IEMA

Illinois Emergency Management Agency

Bureau of Radiation Safety

Report on Environmental Monitoring in the Environs of Palos Park and Argonne National Laboratory for Calendar Year 2014

July 2015

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History of the Site

In the early 1940s, Enrico Fermi and a team of scientists assembled the world's first atomic "pile" (nuclear reactor), named "CP-1" for "Chicago Pile 1" under an abandoned squash court beneath the Stagg Field football stadium at the University of Chicago, resulting in the first self-sustaining nuclear chain reaction on December 2, 1942. Recognizing the potential radiation exposure to the population of the city of Chicago, in 1943, the reactor was transferred to Red Gate Woods which is part of Palos Forest Preserve, a wooded site 20 miles southwest of downtown Chicago. There, the reactor was rebuilt, and renamed CP-2.

An additional reactor, CP-3, was also built on the site. By 1945, research programs were transferred to the current site of Argonne National Laboratory, so CP-2 and CP-3 reactors were decommissioned, surveyed, marginally decontaminated, demolished, and components buried at "Site A" in Red Gate Woods. The U.S. Department of Energy performed a limited remediation for Site A in 1996-1997 after high levels of radioactive material (specifically tritium) were found in surface water that drains from the site. In addition to the 19-acre Site A, radioactive material from nuclear research conducted from 1945-1949 is buried in a 150 feet-by 140-feet area called "Plot M," also in Red Gate Woods. The material in Plot M is "entombed" under a 1-foot thick concrete barrier, with side walls extending down 8 feet into the ground, and covered with 2.5 feet of dirt on top.

Environmental Monitoring Program

The Illinois Emergency Management Agency (IEMA) is charged with protecting the citizens of Illinois from the potentially harmful effects of radioactive materials. To that end, the IEMA's Bureau of Radiation Safety monitors the environment in Illinois for the presence of radionuclides. One of the locations monitored by IEMA is the area in and around the Site A/Plot M Disposal Sites within and around Red Gate Woods. Appendix A includes a map of the area in and around Palos Park indicating the general locations of IEMA and Argonne National Laboratory sampling points.

In partnership with Argonne National Laboratory, Argonne staff collects samples of water and supplies IEMA with 'splits' of samples from six locations in Red Gate Woods near Palos Park (Red Gate Woods Well #5160, Red Gate Wells #10 and #13, and Plot M Boreholes # 4, #10, and #54). These samples are analyzed for man-made and natural radionuclides. IEMA collects water samples from 11 additional locations that are accessible to the public and analyzes them for man-made and natural radionuclides. All samples are collected quarterly.

IEMA also participates in an Annual Inspection conducted by the U.S. Department of Energy's Office of Legacy Management and Argonne National Laboratory staff. This inspection includes an overview of activities during the past year at the site, and a physical inspection of the site and all sampling wells.

Laboratory Analysis

Water samples collected by IEMA staff, and those provided to IEMA from Argonne National Laboratory as "splits" are analyzed by the IEMA Radiochemistry Laboratory in Springfield. Appendices B and C of this report contain tables of results for those samples.

Analyses of samples obtained for this site indicate the level of ground water contamination in publicly-accessible areas is below the U.S. Environmental Protection Agency (US EPA) drinking water standards for the various radionuclides tested. The highest levels of radioactivity were found in water from boreholes around Plot M, but this water is not readily accessible to the public.

Negative numbers in the tables of this report are the values reported by the IEMA Radiochemistry Laboratory. Each batch of samples is counted with a sample "blank" to determine a "background" for each machine and each type of medium being analyzed. That 'background' reading is then subtracted from the analytical results. When the sample has very little radioactivity, subtracting the "background" values may actually result in a negative number.

Understanding a Test Result with a Confidence Interval

What does a tritium result of (519 ± 99.5) pCi/L, with 95% confidence, mean? First, the unit, pCi/L, is used to measure the amount of tritium, in picocuries (pCi), present in one liter (L) of the sample. Thus, the result tells us that the analysis found 519 picocuries of tritium per liter. However, all measurements have some uncertainty associated with them – some range of values which the analysis, if repeated, could reasonably be expected to be the result. In this case, the uncertainty is ± 99.5 pCi/L. If repeated, the analysis could reasonably be expected to return values as low as 519 – 99.5 = 419.5 pCi/L and as high as 519 + 99.5 = 618.5 pCi/L. The statement "with 95% confidence" tells us just how certain we can be about that range of values – in this case, we judge that there is a 95% probability that the sample contains between 419.5 and 618.5 picocuries of tritium per liter of water. Tables of data in Appendix C use the term, "Error" instead of "Uncertainty" only for the sake of brevity in the tables.

Tritium Results

Tritium (H-3) was measured in water samples using ***EPA Method 906.0***. Reported uncertainties are counting uncertainties only, and are at the 95% confidence level, 1.96 sigma. The a priori method detection limit of approximately 170 picocuries per liter (pCi/L) is based on typical instrument background, counting time, and instrument effieciency, and may vary slightly between instruments. Liquid scintillation counting was performed on a liquid scintillation analyzer, calibrated for tritium analysis. To provide additional perspective on tritium concentrations at various locations in and around Palos Park, Appendix B. depicts historical tritium results at sampling locations including "error bars" indicating the uncertainty for each result.

Strontium Results

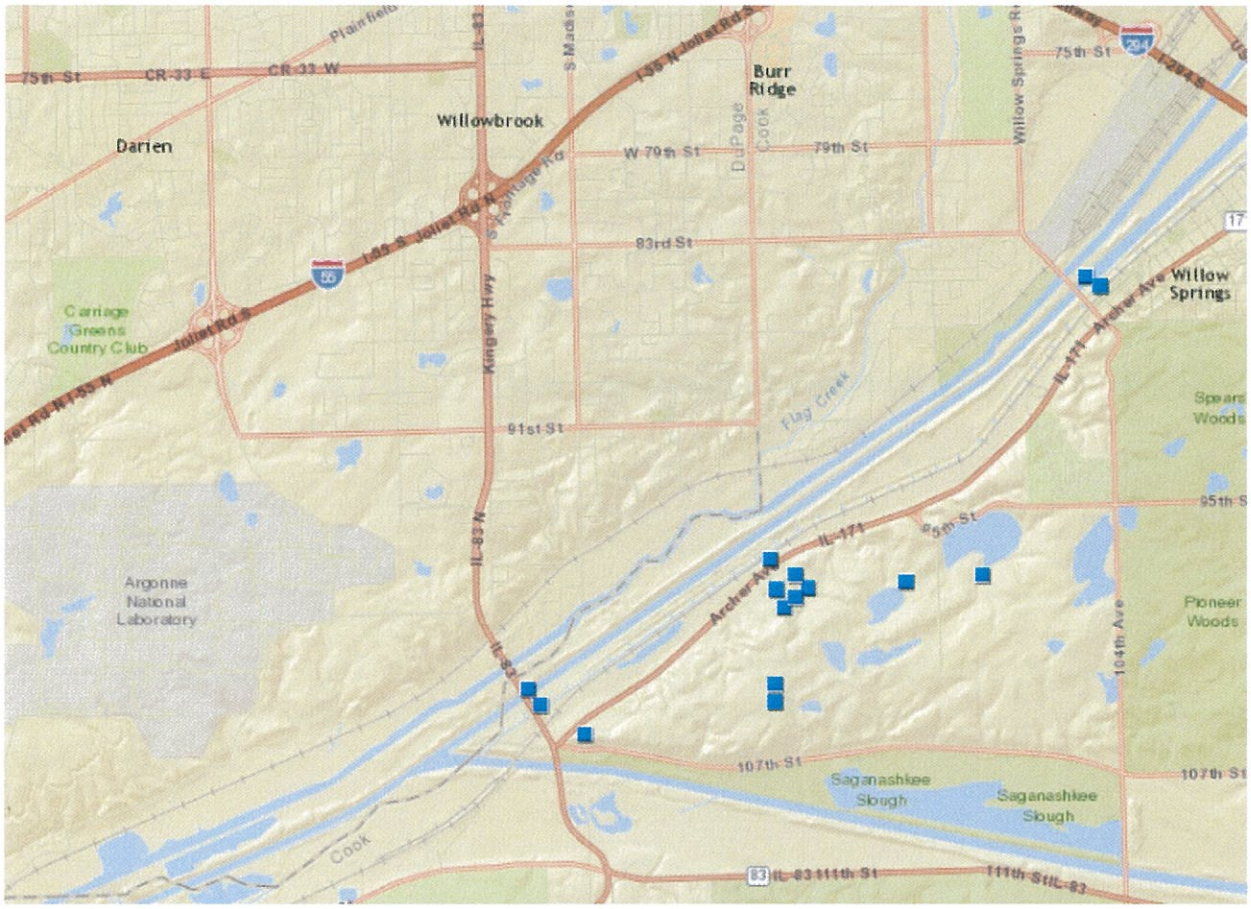
Radiostrontium was measured in water using ***EPA 402-R-10-001d, "Rapid Radiochemical Method for Total Radiostrontium (Sr-90) in Water for Environmental Restoration Following Homeland Security Events."*** The reported uncertainties are at the 95% confidence level, 1.96 sigma. Gas proportional counting was performed on a low-background gas proportional counter. Strontium results can be found in Table C.3. of Appendix C alongside the Gamma Spectroscopy results.

Gamma Spec. Results (K-40, Co-60, and Cs-137)

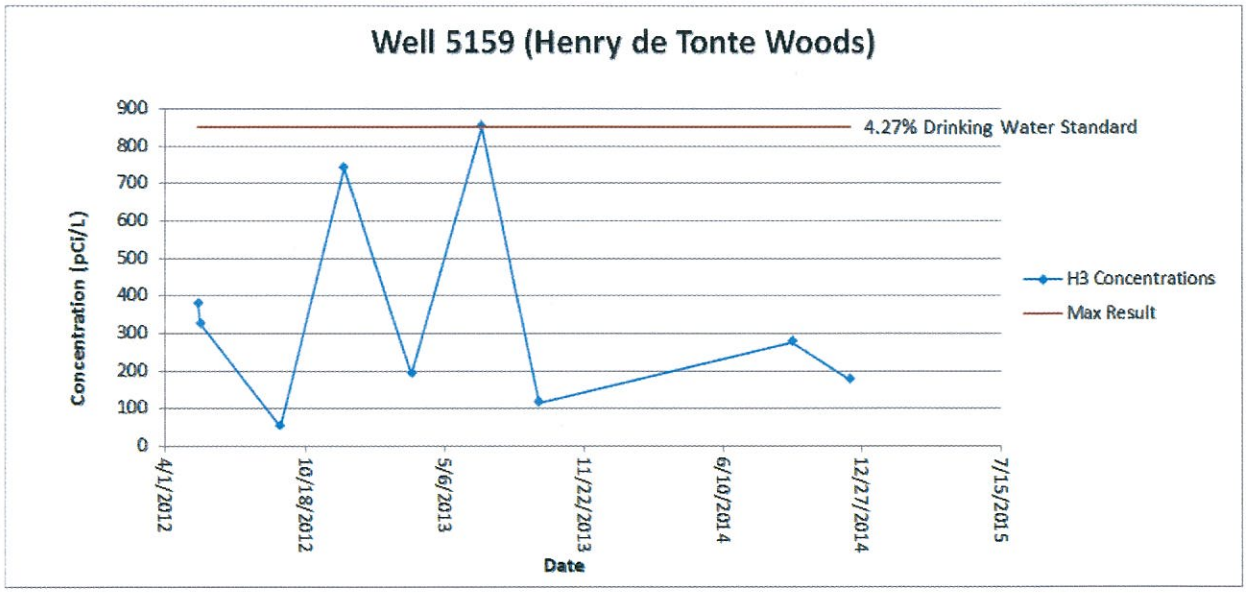
The gamma spectroscopy analyses in water samples were processed using the ***Illinois Emergency Management Method BES-SRC-PLS-115; Gamma Spectroscopy of Samples***. One liter aliquots of unfiltered waters were transferred to 1-L Marinelli beakers and counted for 15 hours. The data was collected with high purity germanium detectors and analyzed with Canberra APEX Lab Productivity Suite/ Genie 2000 software. The reported uncertainties are at the 95% confidence level, 1.96 sigma. The uncertainties are propagated by the Canberra Software and include counting, nuclide half-life, nuclide abundance, and emission rate uncertainties. Uncertainties in the sample volume and reproducibility of the counting geometry relative to the efficiency calibration geometry are not included. Table C.3. of Appendix C contains Gamma Spectroscopy Results.

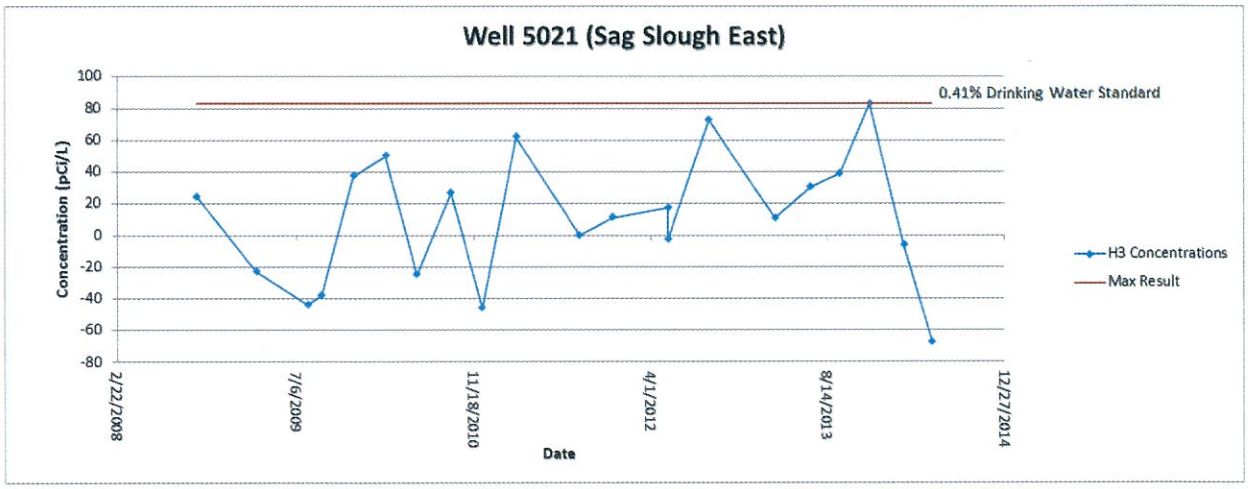
APPENDIX A
Site A / Plot M and Palos Park Sampling Locations

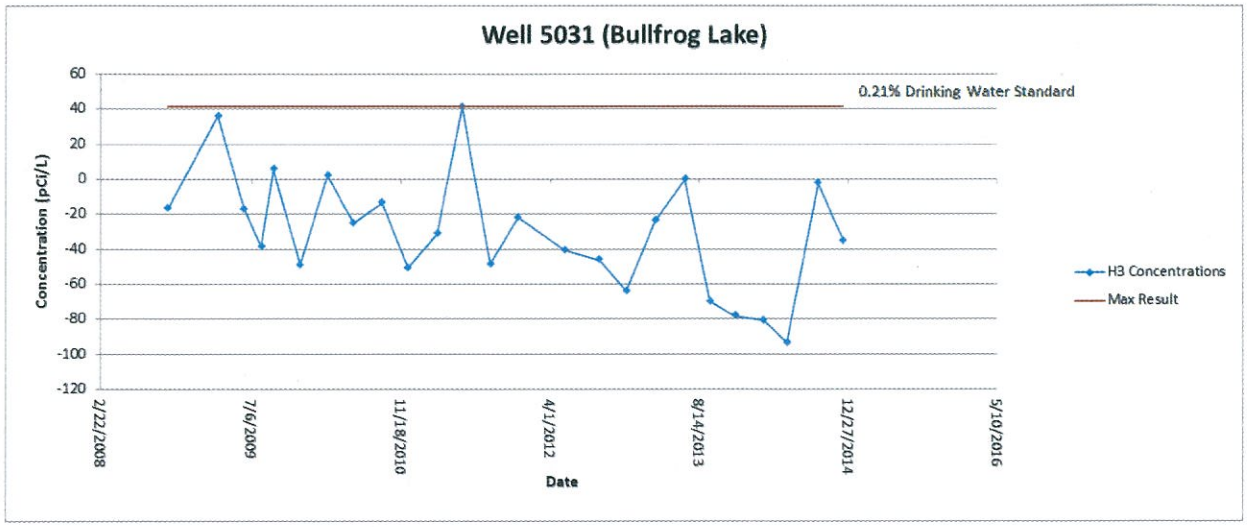
Map A.1. General Location of Site A / Plot M in Palos Park Forest Preserve and Sampling Locations

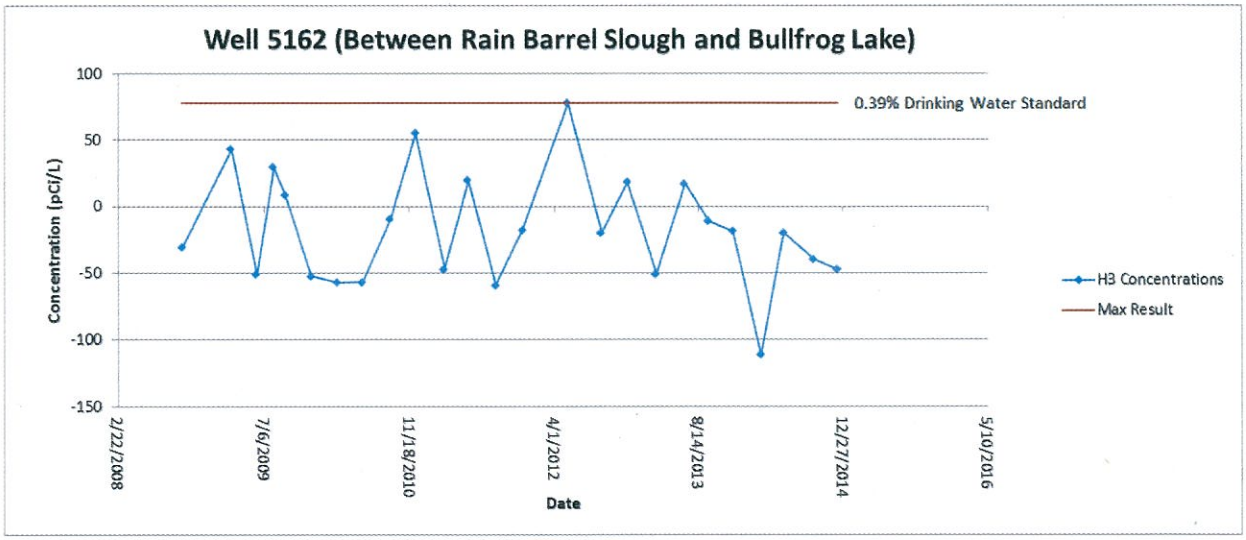


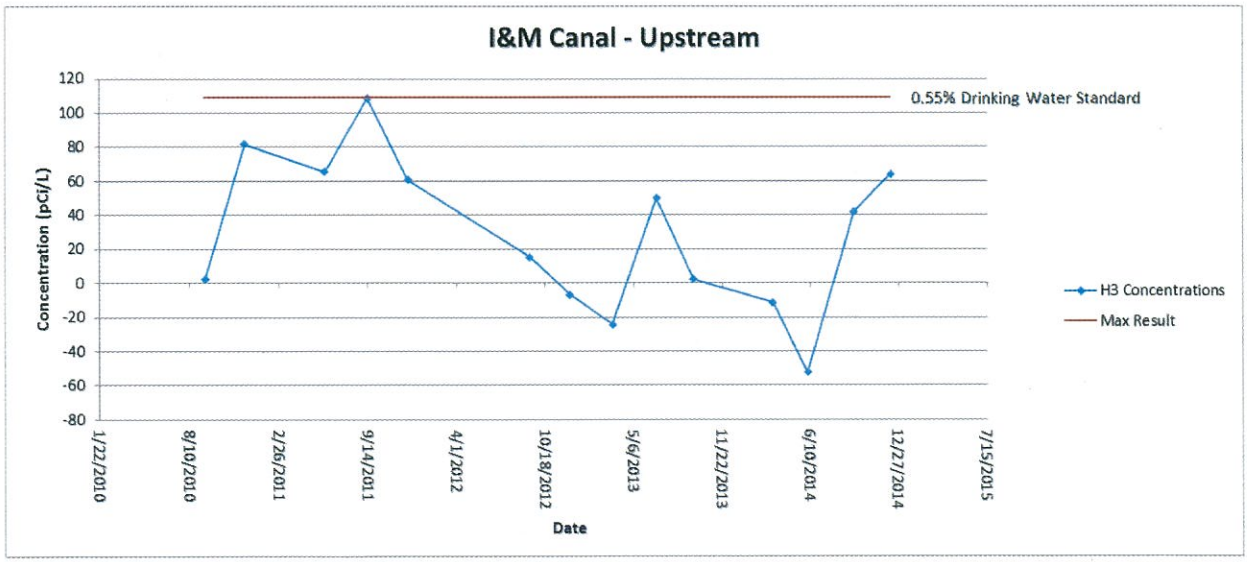
APPENDIX B
Graphical Representations of Tritium (H-3) Water Sample Results through 2014

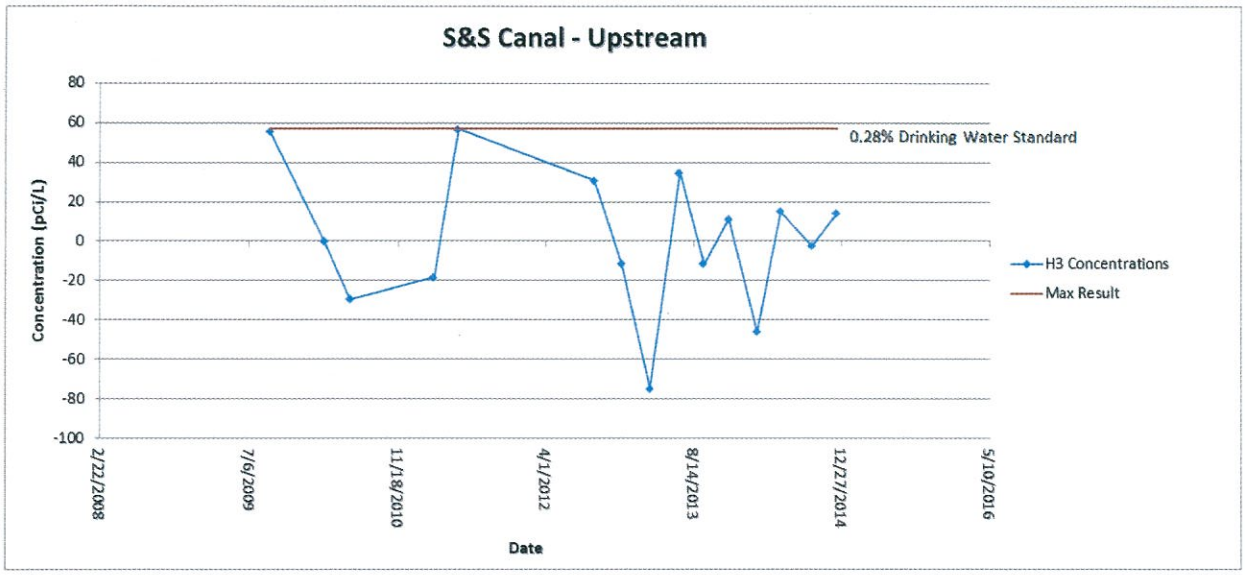


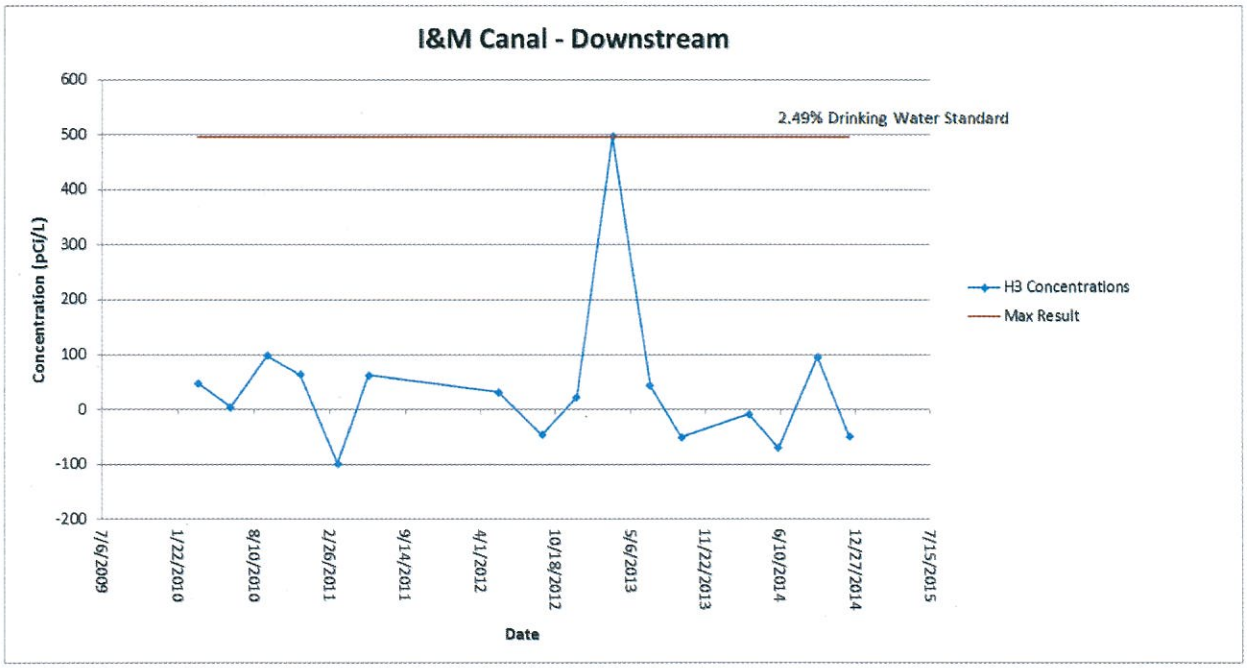


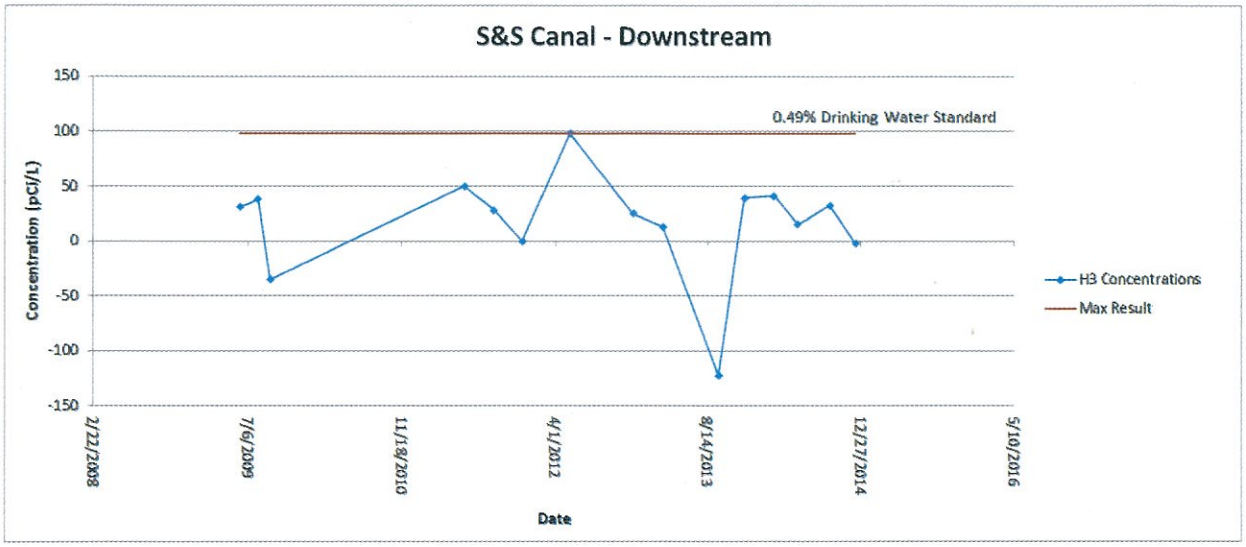

Well 5031 (Bullfrog Lake)
0.21% Drinking Water Standard
Concentration (pCi/L)
60
40
20
0
-20
-40
-60
-80
-100
-120
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
Date
H3 Concentrations
Max Result

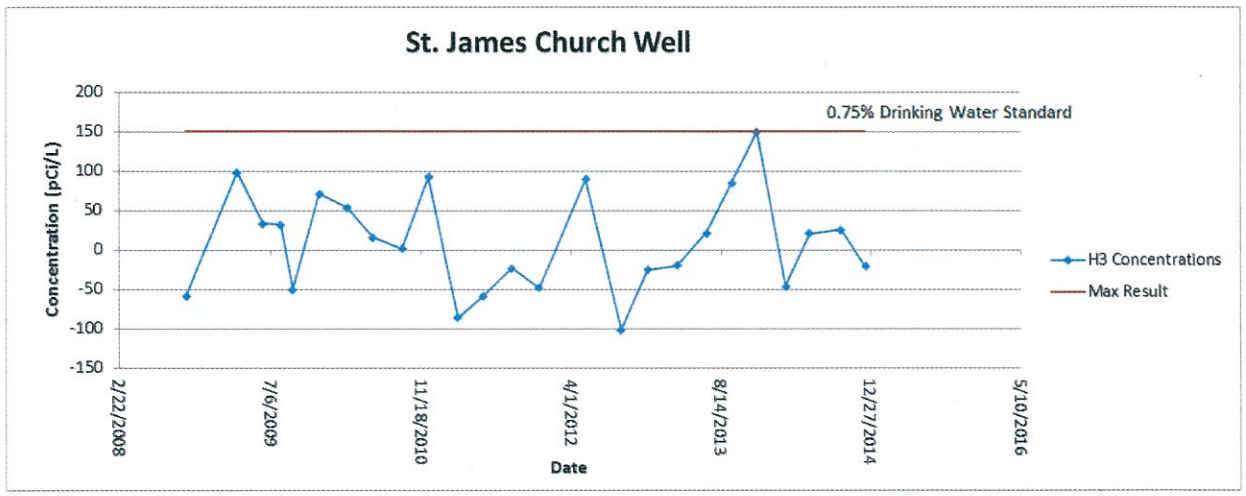

Well 5162 (Between Rain Barrel Slough and Bullfrog Lake)
0.39% Drinking Water Standard
Concentration (pCi/L)
100
50
0
-50
-100
-150
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
Date
H3 Concentrations
Max Result

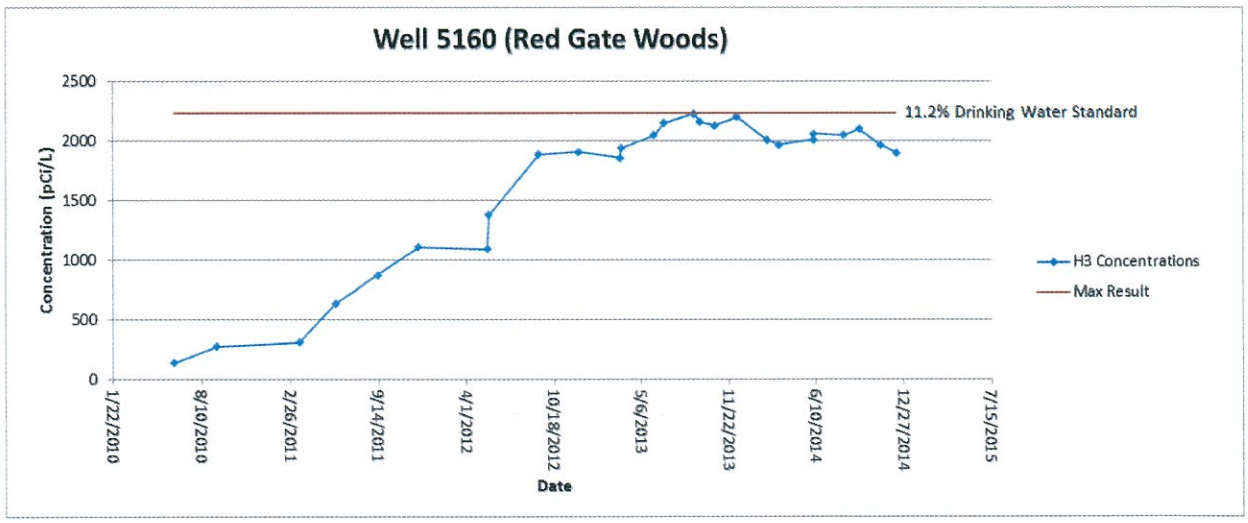

I&M Canal - Upstream
0.55% Drinking Water Standard
Concentration (pCi/L)
120
100
80
60
40
20
0
-20
-40
-60
-80
1/22/2010
8/10/2010
2/26/2011
9/14/2011
4/1/2012
10/18/2012
5/6/2013
11/22/2013
6/10/2014
12/27/2014
7/15/2015
Date
H3 Concentrations
Max Result

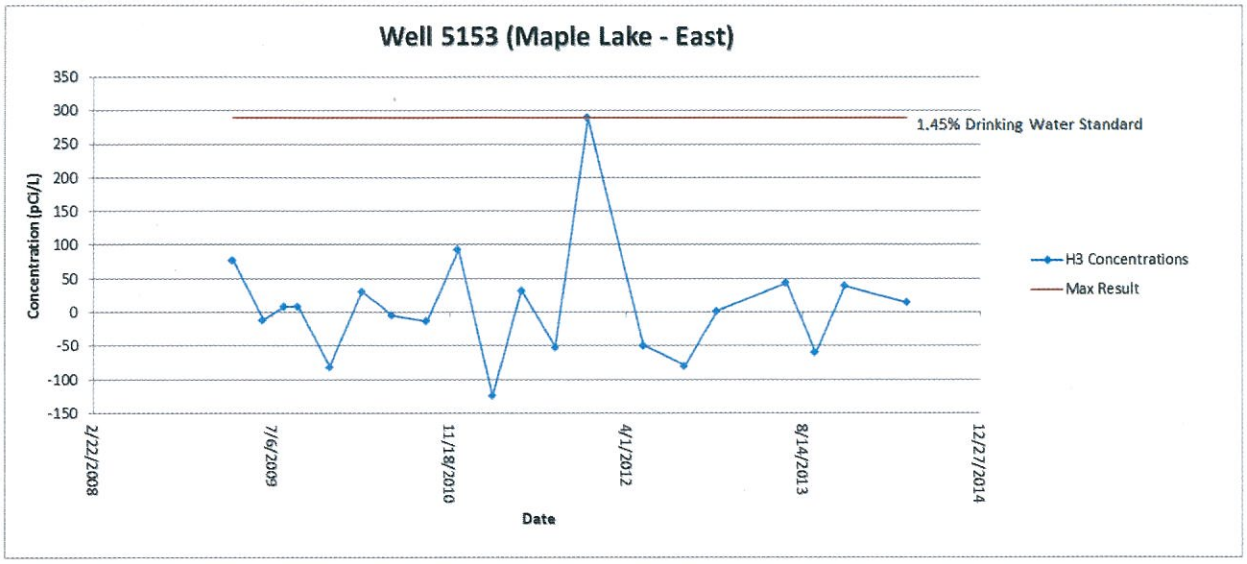

S&S Canal - Upstream
80
60
40
20
0
-20
-40
-60
-80
-100
Concentration (pCi/L)
0.28% Drinking Water Standard
H3 Concentrations
Max Result
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
Date

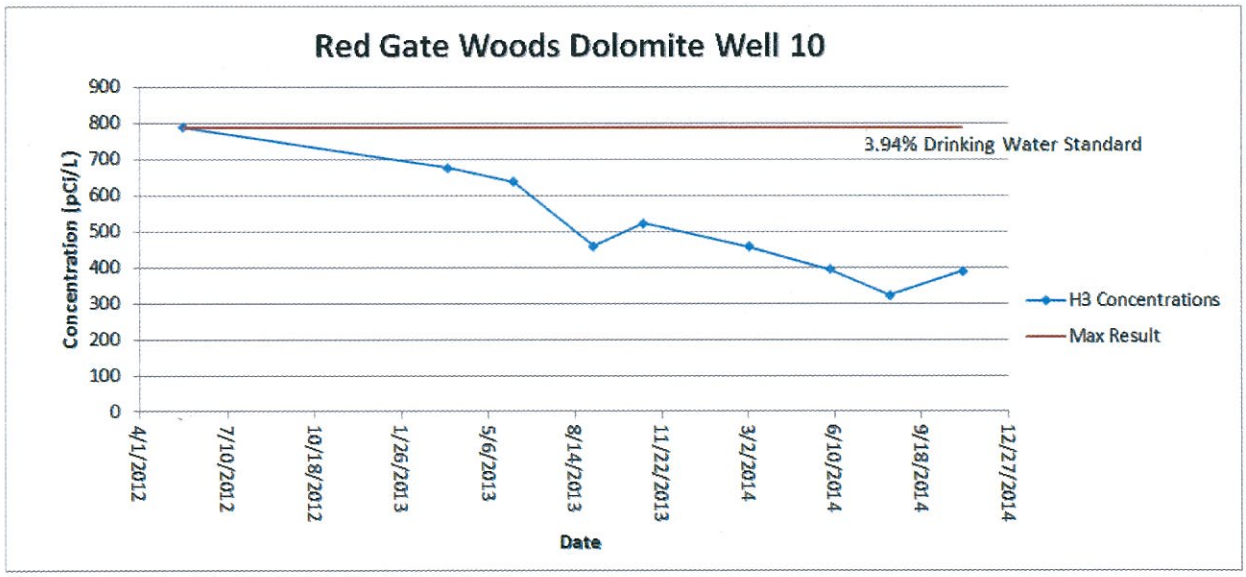

I&M Canal - Downstream
600
500
400
300
200
100
0
-100
-200
Concentration (pCi/L)
2.49% Drinking Water Standard
H3 Concentrations
Max Result
7/6/2009
1/22/2010
8/10/2010
2/26/2011
9/14/2011
4/1/2012
10/18/2012
5/6/2013
11/22/2013
6/10/2014
12/27/2014
7/15/2015
Date

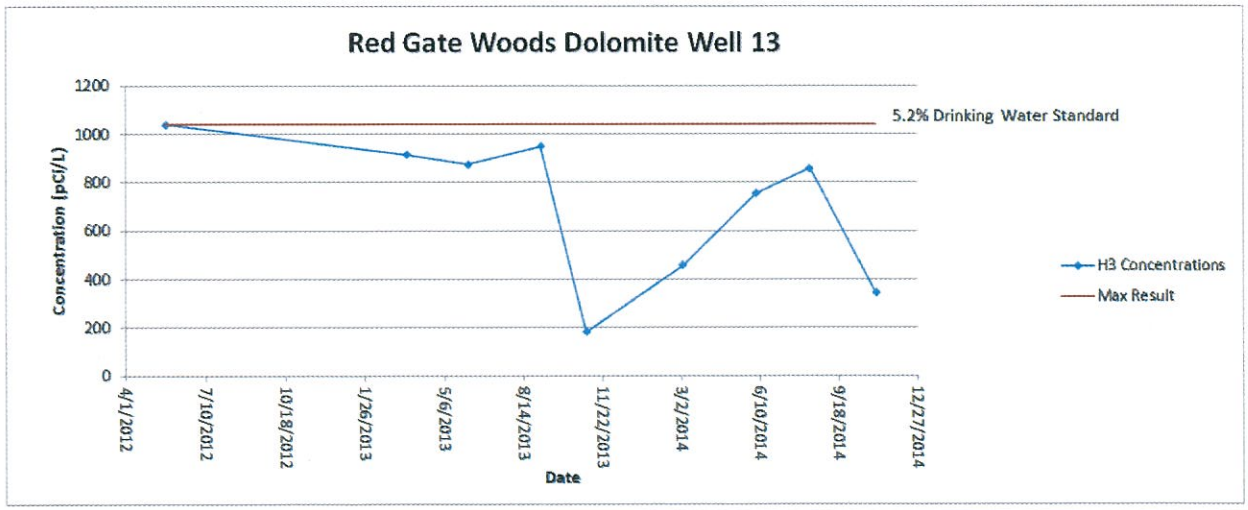

S&S Canal - Downstream
0.49% Drinking Water Standard
Concentration (pCi/L)
150
100
50
0
-50
-100
-150
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
Date
H3 Concentrations
Max Result

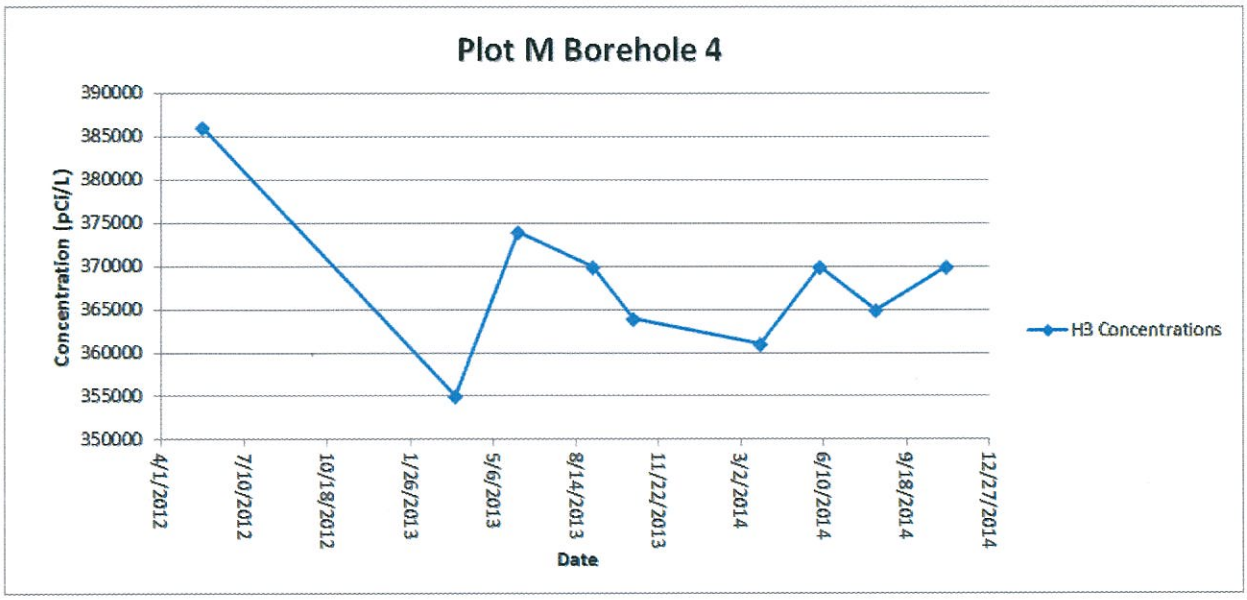

St. James Church Well
0.75% Drinking Water Standard
Concentration (pCi/L)
200
150
100
50
0
-50
-100
-150
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
Date
H3 Concentrations
Max Result

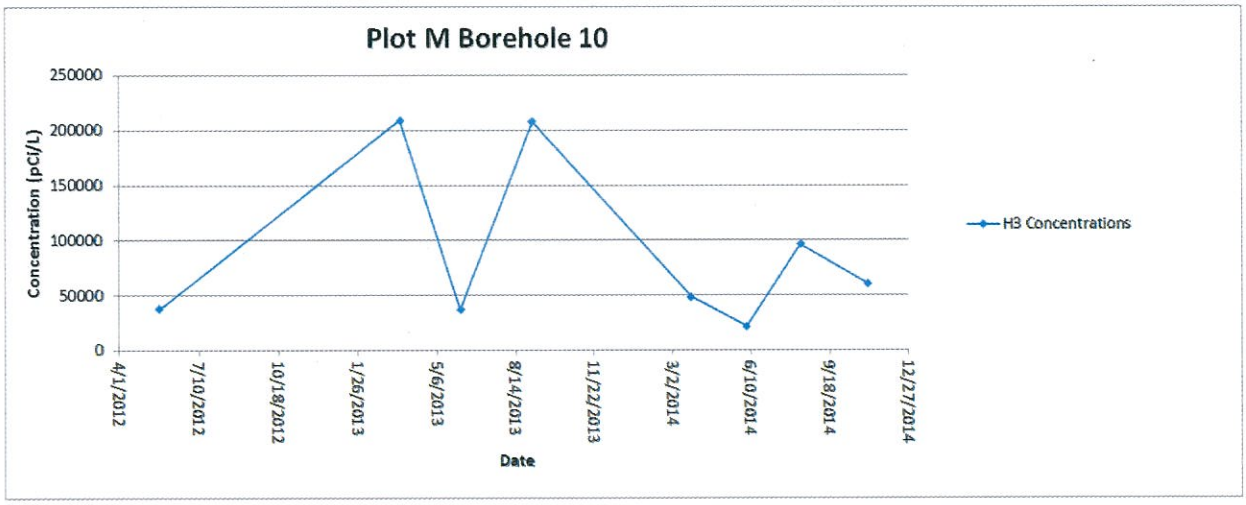

Well 5160 (Red Gate Woods)
11.2% Drinking Water Standard
Concentration (pCi/L)
2500
2000
1500
1000
500
0
1/22/2010
8/10/2010
2/26/2011
9/14/2011
4/1/2012
10/18/2012
5/6/2013
11/22/2013
6/10/2014
12/27/2014
7/15/2015
Date
H3 Concentrations
Max Result

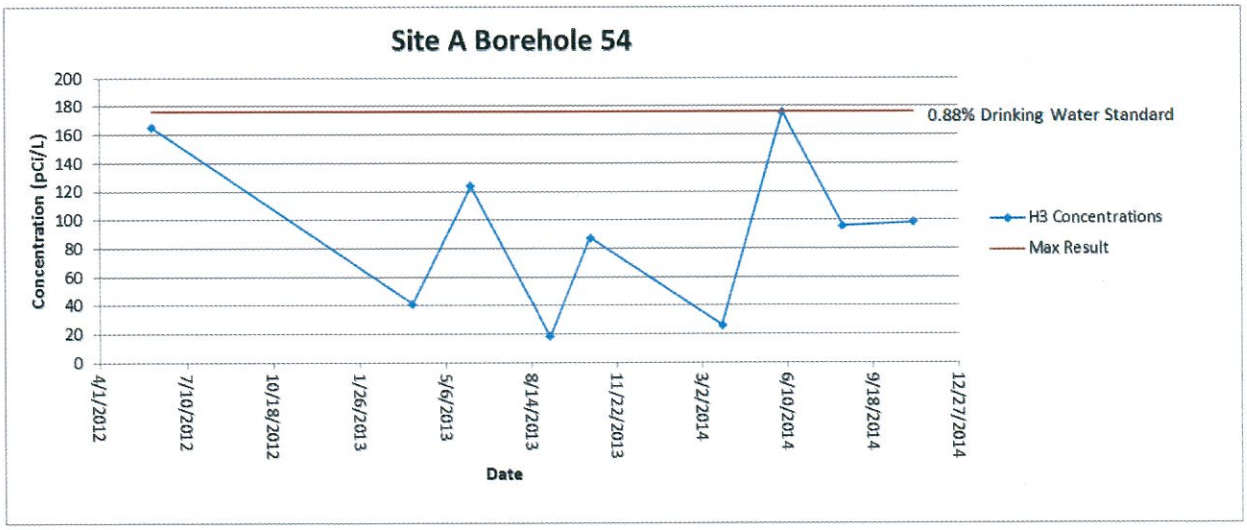

Well 5153 (Maple Lake - East)
Concentration (pCi/L)
350
300
250
200
150
100
50
0
-50
-100
-150
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
1.45% Drinking Water Standard
H3 Concentrations
Max Result


Red Gate Woods Dolomite Well 10
Concentration (pCi/L)
900
800
700
600
500
400
300
200
100
0
4/1/2012
7/10/2012
10/18/2012
1/26/2013
5/6/2013
8/14/2013
11/22/2013
3/2/2014
6/10/2014
9/18/2014
12/27/2014
Date
3.94% Drinking Water Standard
H3 Concentrations
Max Result


Red Gate Woods Dolomite Well 13
Concentration (pCi/L)
1200
1000
800
600
400
200
0
4/1/2012
7/10/2012
10/18/2012
1/26/2013
5/6/2013
8/14/2013
11/22/2013
3/2/2014
6/10/2014
9/18/2014
12/27/2014
Date
5.2% Drinking Water Standard
H3 Concentrations
Max Result


Plot M Borehole 4
Concentration (pCi/L)
390000
385000
380000
375000
370000
365000
360000
355000
350000
4/1/2012
7/10/2012
10/18/2012
1/26/2013
5/6/2013
8/14/2013
11/22/2013
3/2/2014
6/10/2014
9/18/2014
12/27/2014
Date
H3 Concentrations


Plot M Borehole 10
Concentration (pCi/L)
250000
200000
150000
100000
50000
0
4/1/2012
7/10/2012
10/18/2012
1/26/2013
5/6/2013
8/14/2013
11/22/2013
3/2/2014
6/10/2014
9/18/2014
12/27/2014
Date
H3 Concentrations


Site A Borehole 54
Concentration (pCi/L)
200
180
160
140
120
100
80
60
40
20
0
4/1/2012
7/10/2012
10/18/2012
1/26/2013
5/6/2013
8/14/2013
11/22/2013
3/2/2014
6/10/2014
9/18/2014
12/27/2014
Date
0.88% Drinking Water Standard
H3 Concentrations
Max Result

APPENDIX C
Site A / Plot M and Palos Park Sample Results

Table C.1. Tritium (H-3) Results for Ground Water Samples
Results are in picocuries per Liter (pCi/L)

Description	Date	Result		Error
Well #5159 (Opposite Red Gate Woods)	9/17/2014	277.0	±	89.9
Well #5159 (Opposite Red Gate Woods)	12/10/2014	176.0	±	94.4
Well #5021	3/17/2014	-6.6	±	77.8
Well #5021	6/4/2014	-67.8	±	81.1
Well #5031	3/17/2014	-80.8	±	75.8
Well #5031	6/4/2014	-93.5	±	80.4
Well #5031	9/17/2014	-2.3	±	82.7
Well #5031	12/10/2014	-35.2	±	89.2
Well #5162	3/17/2014	-111.0	±	74.9
Well #5162	6/4/2014	-19.6	±	77.3
Well #5162	9/17/2014	-39.6	±	81.7
Well #5162	12/10/2014	-47.0	±	88.9
Illinois & Michigan Canal (UpS)	3/17/2014	-11.5	±	109.0
Illinois & Michigan Canal (UpS)	6/4/2014	-52.3	±	76.4
Illinois & Michigan Canal (UpS)	9/17/2014	42.0	±	83.9
Illinois & Michigan Canal (UpS)	12/10/2014	64.2	±	110.0
Sanitary & Ship Canal (UpS)	3/17/2014	-45.9	±	109.0
Sanitary & Ship Canal (UpS)	6/4/2014	15.2	±	78.2
Sanitary & Ship Canal (UpS)	9/17/2014	-2.3	±	82.7
Sanitary & Ship Canal (UpS)	12/10/2014	14.3	±	109.0
Illinois & Michigan Canal (DnS)	3/17/2014	-8.7	±	77.7
Illinois & Michigan Canal (DnS)	6/4/2014	-69.7	±	75.9
Illinois & Michigan Canal (DnS)	9/17/2014	95.6	±	85.3
Illinois & Michigan Canal (DnS)	12/10/2014	-49.9	±	107.0
Sanitary & Ship Canal (DnS)	3/17/2014	41.5	±	79.1
Sanitary & Ship Canal (DnS)	6/4/2014	15.2	±	78.2
Sanitary & Ship Canal (DnS)	9/17/2014	32.6	±	83.6
Sanitary & Ship Canal (DnS)	12/10/2014	-2.4	±	108.0
St. James Church Well	3/17/2014	-45.8	±	76.7
St. James Church Well	6/4/2014	21.0	±	83.5
St. James Church Well	9/17/2014	25.6	±	83.4
St. James Church Well	12/10/2014	-21.1	±	89.6

Table C.1. (Cont.) Tritium (H-3) Results for Ground Water Samples
Results are in picocuries per Liter (pCi/L)

Description	Date	Result		Error
Red Gate Woods Well #5160	2/16/2014	2010.0	±	121.0
Red Gate Woods Well #5160	3/17/2014	1970.0	±	120.0
Red Gate Woods Well #5160	6/4/2014	2010.0	±	126.0
Red Gate Woods Well #5160	6/4/2014	2060.0	±	127.0
Red Gate Woods Well #5160	8/12/2014	2050.0	±	127.0
Red Gate Woods Well #5160	9/17/2014	2100.0	±	127.0
Red Gate Woods Well #5160	11/4/2014	1970.0	±	130.0
Red Gate Woods Well #5160	12/10/2014	1900.0	±	129.0
Well # 5153	6/4/2014	14.0	±	83.3
Red Gate Dolomite Well #10	3/3/2014	458.0	±	89.7
Red Gate Dolomite Well #10	6/4/2014	394.0	±	93.4
Red Gate Dolomite Well #10	8/12/2014	323.0	±	91.4
Red Gate Dolomite Well #10	11/4/2014	390.0	±	99.3
Red Gate Dolomite Well #13	3/3/2014	458.0	±	89.7
Red Gate Dolomite Well #13	6/4/2014	754.0	±	102.0
Red Gate Dolomite Well #13	8/12/2014	859.0	±	104.0
Red Gate Dolomite Well #13	11/4/2014	343.0	±	98.3
Plot M Borehole #4	3/25/2014	361000.0	±	1230.0
Plot M Borehole #4	6/5/2014	370000.0	±	1290.0
Plot M Borehole #4	8/12/2014	365000.0	±	1280.0
Plot M Borehole #4	11/5/2014	370000.0	±	1290.0
Plot M Borehole #10	3/25/2014	48600.0	±	458.0
Plot M Borehole #10	6/4/2014	21400.0	±	321.0
Plot M Borehole #10	8/12/2014	96200.0	±	663.0
Plot M Borehole #10	11/5/2014	60700.0	±	530.0
Site A Borehole #54	3/25/2014	26.2	±	78.7
Site A Borehole #54	6/4/2014	176.0	±	87.9
Site A Borehole #54	8/13/2014	95.9	±	85.6
Site A Borehole #54	11/4/2014	98.6	±	92.5

Table C.2. Results for Analysis of Co-60, Cs-137, K-40 and Sr in Water Samples
Results are in picocuries per Liter (pCi/L)

Location / Date	Co-60 Result	Co-60 Error	Cs-137 Result	Cs-137 Error	K-40 Result	K-40 Error	Strontium Result	Strontium Error
Illinois & Michigan Canal (DnS)								
3/17/2014	1.5	0.9	-0.9	0.9	0.0	16.0	-0.2	0.8
6/4/2014	0.1	1.2	-0.7	1.1	61.0	14.1		
9/17/2014	2.4	0.9	-0.2	1.0	5.2	15.4	0.2	0.8
12/10/2014	-0.7	1.0	-1.1	0.9	10.0	17.0	0.5	1.1
Illinois & Michigan Canal (UpS)								
3/17/2014	-0.5	1.1	0.3	1.0	25.0	16.0	0.0	0.9
6/4/2014	0.1	0.9	-0.8	0.8	29.1	10.5		
9/17/2014	-2.5	1.1	1.5	0.9	-18.4	17.0	-0.2	0.8
12/10/2014	-0.7	2.0	1.1	1.6	40.0	22.0	-0.1	1.0
Plot M Borehole #10								
3/25/2014	-0.1	1.2	-2.7	1.1	57.0	13.0	-0.2	1.0
6/4/2014	-1.7	1.0	0.5	0.8	18.1	10.9	0.1	0.5
8/12/2014	-0.7	0.8	0.0	0.8	25.8	10.7	0.3	0.5
11/5/2014	-0.3	1.0	-1.6	0.9	10.0	16.0	0.5	1.0
Plot M Borehole #4								
3/25/2014	0.2	1.5	1.1	1.3	39.0	15.0	0.3	1.1
6/5/2014	1.2	1.2	-1.1	1.0	12.8	14.4	0.1	0.6
8/12/2014	-1.3	1.1	-1.0	0.9	-4.4	15.0	0.0	0.5
11/5/2014	1.0	1.6	-0.4	1.6	8.0	26.0	0.0	1.0
Red Gate Dolomite Well #10								
3/3/2014	0.4	1.1	0.8	1.0	5.0	15.0	-0.7	0.9
6/4/2014	0.5	1.0	-0.6	1.0	-4.0	14.0	0.2	0.4
8/12/2014	-0.9	1.2	0.1	0.9	11.8	16.1	-0.1	0.5
11/4/2014	0.8	0.8	-1.3	0.8	10.9	9.9	-0.1	0.9
Red Gate Dolomite Well #13								
3/3/2014	0.3	1.5	-0.3	1.2	-8.0	15.0	-0.9	1.0
6/4/2014	-1.1	1.8	0.5	1.6	35.1	23.3	0.2	0.4
8/12/2014	0.6	0.9	-0.2	0.9	30.3	17.3	0.2	0.4
11/4/2014	-0.2	1.1	0.1	1.1	29.0	11.0	0.3	0.8
Red Gate Woods Well #5160								
2/16/2014	-1.7	1.1	-0.2	0.9	19.0	18.0	0.3	1.1
3/17/2014	1.7	1.3	-3.0	1.4	53.0	16.0	-0.6	1.0
6/4/2014	-2.4	2.4	-3.6	2.0	11.2	32.2	0.1	0.5
8/12/2014	0.8	1.0	0.8	1.0	142.0	12.8	0.4	0.5
9/17/2014	0.0	1.2	-0.7	1.1	37.6	13.7	0.5	1.0
11/4/2014	1.4	0.9	0.3	0.9	-6.3	9.9	0.0	1.1
12/10/2014	0.2	1.7	-0.4	1.6	46.0	22.0	0.0	1.2

Table C.2. (Cont.) Gamma Results for Water Samples
Results are in picocuries per Liter (pCi/L)

Location / Date	Co-60 Result	Co-60 Error	Cs-137 Result	Cs-137 Error	K-40 Result	K-40 Error	Strontium Result	Strontium Error
Sanitary & Ship Canal (DnS)								
3/17/2014	-0.2	0.9	-0.4	0.8	29.0	10.0	0.2	0.9
6/4/2014	-1.8	1.8	1.0	1.7	-20.3	23.0		
9/17/2014	3.6	1.0	-0.9	1.2	11.2	10.6	-0.5	0.8
12/10/2014	0.0	1.8	-0.7	1.7	55.0	22.0	0.4	1.0
Sanitary & Ship Canal (UpS)								
3/17/2014	1.9	1.0	-1.5	1.0	39.0	17.0	-0.2	0.8
6/4/2014	-0.3	1.3	0.2	1.0	33.5	14.2		
9/17/2014	-0.6	1.9	0.6	1.6	-17.3	25.1	0.3	0.7
12/10/2014	1.4	0.7	-0.4	0.9	36.0	11.0	0.1	1.0
Site A Borehole #54								
3/25/2014	1.0	0.9	0.8	0.8	34.0	11.0	-0.3	0.9
6/4/2014	2.2	1.0	-1.2	0.9	-2.0	5.1	0.0	0.4
8/13/2014	0.5	1.0	-1.1	1.1	18.7	10.9	-0.1	0.5
11/4/2014	0.5	1.7	1.4	1.5	-8.0	23.0	-0.1	0.9
St. James Church Well								
3/17/2014	1.5	1.1	0.4	1.0	62.0	14.0	0.2	1.0
6/4/2014	-0.3	1.1	-0.1	1.1	-10.5	16.4		
9/17/2014	1.0	0.9	-0.7	0.9	25.7	15.9	0.1	0.4
12/10/2014	0.3	1.0	0.2	1.0	33.0	17.0	0.0	0.9
Well # 5153								
6/4/2014	-0.9	1.6	0.8	1.0	14.5	14.8		
Well #5021								
3/17/2014	1.5	0.8	-0.7	0.9	-8.0	11.0	-0.1	1.0
6/4/2014	-0.1	0.9	1.5	0.9	-54.8	17.3		
Well #5031								
3/17/2014	0.7	1.8	-0.5	1.7	35.0	19.0	0.5	0.9
6/4/2014	-0.4	2.0	-1.2	1.7	-10.5	26.2		
9/17/2014	1.1	1.2	2.3	1.1	-1.0	11.9	0.6	0.5
12/10/2014	1.8	0.9	0.0	1.0	-1.0	18.0	-0.1	1.0
Well #5159 (Opposite Red Gate Woods)								
9/17/2014	0.0	1.1	1.3	0.9	94.1	14.5	-0.4	0.8
12/10/2014	0.0	1.1	0.5	1.1	21.0	11.0	-0.1	1.1
Well #5162								
3/17/2014	-0.7	1.5	-2.4	1.3	33.0	16.0	-0.1	0.8
6/4/2014	0.9	1.1	-1.1	1.0	7.1	18.0		
9/17/2014	0.3	0.8	-0.1	0.8	41.4	9.4	-0.3	0.8
12/10/2014	-1.3	1.1	0.0	1.0	15.0	15.0	0.0	1.0