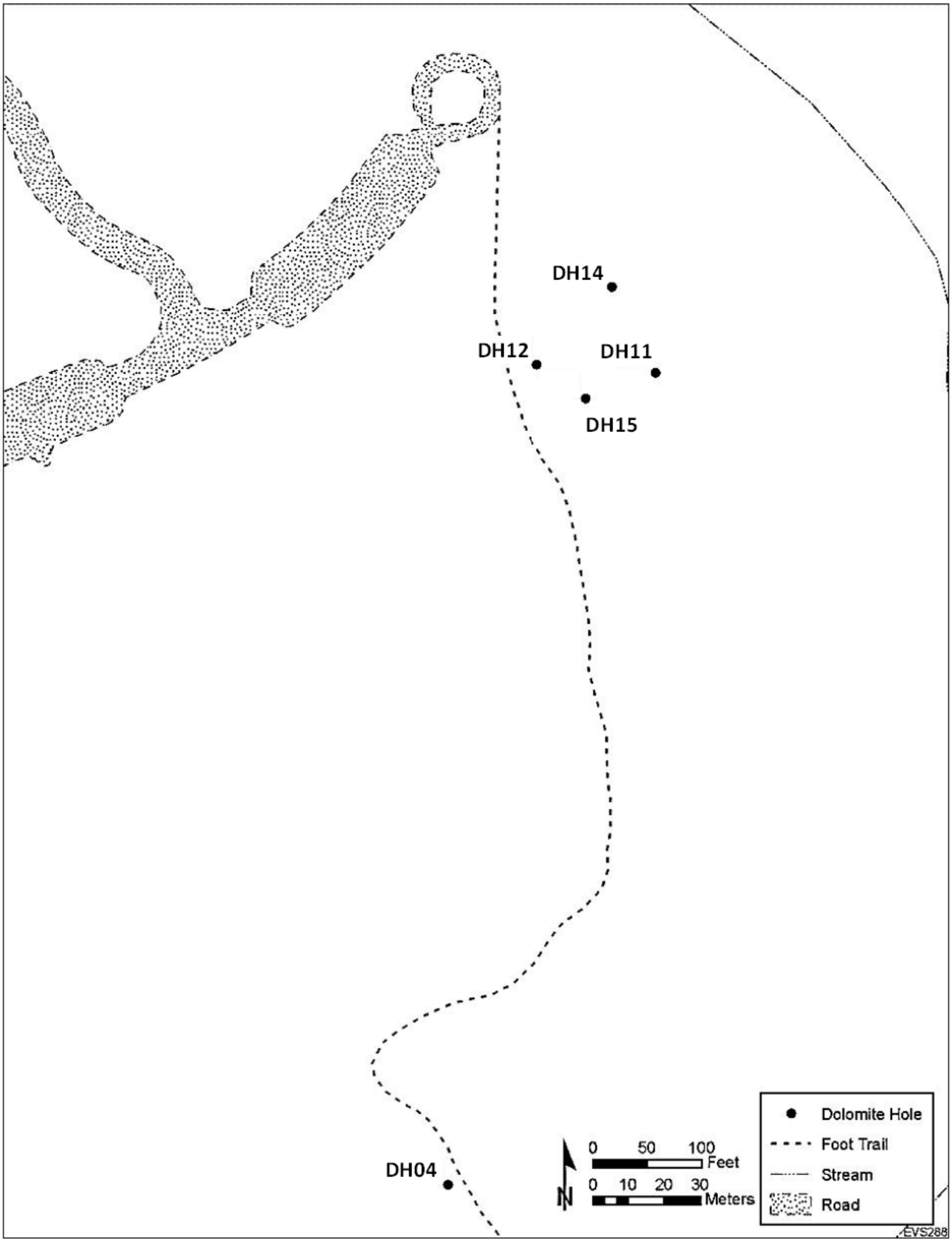

Figure 4-13 Locations of Dolomite Wells North of Plot M

Table 4-9 Hydrogen-3 Content of Dolomite Well Water, 2022

Dolomite Well Number	June 10 (Concentrations in nCi/L)
DH03	0.61
DH04	0.83
DH11	0.51
DH12	0.40
DH14	0.34
DH15	1.94 (1.93)[1]

[1] Duplicate QC sample results are denoted in parentheses.

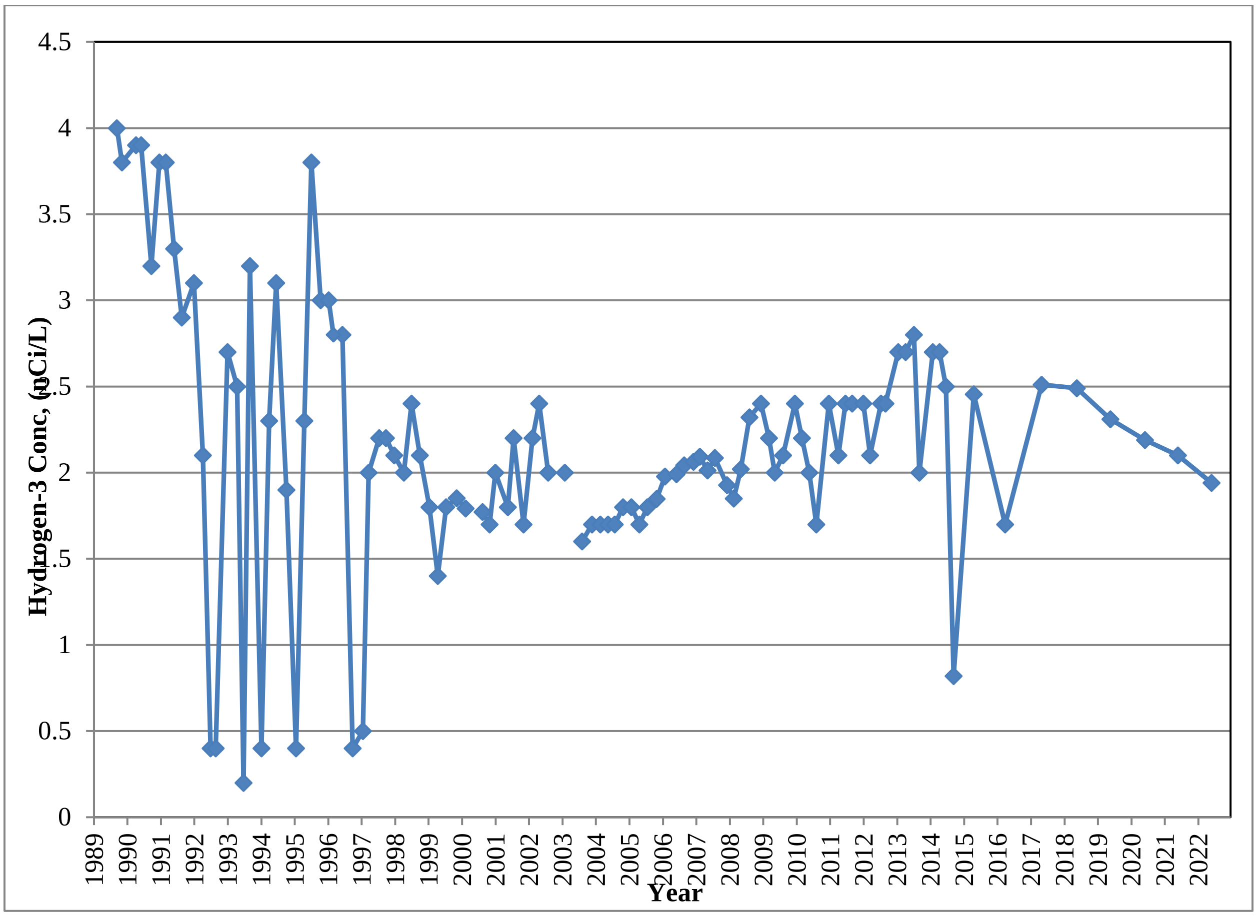

Figure 4-14 Hydrogen-3 Concentrations in Dolomite Well DH15

Water levels were measured in the dolomite wells, as shown in Table 4.10. Since these wells are installed in the dolomite aquifer, which is much deeper and not affected as much by recent weather, the groundwater elevations showed less seasonal variation than what was observed in the shallow glacial till wells. The groundwater elevations were consistent with historical measurements in these wells.

Since the four dolomite wells (DH11, DH12, DH14, and DH15) in this area are located very close to one another, it is not possible to use groundwater elevation information to develop groundwater elevation contour maps. However, the relative elevation of the groundwater surface in the wells indicates that the groundwater is moving towards the nearby canal/river system, as described in the 1994 IT report[42], which concluded that groundwater in this area is moving towards the Des Plaines River Valley.

4.5 Former Picnic Wells

Sampling was conducted once during CY2022 at two former forest preserve picnic wells (#5160 and #5159) located north of Plot M, as shown in Figure 2.2. The Red Gate Woods North Well (#5160) was disabled in 1999 by removing the pump handle, due to high fecal coliform bacteria levels. The well opposite Red Gate Woods (#5159) is located within an undeveloped area of the forest preserve, south of Red Gate Woods parking area and north of Archer Avenue and is unusable as a water source since the pump handle has also been removed. Samples were collected in the second quarter of CY2022 from Picnic wells #5160 and #5159 and were analyzed for hydrogen-3, with the results listed in Table 4.11. The maximum and average hydrogen-3 concentrations since 1996 for wells #5160 and #5159 are presented in Table 4.12. The change in hydrogen-3 concentrations in these wells since 1992 is shown in Figure 4.14.

In previous sampling events, the hydrogen-3 concentration in well #5160 was similar to the concentrations observed since 2008. For unknown reasons, the hydrogen-3 levels in this well increased between 2010 and 2013, after experiencing a significant decrease in 2009. The CY2022 sample collected from well #5159 contained a concentration of hydrogen-3 similar to the previous three years. The concentrations of hydrogen-3 in these picnic wells are below the State of Illinois Primary Drinking Water Standard of 20 nCi/L.

Table 4-10 Water Level Measurements in Dolomite Wells, 2022

Well Number	Ground Surface Elevation (ft. AMSL)	Top of Casing Elevation (ft. AMSL)[1]	June 10	
			Depth to water (ft.)	Water Surface Elevation (ft. AMSL)
DH03	678.10	679.50	96.42	583.08
DH04	673.80	674.60	92.84	581.76
DH11	655.36	656.90	75.70	581.20
DH12	650.34	651.60	76.79	574.81
DH14	651.43	653.20	71.71	581.49
DH15	659.14	660.80	79.34	581.46

[1] From 1994 IT Study report. AMSL = Above Mean Sea Level.

Table 4-11 Hydrogen-3 Content of Former Picnic Wells Near Site A/Plot M, 2022

Date Collected	June 8 (Concentrations in nCi/L)
Opposite Red Gate #5159	0.28
Red Gate North #5160	0.78

[1]

Table 4-12 Hydrogen-3 Concentrations in the Red Gate Woods Wells

	Red Gate Woods North (#5160)		Opposite Red Gate Woods (#5159)	
Year	Maximum (nCi/L)	Annual Average (nCi/L)	Maximum (nCi/L)	Annual Average (nCi/L)
1996	2.19	1.56	0.55	0.33
1997	1.26	1.00	1.13	0.35
1998	1.23	1.03	0.72	0.47
1999	1.22	1.07	2.14	0.45
2000	1.54	1.33	2.20	0.70
2001	1.59	1.49	0.27	0.16
2002	1.47	1.04	3.17	0.45
2003	1.78	1.06	1.49	0.43
2004	1.08	1.00	0.34	0.17
2005	1.01	0.95	0.34	0.19
2006	1.14	1.06	2.63	1.11
2007	1.45	1.28	0.66	0.33
2008	1.24	0.33	0.32	0.26
2009	0.13	0.10	0.50	0.33
2010	0.28	0.19	0.51	0.34
2011	0.91	0.67	3.60	1.10
2012	2.10	1.60	0.74	0.34
2013	2.24	2.14	0.75	0.35
2014	2.02	1.96	0.55	0.37
2015	1.92	-[a]	0.51	-
2016	1.71	-	1.16	-
2017	1.28	-	0.70	-
2018	1.33	-	0.48	-
2019	0.80	-	0.20	-
2020	NS[b]	-	0.31	-
2021	0.80	-	0.20	-
2022	0.78	-	0.28	-

[a] Annual sampling frequency started in 2015.

[b] NS-No sample; well not operational.

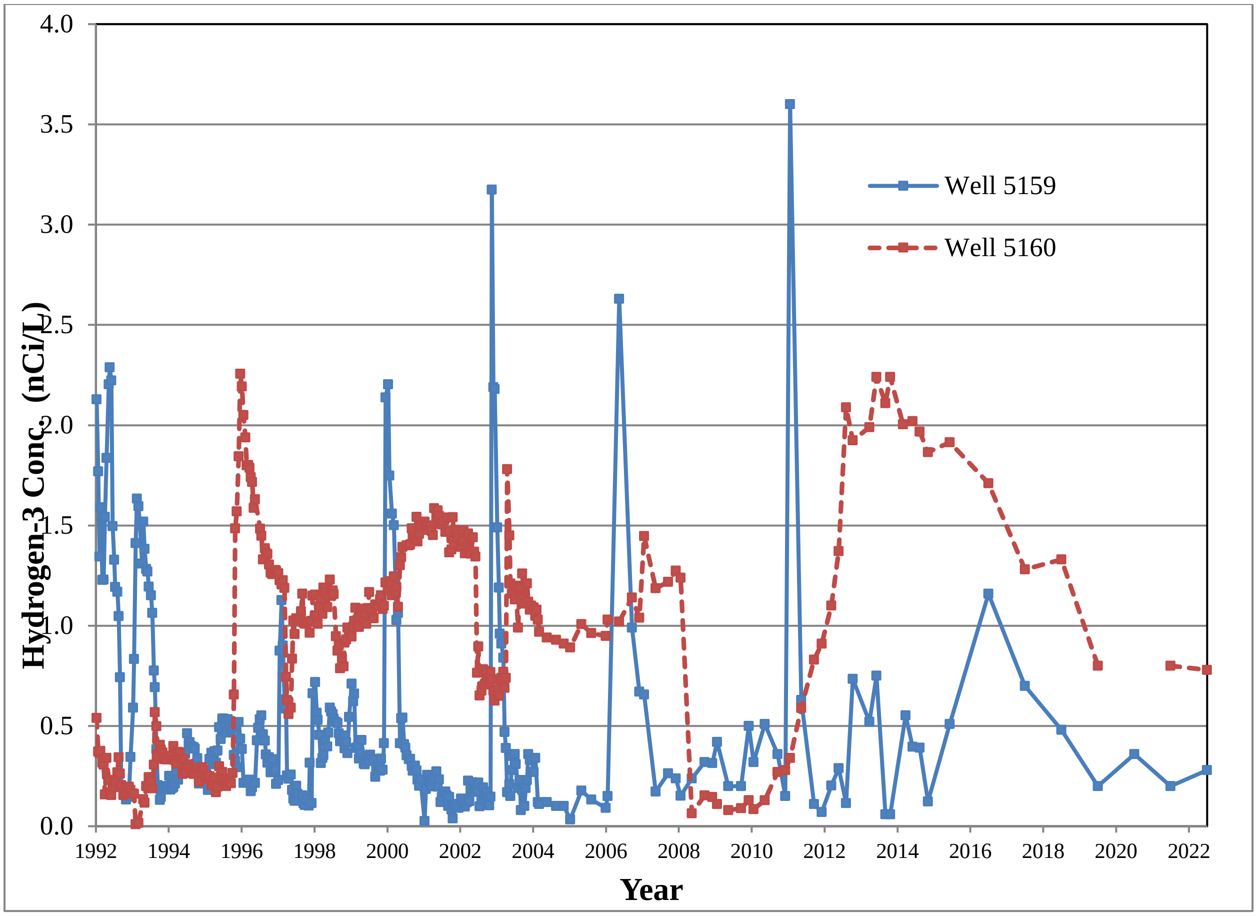

Figure 4-15 Hydrogen-3 in Former Picnic Wells from 1992 through 2022

5.0 SUMMARY OF POTENTIAL RADIATION DOSE AND RISK ESTIMATES

5.1 Dose Estimates

Since there is no human consumption of water from surface water or wells, the radioactive material present in this area does not represent a health risk to the public. However, to evaluate the theoretical risk to health from residual contamination if this water were to be consumed by an individual, the potential radiation dose to a hypothetical individual was estimated using methodology prescribed in DOE Order O 458.1.[43] The committed effective dose equivalent from consumption of water was estimated by calculating the total quantity of hydrogen-3 potentially ingested. Taking a very conservative approach, it was assumed the hypothetical individual drank only surface water containing hydrogen-3 at the maximum levels found at Plot M (Stream Location 6) during CY2022. The concentration of hydrogen-3 was multiplied by the general public water ingestion rate of 730 L/y.[44] This annual intake was then multiplied by the 50-year Committed Effective Dose Equivalent (CEDE) factor.[45] The CEDE for hydrogen-3 in water is 7.2×10^{-5} rem/µCi (based on the derived concentration standard of 1.9×10^{-3} µCi/mL). The worst-case annual dose based on the CY2022 maximum concentration of 12.8 nCi/L was determined to be 0.673 mrem/y. A similar dose calculation was made for the former Red Gate Woods North picnic well (#5160), assuming this was the sole source of water consumed. For this well, based on the CY2022 maximum concentration of 0.78 nCi/L, the estimated dose was 0.041 mrem/y. These estimated doses are shown in Table 5.1. The DOE dose limit for the public is 100 mrem/y, so even under a highly conservative scenario, the potential dose is far below DOE limits.

A more realistic estimation was made based upon the scenario of an occasional visitor to the Plot M area. The doses from this potential exposure were estimated by assuming a visitor drinks one liter of water from Stream Location 6 and one liter of water from the Red Gate Woods North (#5160) picnic well, combining the two doses. The results are shown in Table 5.2. The total maximum estimated dose was 0.00098 mrem per visit. To put the doses into perspective with other types of radiation exposure, comparisons can be made to annual average doses received by the public from natural or other generally accepted sources of radiation.[46] These are listed in Table 5.3. It is obvious that the magnitude of the doses potentially received near Plot M from radioactive substances are insignificant compared to other common sources.

5.2 Risk Estimates

The potential for possible negative health effects from radiation doses received from Plot M were estimated, to gain another perspective on interpreting the effects of radiation. Estimates for carcinogenic risk, the risk of contracting cancer from these exposures, are included in Table 5.1 and Table 5.2. Based on the BIER V report,[47] a dose of one mrem/y equates to an increased cancer risk of 7 x 10^{-7}. This conversion ratio is used to estimate incremental risk of contracting cancer from radiation exposure. For example, a carcinogenic risk of 10^{-7} would mean, on average, one additional person out of 10,000,000 contracts cancer assuming all individuals are under the assumed exposure conditions. The EPA environmental protection standards are based upon an acceptable risk between 10^{-4} and 10^{-6}. Table 5.1 indicates that under a very conservative assumption of ingestion of only Plot M surface water containing hydrogen-3 at the maximum concentration of 12.8 nCi/L, the estimated maximum carcinogenic risk is 4.71 x 10^{-7}, which is consistent with EPA standards. Table 5.2 shows that the hypothetical total maximum dose of 0.00098 mrem/visit to an occasional visitor would result in an increased maximum carcinogenic risk of about 6.84 x 10^{-10}. The incremental risk from exposure to radionuclides at Plot M can be compared to the risk associated with various life events. Examples are shown in Table 5.4. The risk from naturally occurring sources of radioactivity listed in Table 5.3 is estimated to bring about one additional individual that contracts cancer in a population of 4,600. The incremental risk from residual contamination at Site A/Plot M, under even the most conservative assumptions, is low. The monitoring program results have demonstrated that the impact of radioactivity at Site A/Plot M is very low and does not endanger the health of those living in the area or visiting the site.

Table 5-1 Hypothetical Dose from Exposure to Hydrogen-3, 2022

Assumed Source	Maximum Conc. (nCi/L)	Maximum Dose[1] (mrem/y)	Maximum Carcinogenic Risk
Surface Water			
Plot M Location 6	12.8	0.673	4.71×10^{-7}
Well Water			
Red Gate Woods North (#5160)	0.78	0.041	2.87×10^{-8}

[1] DOE Dose limit is 100 mrem/year

Table 5-2 Hypothetical Dose Hydrogen-3 Exposures to a Casual Visitor, 2022

Pathway	Maximum Dose [1] (mrem/visit)	Maximum Carcinogenic Risk
Surface Water		
Plot M Location 6	0.0009	6.45×10^{-10}
Well Water		
Red Gate Woods North (#5160)	0.00006	3.93×10^{-11}
Total	0.00098	6.84×10^{-10}

[1] DOE Dose limit is 100 mrem/year

Table 5-3 Annual Average Dose Equivalent in the U. S. Population

Sources[1]	Dose (mrem)
Natural Sources	
Radon	228
Internal (^{40}K and ^{226}Ra)	29
Cosmic	33
Terrestrial	21
Medical	
Computed Tomography	147
Nuclear Medicine	77
Interventional Fluoroscopy	43
Conventional Radiography & Fluoroscopy	33
Consumer (All Sources)	13
Building Materials	
Commercial Air Travel	
Cigarette Smoking	
Mining and Agricultural	
Combustion of Fossil Fuels	
Highway and Road Construction Materials	
Glass and Ceramics	
Industrial (All Sources)	0.3
Nuclear-power Generation	
DOE Installations	
Decommissioning and Radioactive Waste	
Industrial, Medical, Educational, and Research Activities	
Contact with Nuclear-medicine Patients	
Security Inspection Systems	
Occupational (All Sources)	0.5
Medical	
Aviation	
Commercial Nuclear Power	
Industrial and Commercial	
Education and Research	
Government, DOE, and Military	
Total	**624**

[1]NCRP report No. 160.[48]

Table 5-4 Annual Risk of Death from Various Events

Cause	Risk
Earthquake	1.03×10^{-7}
Flood	1.12×10^{-7}
Storm	3.70×10^{-7}
Firearms	1.2×10^{-6}
Motorcycle	1.6×10^{-5}
Walking	2.4×10^{-5}
Driving	2.07×10^{-5}
Drug Poisoning	2.5×10^{-4}

Source: Insurance Information Institute, CDC, 2020

6.0 QUALITY ASSURANCE PROGRAM

The radiological instrumentation used in this program is calibrated with standardized sources obtained from or traceable to the U. S. National Institute of Standards and Technology (NIST). Calibration of the instrumentation is verified by using secondary counting standards prior to the analysis of the samples. Approximately 10% of the samples are analyzed in duplicate or with the addition of known amounts of a radionuclide to check precision and accuracy.

Argonne participates in the DOE Mixed-Analyte Performance Evaluation Program (MAPEP). The MAPEP is administered by the DOE Radiological and Environmental Sciences Laboratory (RESL), located in Idaho Falls, Idaho. RESL provides an unbiased technical component to DOE oversight of contractor operations at DOE facilities and sites. RESL conducts cost-effective measurement quality assurance programs that help assure that key DOE missions are completed in a safe and environmentally responsible manner. By assuring the quality and stability of key laboratory measurement systems throughout DOE, and by providing expert technical assistance to improve those systems and programs, it assures the reliability of data on which decisions are based. The primary objective of this performance evaluation program is to foster reliability and credibility for the analytical results used in the decision-making process, particularly as it relates to the environment and public health and safety. MAPEP checks for specific analytical proficiencies in radiological, stable inorganic, or organic analyses. The MAPEP study addresses data quality requirements in DOE Order O 458.1, “Radiation Protection of the Public and the Environment.”

MAPEP studies are conducted each February and August. MAPEP samples include water, soil, and air filter matrices that are spiked with environmentally important stable inorganic, organic, and radioactive constituents that are traceable to the National Institute of Standards and Technology. RESL performs sample preparation, distribution, data evaluation, and reporting. The results of Argonne’s participation in this program for CY2022 are published in ANL-21/01.[55]

Many factors enter into an overall quality assurance program other than the analytical laboratory quality control process discussed above. Representative sampling is of prime importance. Appropriate sampling protocols are followed for each type of sample being collected. Water samples are pre-treated in a manner designed to maintain the integrity of the constituent of interest. For example, samples collected for strontium-90 analysis are filtered and acidified immediately after collection to prevent hydrolytic loss of metal ions and reduce leaching from suspended solids. Samples collected for hydrogen-3 analysis do not require filtration or acidification.

To ensure groundwater samples are representative of the in-place groundwater, stagnant water in the well is removed prior to sampling in accordance with USEPA guidance[50]. The volume of stagnant water in the casing is determined by measuring the water depth from the surface. From one to three times the well volume is removed. After the well refills with groundwater, it is sampled by bailing with a Teflon bailer or dedicated pump. Wells that do not recharge quickly are pumped nearly dry and allowed to refill before samples are collected. The Red Gate Woods dolomite wells are not purged since they are open boreholes drilled into the bedrock where stagnant water does not accumulate. All samples are placed in pre-cleaned bottles, labeled, filtered, and preserved (strontium-90 samples only). All sampling equipment is cleaned by field rinsing with Type II deionized water. New equipment is used whenever possible to prevent cross-contamination. The samples are transferred to the analytical laboratory, accompanied by a chain-of-custody transfer document.

6.1 Applicable Standards

The standard relevant to this study is the DOE Order O 458.1, "Radiation Protection of the Public and the Environment," which established a total effective dose limit of 100 mrem/y.[43] The dose limit and dose calculation methodology are applicable to all media: surface water, deep holes, boreholes, and picnic well water. The EPA drinking water standard[44] is not applicable to the picnic wells since they do not meet the definition of a public water system; however, the IEPA standard of 20 nCi/L for hydrogen-3 and the IEPA Class I groundwater standard of 8 pCi/L for strontium-90 are used in this report for comparison purposes.

6.2 Analytical Methods

The analytical methods used to obtain the data in this report are identical to those used to generate the results presented in ANL-22/01.[55]

6.3 Intercomparison Program

Commencing in 2012, Argonne has participated in a program of dividing a subset of the Site A/Plot M water samples collected and submitting one half of each sample to the Illinois Emergency Management Agency (IEMA) for analysis. The IEMA operates a laboratory which conducts radiological analyses using methods similar to Argonne. A duplicate set of two samples during the first, third and fourth quarter, and six samples during the second quarter, is analyzed by both Argonne and the IEMA for hydrogen-3, strontium-90, and cesium-137. The results are compared to identify any discrepancies that may be occurring within the processes being conducted by the two analytical laboratories that would affect the results. The results from the CY2022 split samples are shown in Tables 6.1 through 6.3. The relative percent difference (RPD) for hydrogen-3 results from pairs of samples exhibiting results greater than three times the minimum detectable activity (MDA) is shown in Table 6.1.

Table 6-1 Intercomparison Sample Hydrogen-3 Results for 2022

Sampling Location	Argonne H-3 Results (nCi/L)	Argonne Uncertainty	Argonne MDA	IEMA H-3 Results (nCi/L)	IEMA Uncertainly	IEMA MDA	RPD[a]
First Quarter							
Plot M Borehole BH04	**256**[b]	0.632	0.1	**285**	NA[c]	0.135	10.7%
Plot M Borehole BH10	**14.2**	0.153	0.1	**14.7**	NA	0.135	3.5%
Second Quarter							
Plot M Borehole BH04	**219**	0.599	0.1	**222**	NA	0.135	1.4%
Plot M Borehole BH10	**12.9**	0.150	0.1	**12.7**	NA	0.135	1.6%
Site A Borehole BH56	**0.69**	0.052	0.1	**0.64**	NA	0.135	7.5%
Picnic Well 5160	**0.74**	0.053	0.1	**0.80**	NA	0.173	8.1%
RGW Dolomite Well DH11	**0.43**	0.048	0.1	**0.44**	NA	0.135	2.3%
RGW Dolomite Well DH12	**0.36**	0.046	0.1	**0.31**	NA	0.135	14.9%
Third Quarter							
Plot M Borehole BH04	**248**	0.6357	0.1	**254**	NA	0.135	2.4%
Plot M Borehole BH10	**59.0**	0.312	0.1	**60.5**	NA	0.135	2.5%
Fourth Quarter							
Plot M Borehole BH04	**265**	0.659	0.1	**282**	NA	0.135	6.2%
Plot M Borehole BH10	**DRY**	DRY	0.1	**DRY**	NA	0.135	-

a Relative Percent Difference (RPD) was calculated only for those results where both Argonne and IEMA results were greater than three times the MDA

b Bold font indicates the result is greater than three times the MDA

c IEMA uncertainty was not available for all Hydrogen-3 results

Table 6-2 Intercomparison Sample Strontium-90 Results for 2022

Sampling Location	Argonne Sr-90 Results (pCi/L)	Argonne Uncertainty	Argonne MDA	IEMA Sr-90 Results (pCi/L)	IEMA Uncertainly	IEMA MDA
First Quarter						
Plot M Borehole #4	-0.022	0.0206	0.25	<1.7	NA[a]	1.7
Plot M Borehole #10	0.190	0.0269	0.25	<1.7	NA	1.7
Second Quarter						
Plot M Borehole #4	-0.027	0.0241	0.25	<1.7	NA	1.7
Plot M Borehole #10	0.204	0.0298	0.25	<1.7	NA	1.7
Site A Borehole #56	1.364	0.1252	0.25	<1.7	NA	1.7
Picnic Well 5160	-0.073	0.018725	0.25	<1.6	NA	1.6
RGW Dolomite Well #11	-0.013	0.0165	0.25	<1.7	NA	1.7
RGW Dolomite Well #12	-0.034	0.0184	0.25	<1.7	NA	1.7
Third Quarter						
Plot M Borehole #4	0.009	0.0202	0.25	<1.7	NA	1.7
Plot M Borehole #10	0.146	0.0239	0.25	<1.7	NA	1.7
Fourth Quarter						
Plot M Borehole #4	0.029	0.0288	0.25	<1.7	NA	1.7
Plot M Borehole #10	DRY	DRY	0.25	DRY	NA	1.7

a IEMA uncertainty was not available for all Strontium-90 results

Table 6-3 Intercomparison Sample Cesium-137 Results for 2022

Sampling Location	Argonne Cs-137 Results (pCi/L)	Argonne Uncertainty	Argonne MDA	IEMA Cs-137 Results (pCi/L)	IEMA Uncertainly	IEMA MDA
First Quarter						
Plot M Borehole #4	2.389	2.139	2	<3.5	NA[a]	3.5
Plot M Borehole #10	2.064	2.677	2	<3.5	NA	3.5
Second Quarter						
Plot M Borehole #4	2.103	2.246	2	<3.5	NA	3.5
Plot M Borehole #10	1.073	1.532	2	<3.5	NA	3.5
Site A Borehole #56	2.985	2.591	2	<3.5	NA	3.5
Picnic Well 5160	0.883	1.481	2	<3.5	NA	3.5
RGW Dolomite Well #11	2.44	2.21	2	<3.5	NA	3.5
RGW Dolomite Well #12	-0.324	0.465	2	<3.5	NA	3.5
Third Quarter						
Plot M Borehole #4	0.478	1.14	2	<3.5	NA	3.5
Plot M Borehole #10	1.546	2.57	2	<3.5	NA	3.5
Fourth Quarter						
Plot M Borehole #4	3.427	2.11	2	<3.5	NA	3.5
Plot M Borehole #10	1.800	1.92	2	<3.5	NA	3.5

a IEMA uncertainty was not available for all Cesium-137 results

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