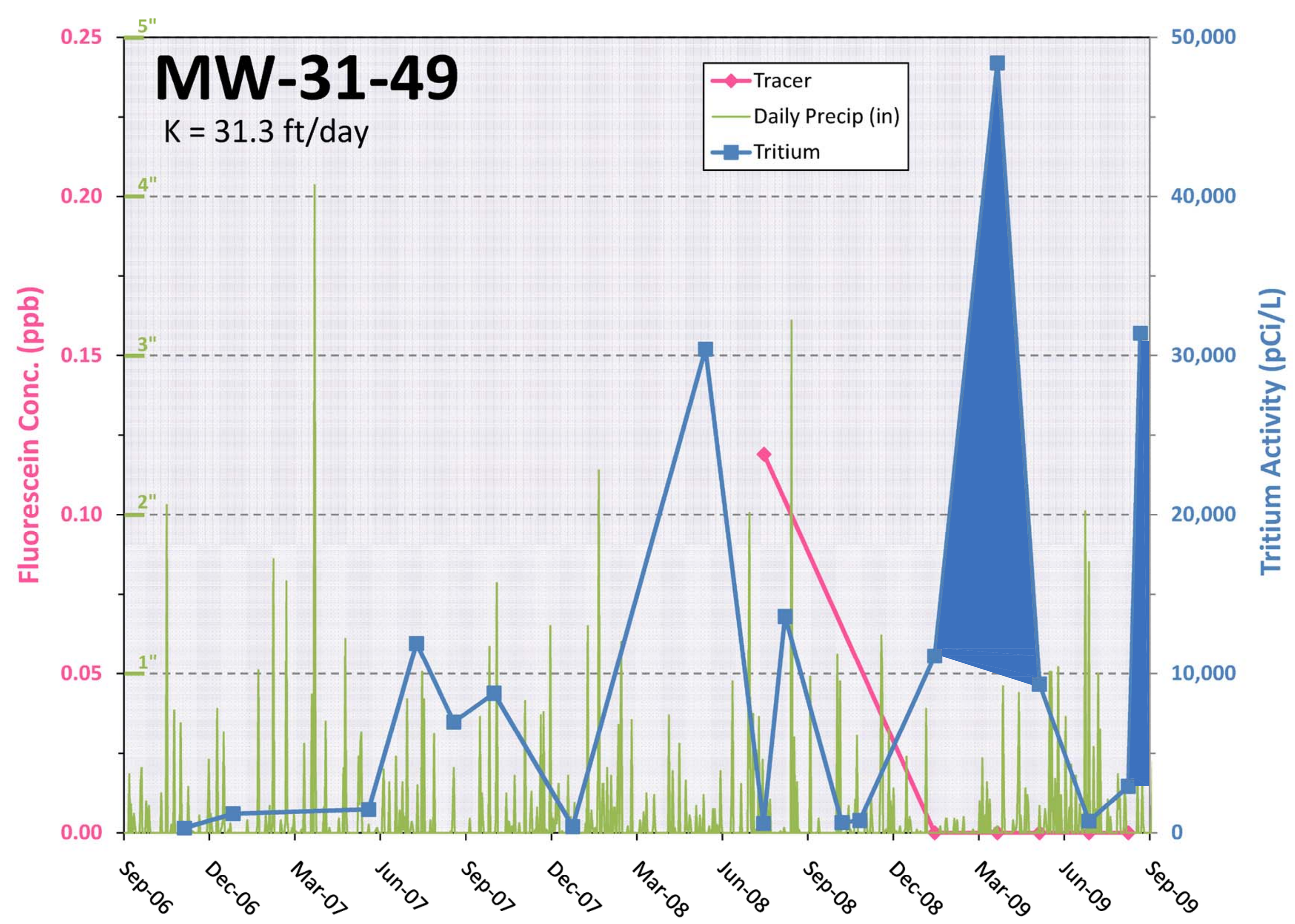
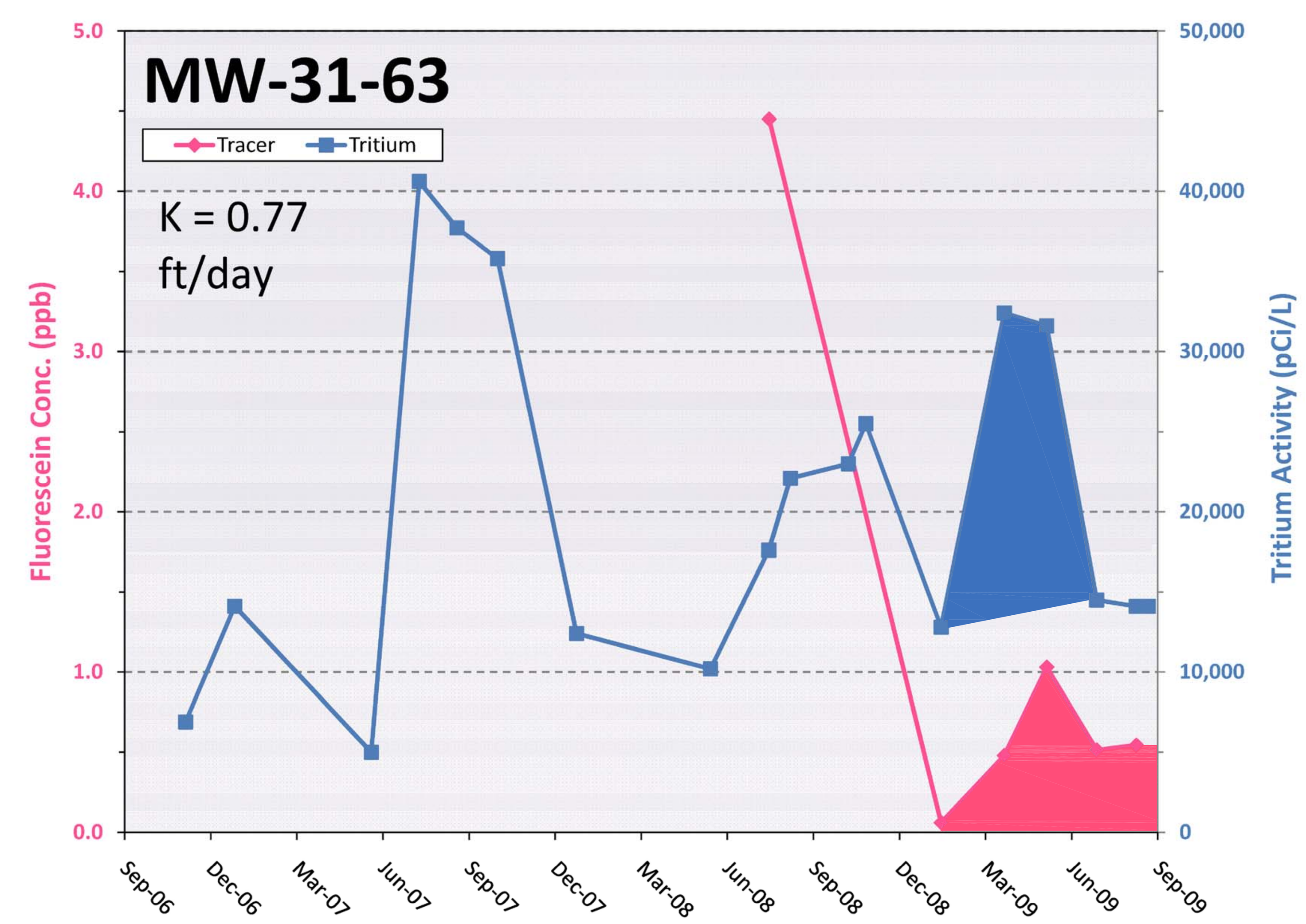
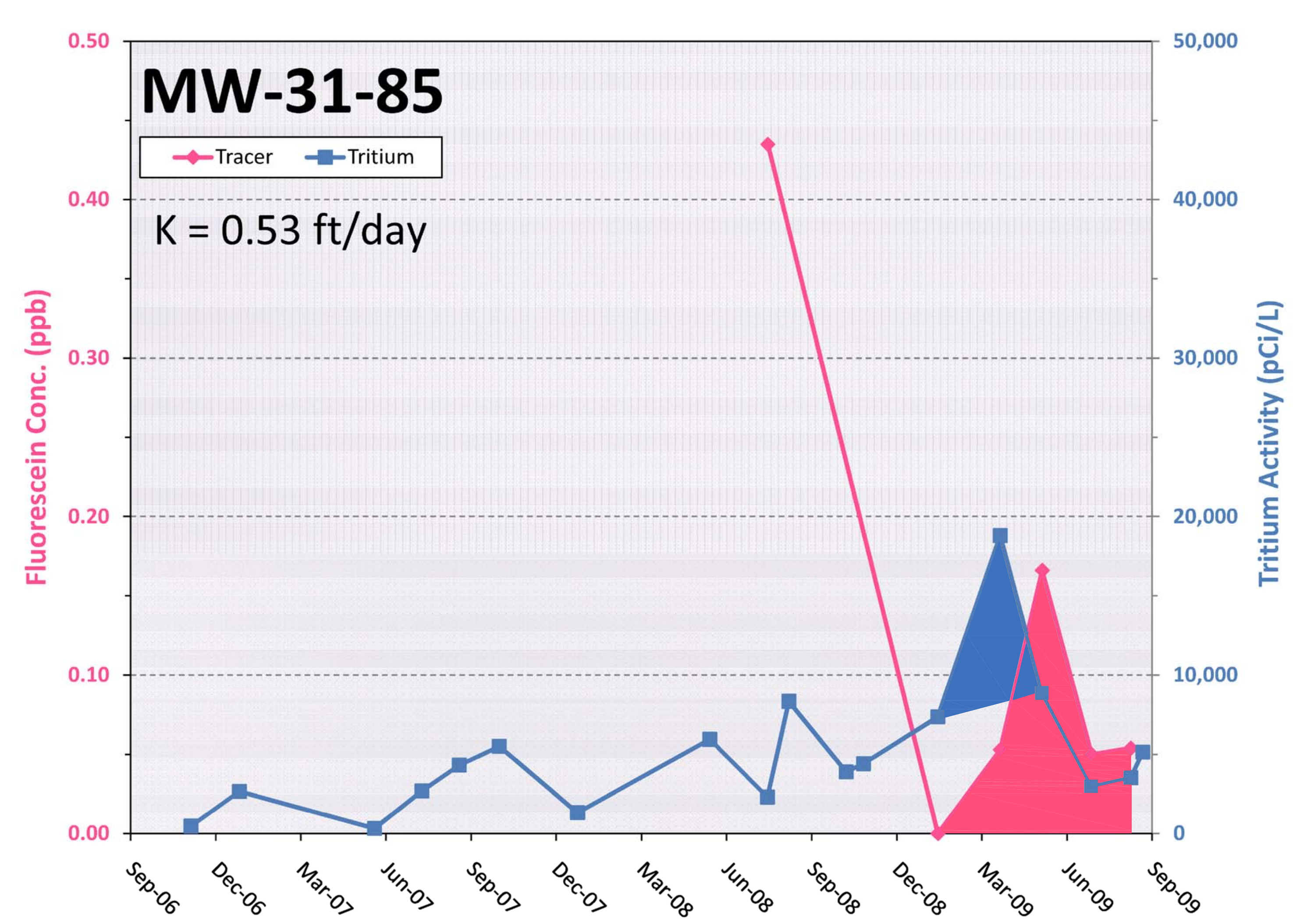
APPENDIX H: RECENT TRACER TESTING DATA

RECENT TRACER DATA

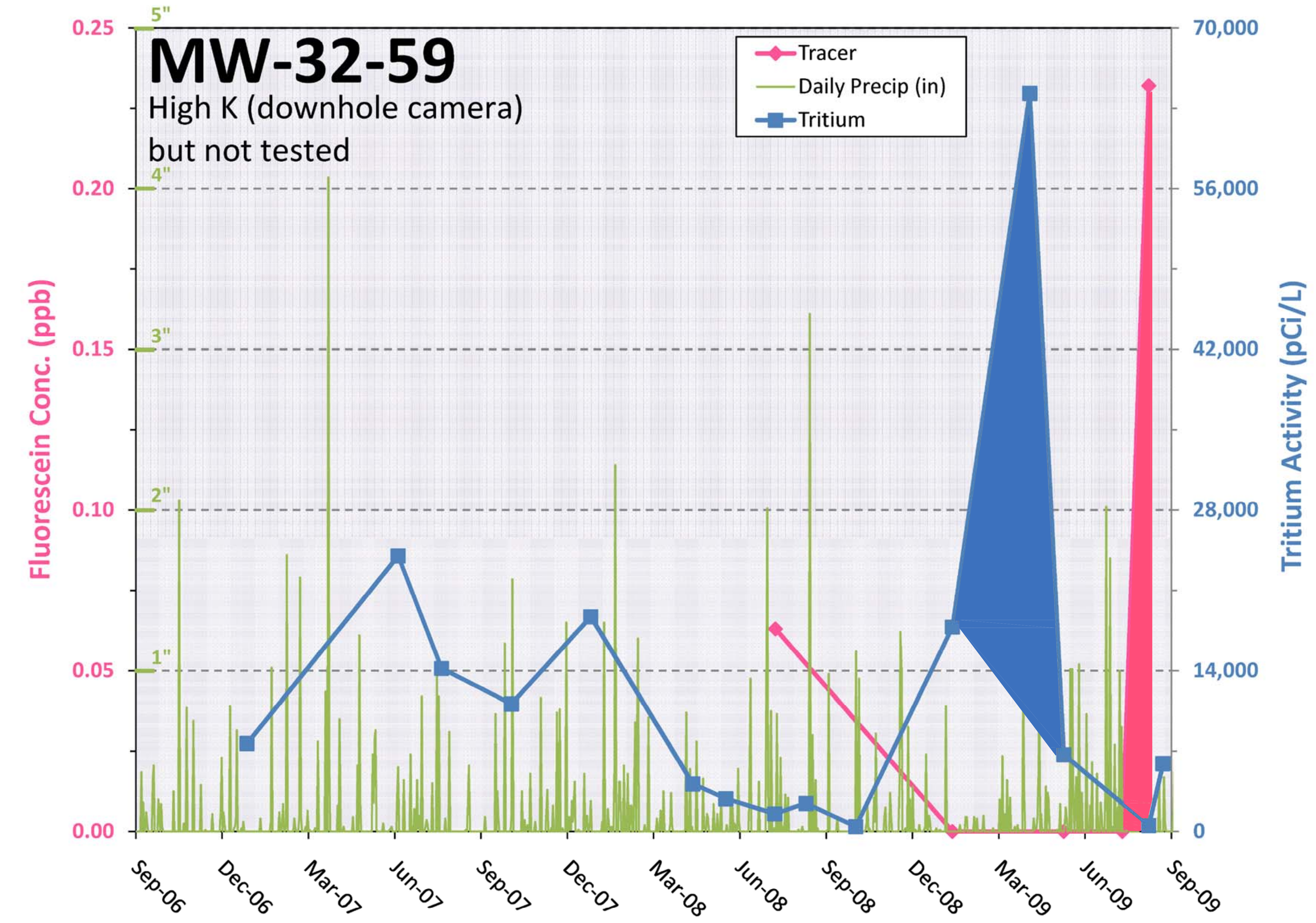
MW-31

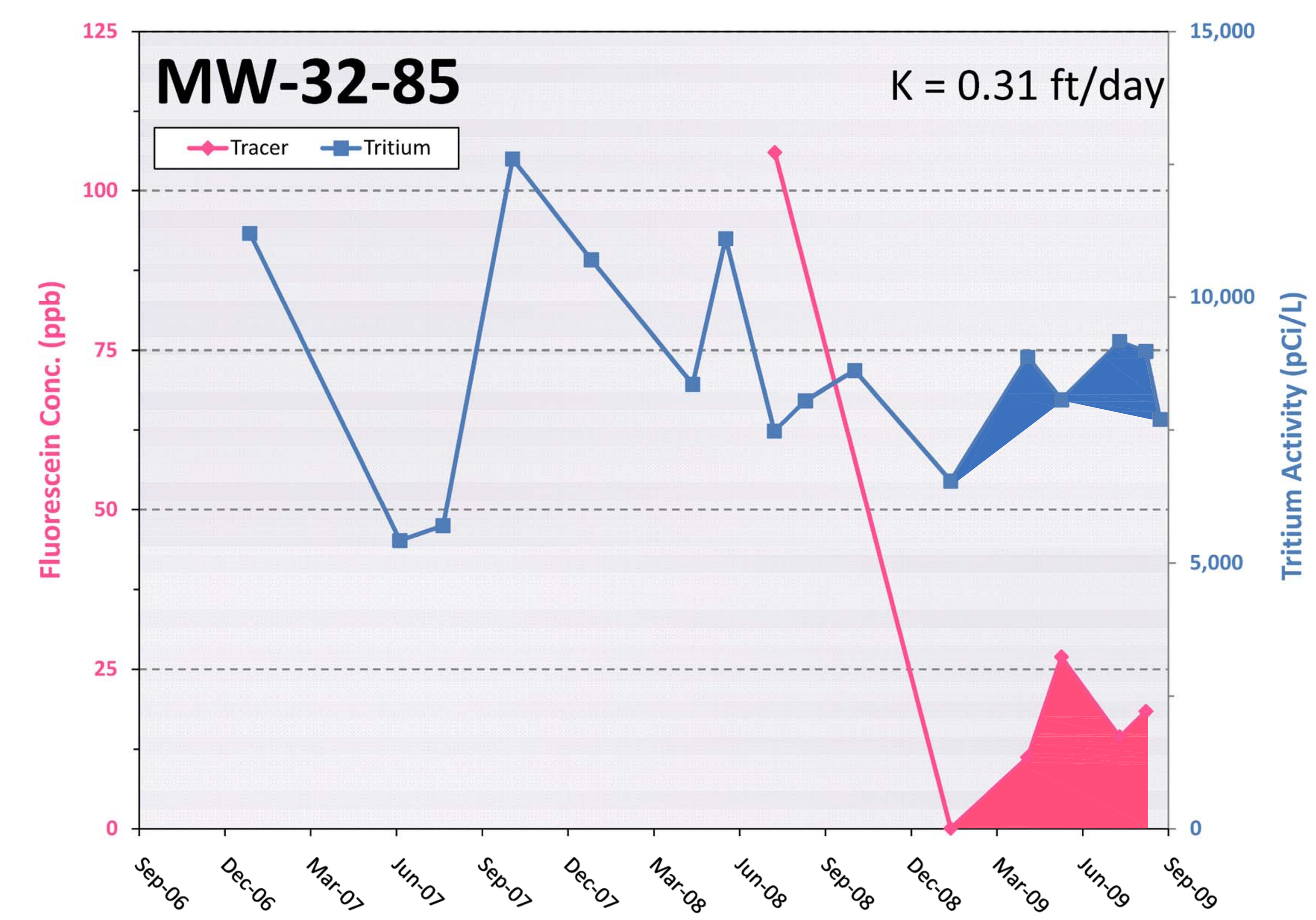


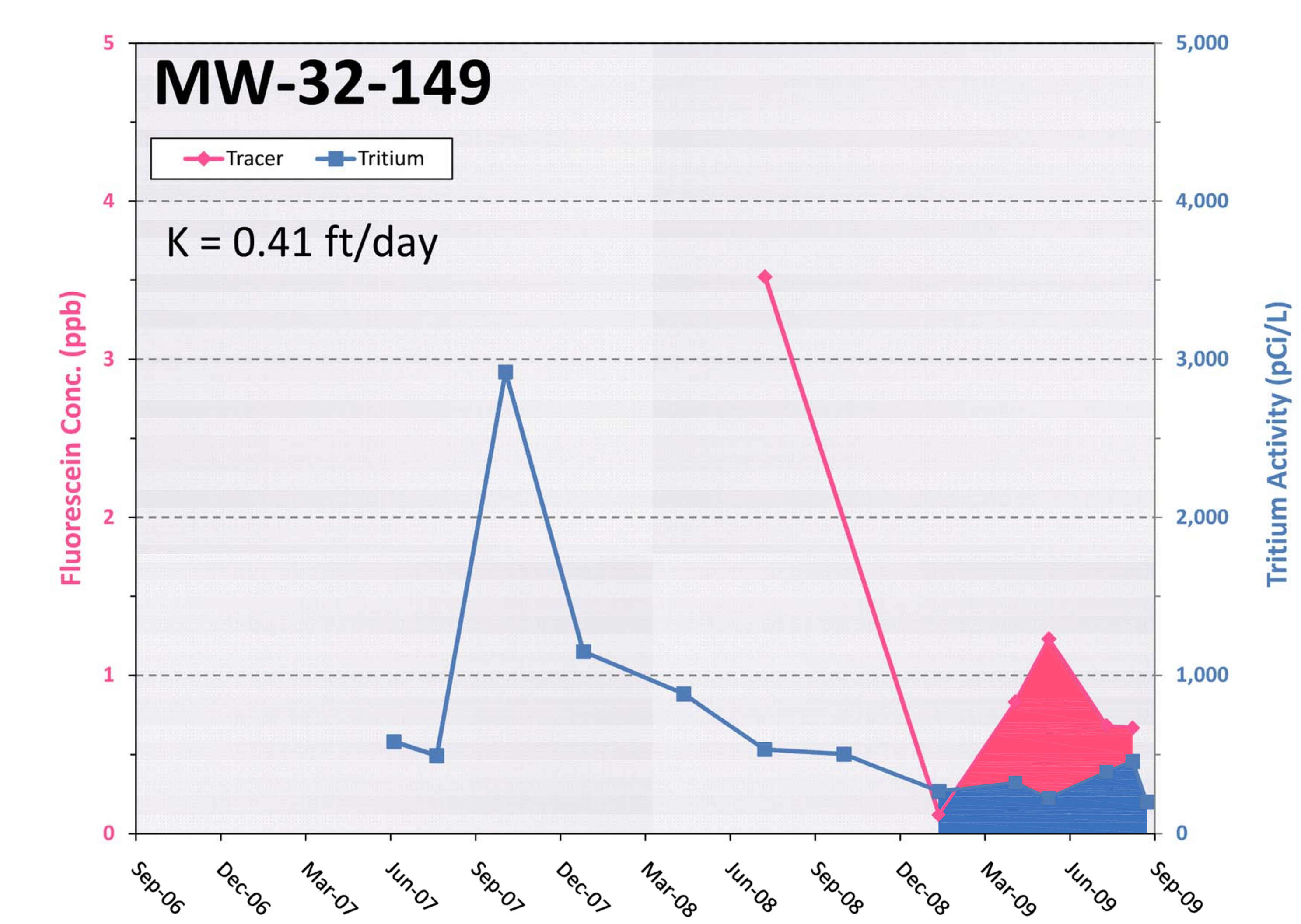


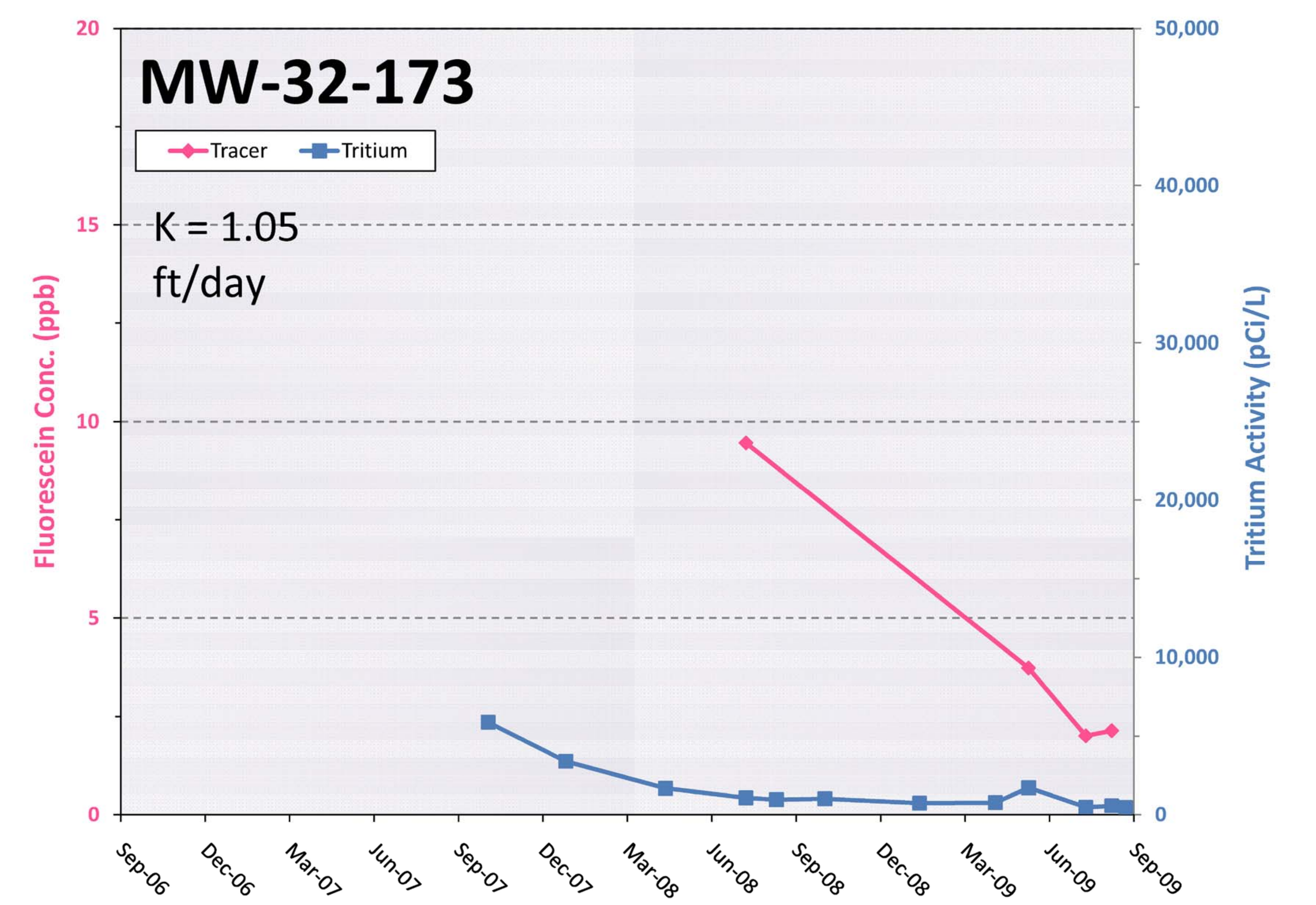


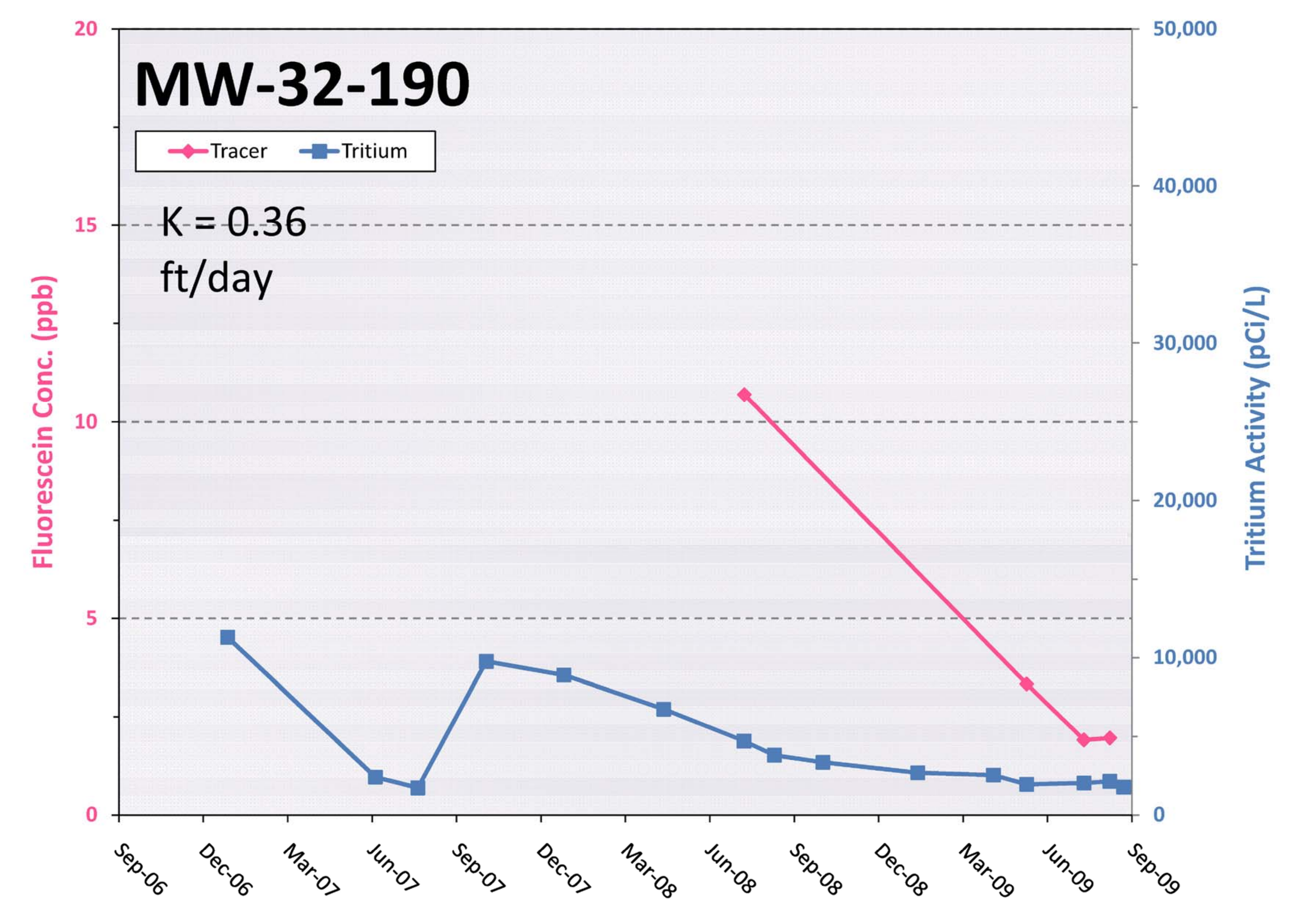
MW-32











GZA GeoEnvironmental, Inc.
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INDIAN POINT ENERGY CENTER
BUCHANAN, NEW YORK

RECENT TRACER DATA

PROJ MGR: MJB	DWG. DATE	06-17-2010	FIGURE NO. H1
DESIGNED BY: MJB			
REVIEWED BY: MJB	JOB NO.	41.0017869.92	
DRAWN BY: GAS			

TABLE H1
FIRST QUARTER 2009
UNIT 2: TRACER AND TRITIUM RESULTS
INDIAN POINT ENERGY CENTER
BUCHANAN, NY

MW-31-49			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
11/20/06	0	11/27/06	2.98E+02
11/27/06	0	1/18/07	1.20E+03
12/4/06	0	6/12/07	1.48E+03
1/18/07	0	8/2/07	1.19E+04
1/25/07	0	9/11/07	6.98E+03
2/1/07	0	10/24/07	8.77E+03
2/8/07	1,600	1/16/08	3.97E+02
2/9/07	746	6/6/08	3.04E+04
2/10/07	1,140	8/7/08	5.94E+02
2/11/07	682	2/6/09	1.11E+04
2/12/07	391	4/14/09	4.84E+04
2/13/07	275	5/29/09	9.34E+03
2/14/07	177		
2/15/07	149		
2/16/07	79.4		
2/17/07	82.5		
2/18/07	58		
2/19/07	50.5		
2/20/07	69.7		
2/21/07	29.1		
2/22/07	35.3		
2/23/07	24.6		
2/23/07	24.7		
2/26/07	24.5		
2/27/07	29.5		
2/28/07	29.9		
3/1/07	11.7		
3/2/07	14.4		
3/5/07	6.2		
3/6/07	1.9		
3/7/07	0.5		
3/8/07	0.2		
3/9/07	5.9		
3/12/07	2.4		
3/15/07	11.0		
3/16/07	15.1		
3/19/07	2.9		
3/19/07	2.8		
3/21/07	0.1		
3/23/07	0.1		
3/23/07	0.1		
3/26/07	0		
3/28/07	0.1		
3/29/07	0.2		
4/2/07	6.2		
4/4/07	0.6		
4/6/07	0.6		
4/9/07	0.4		
4/11/07	0.2		
4/18/07	2.2		
4/18/07	2.2		
4/23/07	1.7		
5/4/07	0.1		
5/4/07	0.1		
5/11/07	0.4		
6/12/07	0.4		
8/7/08	0.1		
2/6/09	0		
4/14/09	0		
5/29/09	0		
7/21/09	0		

MW-31-63			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
11/20/06	0	11/27/06	6.89E+03
11/27/06	0	1/18/07	1.41E+04
12/4/06	0	6/12/07	5.00E+03
1/18/07	0	8/2/07	4.06E+04
1/25/07	0	9/11/07	3.77E+04
2/1/07	0	10/24/07	3.58E+04
2/8/07	0	1/16/08	1.24E+04
2/9/07	0	6/6/08	1.02E+04
2/10/07	0	8/7/08	1.76E+04
2/11/07	212	8/30/08	2.21E+04
2/12/07	1,030	10/30/08	2.30E+04
2/13/07	3,820	11/18/08	2.55E+04
2/14/07	5,830	2/6/09	1.28E+04
2/15/07	7,500	4/14/09	3.24E+04
2/16/07	8,300	5/29/09	3.16E+04
2/17/07	9,340		
2/18/07	9,310		
2/19/07	10,800		
2/20/07	12,400		
2/21/07	9,230		
2/22/07	9,760		
2/23/07	12,700		
2/26/07	11,700		
2/27/07	10,400		
2/28/07	11,800		
3/1/07	10,500		
3/2/07	10,200		
3/5/07	9,460		
3/6/07	9,590		
3/7/07	8,790		
3/8/07	8,370		
3/9/07	7,540		
3/12/07	6,460		
3/15/07	4,390		
3/16/07	3,470		
3/19/07	2,480		
3/21/07	1,470		
3/23/07	1,310		
3/26/07	767		
3/28/07	653		
3/29/07	549		
4/2/07	471		
4/4/07	487		
4/6/07	331		
4/9/07	421		
4/11/07	327		
4/18/07	230		
4/23/07	209		
5/4/07	206		
5/11/07	118		
6/12/07	82.7		
8/7/08	4.5		
2/6/09	0.1		
4/14/09	0.5		
5/29/09	1.0		
7/21/09	0.514		

Refer to Page 4 for table notes.

TABLE H1
FIRST QUARTER 2009
UNIT 2: TRACER AND TRITIUM RESULTS
INDIAN POINT ENERGY CENTER
BUCHANAN, NY

MW-31-85			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
11/20/06	0	11/27/06	4.62E+02
11/27/06	0	1/18/07	2.66E+03
12/4/06	0	6/12/07	3.17E+02
1/18/07	0	8/2/07	2.69E+03
1/25/07	0	9/11/07	4.32E+03
2/1/07	0	10/24/07	5.51E+03
2/8/07	0	1/16/08	1.31E+03
2/9/07	0	6/6/08	5.95E+03
2/10/07	0	8/7/08	2.30E+03
2/11/07	0	8/30/08	8.34E+03
2/12/07	958	10/30/08	3.89E+03
2/13/07	1810	11/18/08	4.41E+03
2/14/07	1680	2/6/09	7.37E+03
2/15/07	1050	4/14/09	1.88E+04
2/16/07	715	5/29/09	8.85E+03
2/17/07	486		
2/18/07	367		
2/19/07	299		
2/20/07	222		
2/21/07	175		
2/22/07	148		
2/23/07	125		
2/26/07	99.7		
2/27/07	84.4		
2/28/07	77.3		
3/1/07	72		
3/2/07	62.6		
3/5/07	38.6		
3/5/07	38.7		
3/6/07	38.4		
3/7/07	21		
3/8/07	23.3		
3/9/07	25		
3/12/07	24.9		
3/15/07	30.7		
3/16/07	59.1		
3/19/07	68.4		
3/21/07	29.3		
3/23/07	14.4		
3/26/07	8.3		
3/28/07	8.2		
3/29/07	6.9		
4/2/07	8.3		
4/4/07	6.1		
4/6/07	4.9		
4/9/07	5		
4/11/07	4		
4/18/07	2.9		
4/23/07	2.5		
5/4/07	2.2		
5/11/07	2.5		
6/12/07	1.8		
8/7/08	0.4		
2/6/09	0		
4/14/09	0.1		
5/29/09	0.2		
7/21/09	0.05		

MW-32-59			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
11/21/06	0	1/19/07	7.67E+03
11/28/06	0	6/28/07	2.40E+04
12/4/06	0	8/13/07	1.42E+04
1/18/07	0	10/26/07	1.11E+04
1/25/07	0	1/18/08	1.87E+04
2/7/07	0	5/5/08	4.15E+03
2/8/07	23,800	6/9/08	2.85E+03
2/9/07	49,000	7/31/08	1.54E+03
2/10/07	14,500	9/2/08	2.44E+03
2/11/07	7,770	10/24/08	4.13E+02
2/12/07	3,950	2/4/09	1.78E+04
2/13/07	2,030	4/27/09	6.43E+04
2/14/07	1,380		
2/15/07	939		
2/16/07	733		
2/17/07	628		
2/18/07	498		
2/19/07	474		
2/20/07	378		
2/21/07	240		
2/22/07	238		
2/23/07	181		
2/26/07	115		
2/27/07	96.4		
2/28/07	89.3		
2/28/07	87.9		
3/1/07	79		
3/2/07	123		
3/5/07	16.8		
3/6/07	1.6		
3/7/07	23		
3/8/07	30.2		
3/9/07	37.8		
3/12/07	48.7		
3/13/07	56.2		
3/14/07	81.9		
3/15/07	79.9		
3/16/07	85.9		
3/19/07	45		
3/21/07	34		
3/23/07	19.5		
3/26/07	8.9		
3/28/07	10.4		
3/29/07	11.4		
4/2/07	35.3		
4/4/07	40.5		
4/6/07	23.9		
4/9/07	16.5		
4/11/07	26.5		
4/18/07	15.1		
4/23/07	2.2		
4/23/07	2.2		
5/4/07	14.6		
5/11/07	14.2		
6/14/07	2.2		
7/13/07	1.9		
7/31/08	0.1		
2/4/09	0.0		
6/2/09	0.0		

Refer to Page 4 for table notes.

TABLE H1
FIRST QUARTER 2009
UNIT 2: TRACER AND TRITIUM RESULTS
INDIAN POINT ENERGY CENTER
BUCHANAN, NY

MW-32-85			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
11/21/06	0	1/19/07	1.12E+04
11/28/06	0	6/28/07	5.42E+03
12/4/06	0	8/13/07	5.70E+03
1/18/07	0	10/26/07	1.26E+04
1/25/07	0	1/18/08	1.07E+04
2/7/07	0	5/5/08	8.36E+03
2/8/07	24,300	6/9/08	1.11E+04
2/9/07	4,730	7/31/08	7.48E+03
2/10/07	15,100	9/2/08	8.05E+03
2/11/07	7,810	10/24/08	8.62E+03
2/12/07	4,130	2/4/09	6.54E+03
2/13/07	2,100	4/27/09	8.87E+03
2/14/07	1,380	6/2/09	8.07E+03
2/15/07	951		
2/16/07	710		
2/17/07	643		
2/18/07	560		
2/19/07	472		
2/20/07	398		
2/21/07	340		
2/22/07	240		
2/23/07	182		
2/26/07	113		
2/27/07	95.7		
2/28/07	94.3		
3/1/07	83.8		
3/2/07	76.3		
3/5/07	70.8		
3/6/07	49.7		
3/7/07	19.9		
3/8/07	14.7		
3/9/07	19.4		
3/12/07	38.5		
3/13/07	71.1		
3/14/07	76.7		
3/15/07	85.7		
3/16/07	103		
3/19/07	141		
3/21/07	160		
3/23/07	195		
3/26/07	219		
3/28/07	235		
3/29/07	208		
4/2/07	234		
4/4/07	299		
4/6/07	340		
4/9/07	367		
4/11/07	407		
4/18/07	446		
4/23/07	461		
5/4/07	503		
5/11/07	442		
6/14/07	446		
7/13/07	275		
7/31/08	106		
2/4/09	0.1		
4/27/09	11.2		
6/2/09	26.9		
8/3/09	14.4		
8/31/09	18.4		

MW-32-149			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
2/7/07	0	1/19/07	1.05E+04
2/8/07	0	6/28/07	5.81E+02
2/9/07	0	8/13/07	4.93E+02
2/10/07	36.9	10/26/07	2.92E+03
2/11/07	1,650	1/18/08	1.15E+03
2/12/07	3,850	5/5/08	8.83E+02
2/12/07	3,840	7/31/08	5.32E+02
2/13/07	4,160	10/24/08	5.03E+02
2/14/07	3,620	2/4/09	2.65E+02
2/14/07	3,620	4/27/09	3.21E+02
2/15/07	2,650	6/2/09	2.24E+02
2/16/07	1,970		
2/16/07	1,990		
2/17/07	1,590		
2/18/07	1,270		
2/19/07	1,120		
2/20/07	926		
2/21/07	682		
2/22/07	605		
2/23/07	489		
2/26/07	121		
2/27/07	97.7		
2/28/07	92.9		
3/1/07	87.8		
3/2/07	72.4		
3/5/07	98.2		
3/6/07	110		
3/7/07	102		
3/8/07	102		
3/9/07	97.3		
3/12/07	105		
3/13/07	102		
3/14/07	98.3		
3/15/07	95.1		
3/16/07	94.8		
3/19/07	84.8		
3/21/07	79.5		
3/23/07	88.2		
3/26/07	75.3		
3/28/07	67.8		
3/29/07	62.4		
4/2/07	52.5		
4/4/07	51.8		
4/6/07	53.7		
4/9/07	48.3		
4/11/07	45.2		
4/18/07	38.2		
4/23/07	33		
5/4/07	28.6		
5/11/07	25.2		
6/14/07	16.4		
7/13/07	11.7		
7/31/08	3.52		
2/4/09	0.117		
4/27/09	0.832		
6/2/09	1.23		

Refer to Page 4 for table notes.

TABLE H1
FIRST QUARTER 2009
UNIT 2: TRACER AND TRITIUM RESULTS
INDIAN POINT ENERGY CENTER
BUCHANAN, NY

MW-32-173			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
7/31/08	9.46	10/26/07	5.89E+03
6/2/09	3.73	1/18/08	3.40E+03
		5/5/08	1.69E+03
		7/31/08	1.08E+03
		9/2/08	9.72E+02
		10/24/08	1.03E+03
		2/4/09	7.56E+02
		4/27/09	7.86E+02
		6/2/09	1.72E+03

MW-32-190			
Date	**Tracer (ppb)**	**Date**	**Tritium (pCi/L)**
11/21/06	0	1/19/07	1.13E+04
11/28/06	0	6/28/07	2.41E+03
12/4/06	0	8/13/07	1.72E+03
1/18/07	0	10/26/07	9.76E+03
1/25/07	0	1/18/08	8.89E+03
1/25/07	0	5/5/08	6.73E+03
2/7/07	0	7/31/08	4.71E+03
2/8/07	0	9/2/08	3.81E+03
2/9/07	0	10/24/08	3.35E+03
2/10/07	0	2/4/09	2.69E+03
2/11/07	0	4/27/09	2.54E+03
2/12/07	0	6/2/09	1.95E+03
2/13/07	0		
2/14/07	1.4		
2/15/07	16		
2/16/07	75		
2/17/07	143		
2/18/07	247		
2/19/07	417		
2/20/07	385		
2/21/07	525		
2/22/07	581		
2/23/07	569		
2/26/07	621		
2/27/07	558		
2/28/07	543		
3/1/07	488		
3/2/07	380		
3/5/07	326		
3/6/07	297		
3/7/07	210		
3/8/07	168		
3/9/07	159		
3/12/07	160		
3/13/07	142		
3/14/07	145		
3/15/07	148		
3/16/07	140		
3/19/07	132		
3/21/07	135		
3/23/07	150		
3/26/07	147		
3/28/07	150		
3/29/07	131		
4/2/07	137		
4/4/07	141		
4/6/07	148		
4/9/07	156		
4/11/07	142		
4/18/07	129		
4/23/07	117		
5/4/07	109		
5/11/07	88		
6/14/07	56		
7/13/07	38.6		
7/31/08	10.7		
6/2/09	3.3		

Notes:
1. For Waterloo multi-level systems, the suffix of the sample identification indicates depth (rounded to nearest foot) from reference point on casing to top of sampling port.
2. Sampling depths within sampling intervals (location of pump intake) have been established at location of most transmissive zone to the extent possible.
3. Current well identifications are shown for each location. Minor name changes have been made based on altered transducer installations.
4. Tracer samples were analyzed by Ozark Underground Laboratory, Inc. (OUL) of Protem, Missouri for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Eosine and RWT dyes were not detected. Therefore this table summarizes fluorescein dye concentrations.
5. Dye concentrations are reported in parts per billion (ppb).

GZA GeoEnvironmental, Inc.

Engineers and Scientists

MEMORANDUM

TO: Mr. Patrick Donahue – Entergy
Mr. Bob Evers – Enercon

FROM: Matthew Barvenik and Dave Rusczyk – GZA

DATE: June 14, 2010

RE: Memorandum - Additional Tracer Test Analyses

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As part of the hydrogeological investigation program performed at the Indian Point Energy Center (IPEC) site located in Buchanan, New York, GZA GeoEnvironmental, Inc. (GZA), on behalf of Entergy, previously conducted an extensive tracer study in the vicinity of the Unit 2 Spent Fuel Pool (IP2-SFP). The purpose of this technical Memorandum, prepared at your request, is to provide the results of additional tracer sampling and analyses subsequently conducted as part of the Quarter 3 2008 Long Term Monitoring Program[1].

BACKGROUND

The groundwater tracer testing was initiated on February 8, 2007 with the injection of fluorescein dye into the vadose zone at the top of the bedrock surface immediately adjacent to the IP2-SFP and monitoring well MW-30. Subsequent to the injection, routine groundwater sampling and analyses were conducted through approximately June 2007[2] with the results presented in the January 2008 Final Hydrogeologic Site Investigation Report (Final Report[3]).

As initially identified in the Final Report and more recently discussed in the Q1 2009 Long Term Monitoring Report, the Unit 2 Tritium plume has decreased in concentration relative to the samples taken just after identification of the 2005 shrinkage crack leak[4] and continues to show a general trend of decreasing concentrations over time. However, the plume still exhibits concentrations greater than we can explain if there were no further Tritium inputs <u>to the groundwater</u>; i.e., the plume would attenuate more quickly than observed[5]. This reduced rate of Tritium decrease over time can be explained by either: 1) an ongoing small (< 5L/day) leak in the IP2- SFP; 2) a "retention mechanism" in the saturated and unsaturated zones under the IP2-SFP that can retain

[1] These tracer data were also provided in the IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarters Two and Three, Report No. 3, February 6, 2009.

[2] Additional more limited sampling was conducted through approximately August 2007. However, the "current" sampling data presented in the Final Report (as Figure 7.3) was through June 2007 to take advantage of the increased number of sampling locations up to that time.

[3] Hydrogeologic Site Investigation Report, January 7, 2008, prepared by GZA GeoEnvironmental, Inc, on behalf of Enercon Services, Inc., for Entergy Nuclear Northeast, Indian Point Energy Center, 450 Broadway, Buchanan, NY 10511.

[4] For example, the earliest samples taken from directly below the SFP in MW-30 (open borehole and packer testing samples) yielded Tritium concentrations over 600,000 pCi/L. More currently, maximum concentrations detected have been below one-half of those initial concentrations.

[5] Rapid attenuation of the Tritium plume would be expected based on 1) Tritium's lack of partitioning to solid materials in the subsurface; 2) the crystalline nature and low storativity of the bedrock; and 3) the computed and observed groundwater transport rate.

substantial volumes of highly tritiated water (e.g., SFP leakage) for substantial amounts of time[6]; and/or 3) a combination of the above.

While Tritium concentrations in the groundwater plume could be impacted by both an ongoing leak and the retention mechanisms cited above, tracer concentrations in the groundwater cannot be replenished by SFP leakage. Given the elapsed time of approximately one and a half years from the initial tracer injection, we calculate that in the absence of groundwater storage mechanisms, significant concentrations of the tracer would now have been flushed from the groundwater flow system. As shown in Figure 1 and discussed below, significant tracer still remains.

RESULTS

To provide further data with which to continue testing the validity of the Conceptual Site Model (CSM), additional groundwater samples were collected and analyzed for fluorescein concentrations during the Third Quarter of the 2008 (Q3 2008) Long Term Groundwater sampling round. A summary of the results of the fluorescein analyses is presented in Table 1**.** These data, as discussed below, continue to support the existence of storage/retention mechanisms, which explain the currently observed decreased rate of Tritium reduction in the groundwater over time[7].

Figure 1 is patterned after Figure 7.3 from the Final Investigation Report. For Figure 1, the "current tracer concentration isopleths" reflect an August 2008 sampling date rather than the then current June 2007 date cited in Figure 7.3; over one year later. As compared to that shown on Figure 7.3, the current tracer plume shows reduced concentrations proximate to the IP2-SFP, but also shows that the plume length has extended along the Tritium plume alignment all the way to the river. Additionally, we note that:

- To the extent defined by this more limited data set, the general plume shape has remained approximately the same, with additional elongation towards the river;
- Although reduced in magnitude, the current concentrations generally match the relative trends exhibited previously; i.e., pursuant to variation between proximate locations and over depth at individual locations. For example, the middle sampling zone in MW-31 still shows the highest concentration for this location, followed by the lowest zone and then the uppermost zone[8]; and
- Water was found in the vadose zone above the top packer in RW-1. This "trapped water" was sampled and yielded a very high tracer concentration (39,000 ppb as compared to the highest concentration detected in the groundwater over the entire test duration; i.e., 49,000 ppb in MW-32 near the very beginning of the testing. We believe these data demonstrate that "dead end fractures" have the capacity to store substantial contaminant concentrations over relatively long periods of time.

[6] This hypothesized "retention mechanism" is supported by our understanding of the construction methods used for the IP2-SFP and adjacent structures, evaluations of contaminant concentration variability trends over short timeframes and precipitation events, as well as the original tracer test results, as further described in Sections 7.0 and 8.0 of the Final Report.
[7] Decreased rate as compared to the case where there are no continuing additions of Tritium to the groundwater flow regime from the vadose zone.
[8] As provided in the figure legend, the tracer concentrations for the "June 2007 current plume" are provided to the left of the bar graphs for each sampling depth.

CONCLUSIONS

Overall, these findings from the most recent tracer sample analyses are consistent with the previous tracer data, and the associated conclusions presented in the Final Report. As such, the current demonstration that the tracer persists in the groundwater flow regime over even much longer time frames now provides even stronger support for the existence of "retention mechanisms," as posited by existing the CSM for the IPEC site. In fact, a direct analog for "contaminant storage in dead-end bedrock fractures" is provided by the high tracer concentrations found above the upper packer in the vadose zone in RW-1. Therefore, given that tritiated water behaves much as the tracer does, it should be expected that once highly tritiated water has been released from the SFP, it becomes "trapped" (held in storage) and is slowly released to the groundwater flow regime over substantial periods of time. These retention mechanisms therefore act as a continuing source to the groundwater and thus can explain the observed slow rate of Tritium concentration reduction in the Unit 2 plume. Therefore, the persistence of the Unit 2 Tritium plume does not, in and of itself, demonstrate that the Unit 2 SFP must still be leaking. In fact, the currently observed behavior was predicted in the Final Report based on the then available data.

We appreciate the opportunity to be of service to you. Should you have any questions or comments, please feel free to contact Matt or Dave at (781) 278-3805 or (860) 858-3110.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

Matthew J. Barvenik, LSP
Senior Principal

Date:June 14, 2010

David Rusczyk, PE
Senior Project Manager

Date:June 14, 2010

Michael Powers, PE
Consultant/Reviewer

Date:June 14, 2010

Attachments: Table 1: 2008 3rd Quarter Groundwater Analytical Results for Tracer Dye (Fluorescein)

Figure 1: Current Tracer (Fluorescein) Concentration Isopleths in Groundwater

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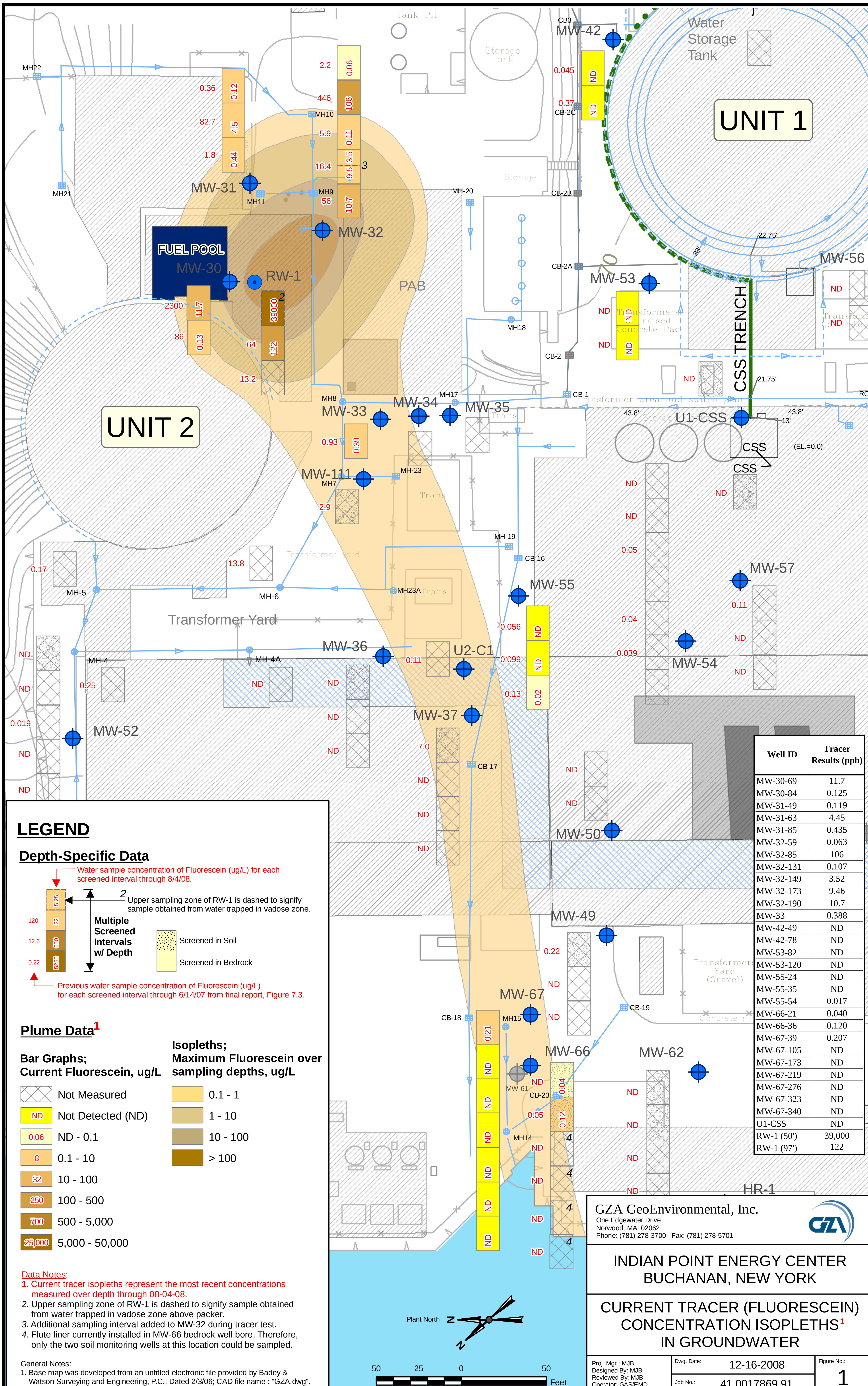
TABLE 1
2008 3rd QUARTER
GROUNDWATER ANALYTICAL RESULTS
for TRACER DYE (FLUORESCEIN)
INDIAN POINT ENERGY CENTER
BUCHANAN, NY

Well ID[1]	Sample Collection		Results	
	Date	Time	Peak (nm)[2]	Concentration (ppb)[2]
MW-30-69	8/5/08	10:24	515.1 [3]	11.7
MW-30-84	8/5/08	10:30	513.4 [3]	0.125
MW-31-49	8/7/08	11:34	514.1 [3]	0.119
MW-31-63	8/7/08	9:17	512.7 [3]	4.45
MW-31-85	8/7/08	9:13	513.9 [3]	0.435
MW-32-59	7/31/08	11:57	512.8 [3]	0.063
MW-32-85	7/31/08	13:30	509.2	106
MW-32-131	7/31/08	11:29	508.6	0.107
MW-32-149	7/31/08	9:54	508.8	3.52
MW-32-173	7/31/08	9:52	508.5	9.46
MW-32-190	7/31/08	9:50	508.7	10.7
MW-33	8/1/08	12:45	508.5	0.388
MW-42-49	8/4/08	13:52	ND [4]	ND
MW-42-78	8/4/08	12:08	ND	ND
MW-53-82	8/4/08	10:02	ND	ND
MW-53-120	8/4/08	9:40	ND	ND
MW-55-24	8/1/08	10:10	ND	ND
MW-55-35	8/1/08	9:44	ND	ND
MW-55-54	8/1/08	9:26	508.6 [3]	0.017
MW-66-21	7/29/08	10:20	508.2 [5]	0.040
MW-66-36	7/29/08	10:25	509.0	0.120
MW-67-39	7/28/08	12:42	508.7	0.207
MW-67-105	7/28/08	12:40	ND	ND
MW-67-173	7/28/08	12:35	ND	ND
MW-67-219	7/28/08	9:33	ND	ND
MW-67-276	7/28/08	9:35	ND	ND
MW-67-323	7/28/08	9:40	ND	ND
MW-67-340	7/28/08	9:26	ND	ND
U1-CSS	8/1/08	13:50	ND	ND
RW-1 (50')	8/5/08	11:25	508.7	39,000
RW-1 (97')	8/5/08	11:45	508.5	122

Notes:

* Dye concentrations are based upon standards used at the Ozark Underground Laboratory. The standard concentrations are based upon the as-sold weight of the dye that the OUL uses. The is a mixture of 75% dye and 25% diluent.

1. For nested multi-level monitoring wells, suffix of well ID indicates depth (rounded to nearest foot) from reference point on casing to bottom of well screen. For Waterloo multi-level systems, suffix indicates depth (rounded to nearest foot) from reference point on casing to top of sampling port. Well IDs without a suffix are open bedrock wellbores.
2. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).
3. A fluorescence peak is present that does not meet all the criteria for this dye. However, it has been calculated as though it were the tracer dye.
4. ND indicates that tracer (fluorescein) was not detected.
5. A fluorescence peak is present that does not meet all the criteria for a positive dye result. However, it has been calculated as though it were the tracer dye.



Well ID	Tracer Results (ppb)
MW-30-69	11.7
MW-30-84	0.125
MW-31-49	0.119
MW-31-63	4.45
MW-31-85	0.435
MW-32-59	0.063
MW-32-85	106
MW-32-131	0.107
MW-32-149	3.52
MW-32-173	9.46
MW-32-190	10.7
MW-33	0.388
MW-42-49	ND
MW-42-78	ND
MW-53-82	ND
MW-53-120	ND
MW-55-24	ND
MW-55-35	ND
MW-55-54	0.017
MW-66-21	0.040
MW-66-36	0.120
MW-67-39	0.207
MW-67-105	ND
MW-67-173	ND
MW-67-219	ND
MW-67-276	ND
MW-67-323	ND
MW-67-340	ND
U1-CSS	ND
RW-1 (50')	39,000
RW-1 (97')	122

LEGEND

Depth-Specific Data

Water sample concentration of Fluorescein (ug/L) for each screened interval through 8/4/08.

2 Upper sampling zone of RW-1 is dashed to signify sample obtained from water trapped in vadose zone.

Multiple Screened Intervals w/ Depth

Screened in Soil

Screened in Bedrock

Previous water sample concentration of Fluorescein (ug/L) for each screened interval through 6/14/07 from final report, Figure 7.3.

Plume Data[1]

Bar Graphs; Current Fluorescein, ug/L

- Not Measured
- ND — Not Detected (ND)
- 0.06 — ND - 0.1
- 8 — 0.1 - 10
- 32 — 10 - 100
- 250 — 100 - 500
- 700 — 500 - 5,000
- 25,000 — 5,000 - 50,000

Isopleths; Maximum Fluorescein over sampling depths, ug/L

- 0.1 - 1
- 1 - 10
- 10 - 100
- > 100

Data Notes:

1. Current tracer isopleths represent the most recent concentrations measured over depth through 08-04-08.
2. Upper sampling zone of RW-1 is dashed to signify sample obtained from water trapped in vadose zone above packer.
3. Additional sampling interval added to MW-32 during tracer test.
4. Flute liner currently installed in MW-66 bedrock well bore. Therefore, only the two soil monitoring wells at this location could be sampled.

General Notes:

1. Base map was developed from an untitled electronic file provided by Badey & Watson Surveying and Engineering, P.C., Dated 2/3/06; CAD file name : "GZA.dwg".

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INDIAN POINT ENERGY CENTER
BUCHANAN, NEW YORK

CURRENT TRACER (FLUORESCEIN) CONCENTRATION ISOPLETHS[1] IN GROUNDWATER

Proj. Mgr.: MJB
Designed By: MJB
Reviewed By: MJB
Operator: GAS/EMD

Dwg. Date: 12-16-2008

Job No.: 41.0017869.91

Figure No.: 1

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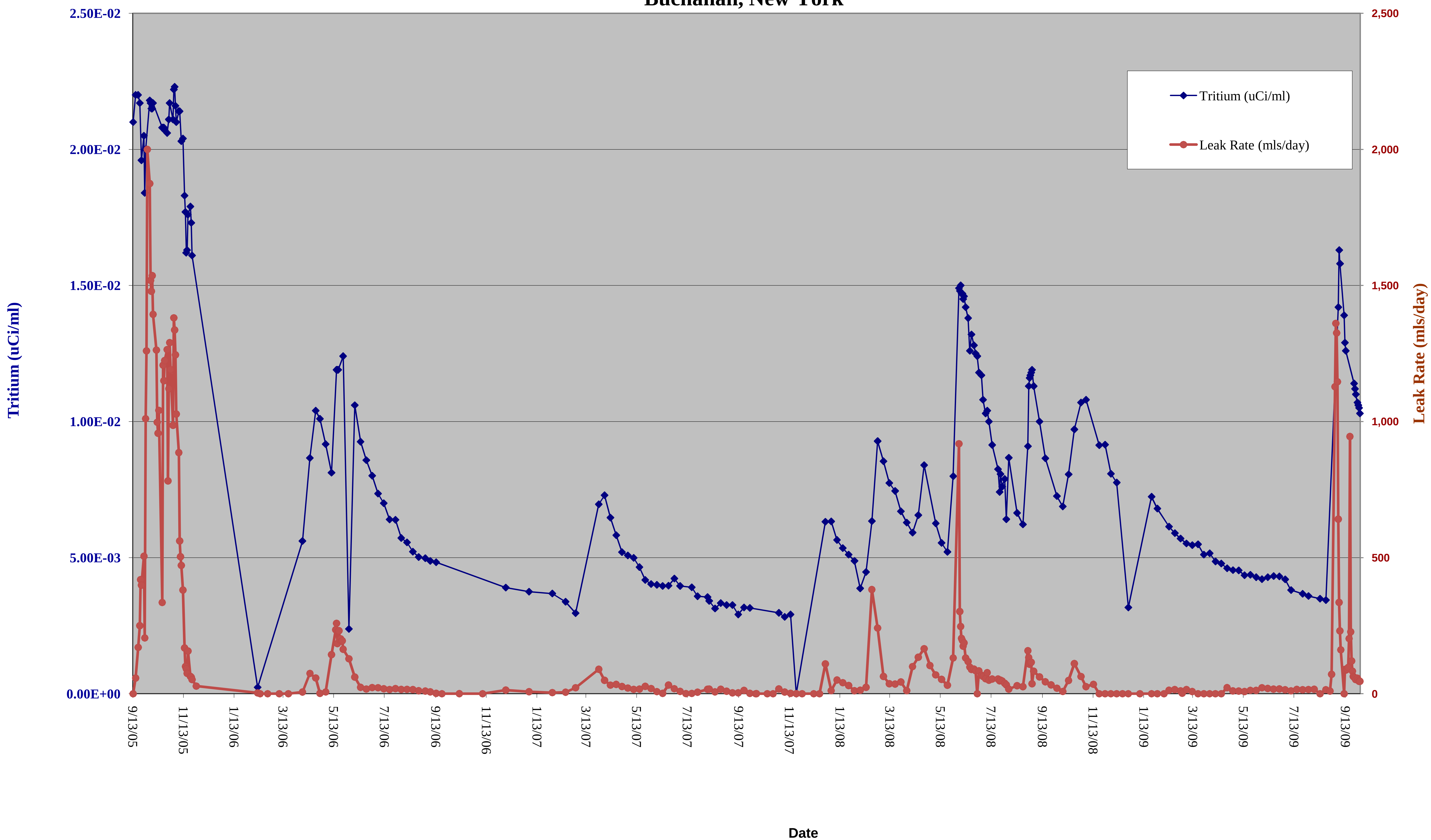
APPENDIX I: LEAK COLLECTION BOX DATA

Figure I-1
Collection Box Data
Indian Point Energy Center
Buchanan, New York



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November 19, 2009

APPENDIX J: LAFARGE WELL LAF-002 REFURBISHMENT

GZA GeoEnvironmental, Inc.

Engineers and Scientists

MEMORANDUM

TO: Mr. Patrick Donahue – Entergy
Mr. Bob Evers – Enercon

FROM: Matthew Barvenik and Dave Rusczyk – GZA

DATE: June 14, 2010

RE: Memorandum - LaFarge Well Refurbishment Summary

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At the request of Entergy Nuclear Northeast, Inc. (Entergy) and under subcontract to Enercon Services, Inc., GZA GeoEnvironmental of New York (GZA) refurbished existing bedrock monitoring well LAF-002 (also previously referred to as MW-2) located at the LaFarge Gypsum property to the south of the Indian Point Energy Center (IPEC). Well LAF-002 is being refurbished for use in IPEC's Long Term Groundwater Monitoring Program (LTMP). The following is a summary of the condition of well LAF-002 prior to refurbishment and the refurbishment activities performed in November 2008 by GZA.

- According to installation logs included in a letter report dated February 12, 2001 by Earth Data Incorporated, LAF-002 was constructed with 26.5 feet of six-inch interior diameter steel casing set into the bedrock surface (approximately 10 feet below grade [fbg]). The well originally consisted of an open borehole from 26.5 to 50 fbg; however the well was later extended to 140 fbg in an attempt to increase well yeild. Potential fractures were observed at 42 fbg, 48 fbg, 80-90 fbg, 110-115 fbg, and 135 fbg. After deepening, the well yield was estimated to have doubled, but still less than ¼ gallons per minute (gpm).

- LAF-002 is located adjacent to large gypsum piles and the steel casing for the well is cut-off flush with the ground surface (See Photographs #1, #2 and #3 below). It is also noted that the gypsum pile has, in the recent past, extended over the well, which was, at that time, extended above the pile with PVC casing (See Photograph #4). The well is equipped with an expandable cap; however given the condition of the well and the proximity of the gypsum pile, groundwater quality within the well may potentially be influenced by surface water infiltration. Since this well has been incorporated into the IPEC LTMP, the well was redeveloped and the top of the well refurbished to mitigate potential surface water infiltration.

PHOTOGRAPH #1 PHOTOGRAPH #2

PHOTOGRAPH #3 PHOTOGRAPH #4

- Between November 24th and 25th, 2008, SGS Drilling Services (SGS) of West Creek, NJ, under contract to and supervision by GZA, mobilized to the Site to redevelop and refurbish the well head of monitoring well LAF-002. Prior to re-development, GZA temporarily removed the dedicated bladder pump and tubing from the well and measured a total well depth of 148.5 fbg feet[1].

- SGS advanced a roller bit to the bottom of the well to break up the settled materials present at the bottom of the well[2] (See Photographs #5 and #6 below). During this process, water was flushed through the drilling rods to the bottom of the well and subsequently up to the ground surface. The flushed material was slightly turbid and included PVC cuttings, other plastic debris, metal shavings, sand, gravel, and black rock.

[1] The measured depth to bottom of the well is different from that noted on the boring log (140') in the Earth Data Incorporated letter report, dated February 12, 2001. Given the presence of the adjacent gypsum pile, it is likely the grade in the vicinity of the well has changed.
[2] While lowering the drilling rods, it became apparent that the borehole was not vertical, nor linear, given the drill rod binding observed. GZA believes that the well was installed at a slight angle and that the borehole curves slightly to the south with depth.

PHOTOGRAPH #5

PHOTOGRAPH #6

- SGS subsequently utilized a customized surge block to surge the length of the well three times (See Photograph #7 below). Additional surging was also performed in the three zones within the borehole containing the most productive fractures (as based on the original drilling logs) and twenty-feet above the static water table. Water was added to the well casing so that the interval above the static water column could be surged.

PHOTOGRAPH #7

- Following surging, SGS used air lifting techniques to remove both coarse and fine materials from the well. This technique involved injecting air into the bottom of the well at relatively high pressures resulting in a rapid evacuation of the contents of the well and the creation of a differential pressure between the static groundwater surrounding the borehole and the bottom of the well. This differential pressure forced groundwater to flow into the well from the productive fractures and further flush sediment out of the bedrock fractures. During this process, GZA observed additional debris (PVC cuttings, plastic, and metal shavings) and sediment (sand, silt, gravel, and rock) among the evacuated materials.

- The following day, SGS purged the well at approximately five gpm using a submersible pump (See Photographs #8 and 9 below). This process was continued until the well purged dry. It should be noted that the purge water ran clear within a few minutes of purge commencement.

PHOTOGRAPH #8

PHOTOGRAPH #9

- SGS repaired the wellhead to protect it from runoff, intrusion of debris and foreign materials, and damage by moving vehicles and equipment. SGS welded a length of 6-inch steel casing onto the top of the existing casing so that it extended approximately three feet above the surrounding ground surface. SGS also installed a concrete pad around the base of the well casing and four 5-foot concrete filled bollards a few feet from each corner of the pad. The well casing and bollards were painted yellow and a lockable cap with lock was installed on the well head. (See Photograph #10 below).

PHOTOGRAPH #10

We appreciate the opportunity to be of service to you. Should you have any questions or comments, please feel free to contact Matt or Dave at (781) 278-3805 or (860) 858-3110.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

Matthew J. Barvenik, LSP
Senior Principal

Date:June 14, 2010

David Rusczyk, PE
Senior Project Manager

Date:June 14, 2010

Michael Powers, PE
Consultant/Reviewer

Date:June 14, 2010

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APPENDIX K: GROUNDWATER LEVEL TRANSDUCER REDEPLOYMENT

GZA GeoEnvironmental, Inc.

Engineers and Scientists

MEMORANDUM

TO: Mr. Patrick Donahue – Entergy
Mr. Bob Evers – Enercon

FROM: Matthew Barvenik and Dave Rusczyk – GZA

REVIEWED BY: Michael Powers – GZA

DATE: June 14, 2010

RE: Memorandum on Proposed Redeployment of Groundwater Level Transducers for the Long Term Monitoring Program

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Massachusetts
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Norwood, MA 02062
Phone: 781-278-3700
Fax: 781-278-5701

At the request of Entergy Nuclear Northeast, Inc. (Entergy) and under subcontract to Enercon Services, Inc., GZA GeoEnvironmental of New York (GZA) has evaluated the continued use of the existing groundwater level transducers as part of the Long Term Monitoring Program. The following memo provides the basis for our recommendation that a limited number of these transducers be maintained in long-term operation.

BACKGROUND

As a part of the Hydrologic Site investigation for the Indian Point Energy Center (IPEC), electronic pressure transducers were placed in a large number of monitoring wells[1] at the site to routinely record groundwater levels over time. These data were converted into groundwater elevations, both water table elevations and piezometric elevations at multiple depths in the formation up to 350 feet below ground surface. The groundwater elevations were then used to develop groundwater contours and thus horizontal and vertical gradients across the site. These gradients, along with the hydraulic conductivities (measured using other investigation methods), were employed to compute groundwater flow rates through the site. These data, in part, formed the basis for the formulation, and refinement over time, of the Conceptual Site Model (CSM). The large amount of multi-level transducer data collected during the investigations (and initial Long Term Monitoring Program) allowed the conclusion to be reached (and further verified) that the behavior of the fractured bedrock could be characterized as a blocky porous medium, a major finding which significantly simplifies site analysis. Further summaries of this work are provided in the Final Hydrologic Site Investigation Report[2].

One specific objective of the work referenced above was to develop a method for routinely computing the estimated total yearly activity of radionuclides flowing to the Hudson River via the groundwater pathway (both directly to the river and also through the Discharge Canal). This total yearly activity is computed as the product of the groundwater flow rate and its radionuclide activity ("concentration"), as measured by analyses of groundwater samples collected from the monitoring installations, over time. The yearly total activity is then used to compute the radionuclide dose to the river.

[1] As used in this memo, "monitoring well" includes a number of different types of groundwater monitoring instrumentation including: 2" standard single monitoring well casings/screens, small diameter (1") multi-level nested well casings/screens, multi-level Waterloo installations, and stilling wells.

[2] Hydrogeologic Site Investigation Report, January 7, 2008, prepared by GZA GeoEnvironmental, Inc, on behalf of Enercon Services, Inc., for Entergy Nuclear Northeast, Indian Point Energy Center, 450 Broadway, Buchanan, NY 10511.

To routinely estimate groundwater flow (i.e., groundwater mass flux) through the Site, an analytical groundwater flow computation was formulated based on a Precipitation Mass Balance Model. This model is based on the precept that, on a long term average, the groundwater flowing through and discharging from the aquifer is equal to the watershed infiltration recharge. This mass balance approach recognizes that the only substantial source of recharge to the aquifer is areal recharge derived from precipitation.

The Precipitation Mass Balance Model was calibrated[3] to groundwater fluxes computed using a Darcy's Law Model[4] based on site-specific groundwater elevation gradients and hydraulic conductivities. As summarized above, the groundwater pressure transducers provided an integral part of the data used to develop the overall CSM, as well as the Darcy's Law Model with respect to the groundwater flux distribution, both laterally and with depth throughout the site. The calibration compared the total groundwater flux values for each of six flow zones[5] computed independently[6] using the Precipitation Mass Balance Model and the Darcy's Law Model. This calibration not only verified the reasonableness of the overall groundwater flow rates predicted by the Precipitation Mass Balance Model, but also allowed further discretization of the groundwater flow into upper and lower flow zones as well as flow volumes upgradient and downgradient of the Discharge Canal, as described more fully in the Hydrogeologic Site Investigation Report.

The initial calibration was performed using gradients derived from contours of groundwater elevation measured on June, 1 2007. As part of the initial portions of the Long Term Monitoring Program, this calibration has been evaluated quarterly to verify that seasonal changes in groundwater elevations do not materially impact the validity of the calibration. To date, quarterly groundwater elevations measured with the transducers at representative low river tides[7] have been used to verify the Precipitation Mass Balance Model for the 2nd, 3rd, and 4th quarters of 2007[8], the 1st, 2nd, 3rd and 4th quarters of 2008 and the 1st and 2nd quarters of 2009[9]. As further described in these quarterly reports[10], the Precipitation Mass Balance Model has continued to provide suitably accurate approximations of the groundwater flow values computed using the Darcy's Law Model. Therefore, given the small variability of flow over the seasons monitored to date, as well as the overall recognition that the computed doses to the river are a small fraction of the permitted amounts, GZA believes that further calibration of the Precipitation Mass Balance Model is

---

[3] The process of achieving the desired degree of correspondence between the model results and observations of the physical hydrogeologic system.
[4] Both analytic modeling techniques as well as a 3-dimensional numerical model (Modflow), all based on Darcy's law for porous media, were used for the calibration of the Precipitation Mass Balance Model.
[5] See Hydrogeologic Site Investigation Report.
[6] The two models use different sets of input parameters which are not dependent or related to each other. The groundwater flow computed using the Precipitation Mass Balance Model is based on yearly precipitation amounts and the proportion of this precipitation that results in infiltration recharge to the groundwater. The Darcy's Law Model, on the other hand, is based on the measured groundwater flow gradients (as computed from groundwater elevation contours constructed from the transducer readings) and estimates of the formation hydraulic conductivity.
[7] Previous evaluations (provided in the Hydrogeologic Site Investigation Report) have shown that the shape of the groundwater contours is relatively unchanged at different times of the tidal cycle. However, the use of low tide contours provides the greatest transient gradients (larger than the average gradient) and therefore result in a computed groundwater flux from the Site that is biased high. Computation of radionuclide release rates to the river based on these data will therefore also have a high bias (i.e., they will be conservative).
[8] There was no formal 1st quarter monitoring event in 2007 given that the Long Term Monitoring Program had not yet been initiated.
[9] Transducer level data has also been collected and analyzed for Quarter 2 of 2009. While Quarter 2 technically post-dates the timeframe covered by this report, these data were included given their availability at the time of the writing of the report and also because Q2 is the last quarter for which full rounds of transducer data is to be collected.
[10] See Quarterly Reports prepared by GZA including: Final 2007 Quarterly Report dated May 1, 2008; Quarter 1 2008 Quarterly Report dated May 15, 2008; Quarter 2 and 3 2008 Quarterly Report dated February 6, 2009; and Quarter 4 2008 Quarterly Report dated September 1, 2009.

no longer warranted beyond Quarter 2, 2009. While transducer operation for further calibrations of the Precipitation Mass Balance Model are no longer recommended, a limited number of transducers should be maintained to continue to verify that the basic assumptions inherent in the model continue to remain valid. The locations and rational for these specific transducers are summarized below.

TRANSDUCER REDEPLOYMENT RECOMMENDATIONS

The primary objective of maintaining a limited number of transducers as part of the Long Term Monitoring Program is to provide ongoing confirmatory data that demonstrate substantial changes to the on-site groundwater flow field have not taken place[11], which thus supports the continuing validity of the Precipitation Mass Balance Model calibration. The most straightforward approach to demonstrate stasis would be to maintain the full complement of existing transducers, thus allowing the continued production of groundwater contours for the site. However, this level of detail is costly and is no longer considered necessary given the relatively small variability of seasonal and annual groundwater flow and the overall recognition that the computed dose to the river is only a small fraction of the permitted levels. More specifically, from a radionuclide groundwater contamination perspective, it is noted that:

- The only receptor for radionuclide releases to the groundwater is currently the Hudson River located immediately West of the power block area.
- The majority of this groundwater release to the river is concentrated within a small portion of the site just downgradient of the Unit 1 and 2 SFPs.
- The total yearly groundwater radionuclide release to the river is less than 1/100th of the allowable level.
- The primary radionuclide associated with the two operating units (Unit 2 and Unit 3) is Tritium, which is responsible for less than 1/1000th of the total current dose computed for the river. Therefore, the current Tritium release rate to the river results in approximately 1/100,000th of the allowable release level. As such, very substantial increases to the existing Tritium plume levels would have to occur to even begin to approach allowable annual release levels for tritium.
- Strontium is responsible for the majority of the current total computed dose to the river. The primary source of Strontium was leakage from Unit 1. As of the fall of 2008, the residual Unit 1 fuel has been removed and the fuel pools drained and cleaned. Therefore, the source term has been terminated and the associated total Strontium activity in the formation can only decrease with time. As such, it is hard to envision future conditions which would result in substantial increases to the Strontium levels in the groundwater plume.

---

[11] It is possible that material changes to the groundwater flow field could occur due to variations in the seasonal precipitation, or perhaps on a longer term basis, changes to the level of the Hudson River associated with global warming. For example, a prolonged drought could substantially reduce the groundwater mound existing to the South of the power block which prevents power block groundwater from migrating to the South towards the quarry. In addition to natural variability, changes to on-site and/or off-site operations could also impact groundwater flow fields. These anthropogenic impacts could include those from construction at or near the facility, changes to foundation drain pumping, changes to storm drains and/or site grading, infiltration of clean water from operations, installation of off-site pumping facilities, etc.

From a groundwater flow perspective, a doubling of the dose to the river (still <2% allowable) would require the groundwater flow rate to double[12]. Given that the hydraulic conductivity of the bedrock and overburden formations below the site are fixed, a generalized, big picture analysis[13] shows that a doubling of the groundwater flow rate would require the gradient to double. Assuming the river elevation remains relatively constant[14], the upgradient groundwater elevations would therefore generally have to also double[15] (to double the gradient and thus flow rate to the river). However, this condition is not plausible because such a doubling of groundwater elevations would require the groundwater to extend above the respective ground surface elevations[16]. Therefore, even a relatively insignificant doubling of the radiological dose to the river due to an increase in groundwater flux is not plausible given the required increase in groundwater elevations as well as the increased rainfall.

Given the above summarized analysis, a strong case could be made that no further transducer monitoring is required. However, it is recommended that a limited number of transducers be maintained as part of the Long Term Monitoring Program to demonstrate that substantial changes to the on-site groundwater flow field have not taken place, and thus further substantiate the continued validity of the Precipitation Mass Balance Model calibration, as well as the overall CSM[17]. Therefore, the following subsections, organized into general functional groups, provide recommendations for transducer redeployment on a long term basis. The recommended locations for long term transducer redeployment are summarized on Figure 1.

Upgradient Southern, Eastern and Northern Boundaries

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[12] This assumes that the activity levels remained constant in the groundwater after the flow rate doubled. This is unlikely to occur over any sustained length of time because it would require additional leakage from the SSCs to maintain a doubling of the source term.

[13] While the intrinsic permeability of the formation materials is essentially fixed, it is recognized that as the groundwater elevation increases, portions of the unsaturated zone become saturated and thus will then also contribute to groundwater flow. If the hydraulic conductivity of these upper portions of the bedrock/overburden is substantially higher than that of the current saturated zone, then the overall effective formation hydraulic conductivity would in fact increase. However, the borehole geophysics data does not show a substantial increase in fracturing in the vadose zone as compared to the upper portion of the saturated zone. In addition, while the overburden can be substantially more pervious than the bedrock, in the area of the Tritium and Strontium plumes, current ground surface/foundation elevations are generally consistent with or below the original bedrock elevations. Therefore, overburden thicknesses are anticipated to generally be relatively shallow or non-existent. An exception to this generalization is where backfilling around structures was completed with soil (primarily Unit 2) rather than concrete (primarily Unit 1). However, the recharge to these higher conductivity preferential flow paths is still generally limited by the bedrock groundwater flow rates. In addition, a number of these soil backfilled areas are drained by foundation drains which are independently monitored (e.g., the U1-NCD). Finally, it is further noted that even if the effective formation hydraulic conductivity were to increase substantially with an increase in groundwater elevations, to double the groundwater flow through the site on a yearly average basis would require a doubling of the rate of rainfall infiltration. Even if the annual rainfall were to double, a highly improbable event (the on-site met. station measured a maximum variation in annual rainfall of only approximately 30% over the last thirteen years), the infiltration would likely not double given the increased surface water runoff that would be expected with such a large increase in rainfall (i.e., the infiltration rate would likely not increase linearly with rainfall increases as a higher percentage would become surface runoff).

[14] It is noted that any long term changes to river level will likely be gradual and the river elevation is already very nearly equal to Mean Sea Level. Therefore, river elevations can't decrease significantly so as to reduce the required increase in upgradient groundwater elevations. In fact, in the long term, river elevations are predicted to increase based on global warming impacts.

[15] In actuality, the difference between the upgradient groundwater elevations and the river elevation would have to double, to double the gradient. However, given that the river elevation is numerically sufficiently close to zero, for all intents and purposes, a doubling of the numerical value of the upgradient elevations is sufficient.

[16] The groundwater elevations upgradient of the power block area range from approximately el. 45' to el. 55' (wells I-2, MW-65, MW-51 and MW-40). The ground surface elevations in these areas range from approximately el. 70' to el. 80'. Therefore, a doubling of the groundwater elevations would substantially exceed the ground surface elevations. This is not plausible because once the groundwater reached the ground surface, it would dissipate as surface water runoff to the storm drains, and thus be unable to increase further in elevation.

[17] As part of the further validation of the overall CSM, long term transducer data will aid in detecting anthropogenic changes such as potential impacts if off-site groundwater pumping were to be initiated proximate to the site, the quarry were drained or filled, etc.

As presented in the Hydrogeologic Site Investigation Report, groundwater flow in both the upper and lower flow zones is toward the power block area from the North, East and South, with subsequent discharge to the Hudson River to the West. A corollary to this conclusion is that there is no groundwater flow, and thus no off-Site radionuclide migration from the power block area to the North, East or South. Groundwater flow associated with infiltration from the watershed may be as deep as 350 feet, but still ultimately discharges to the river.

Groundwater elevations rise to the South from the power block area, as is consistent with the increase in topographic elevations. Farther to the South, ground surface and groundwater elevations decrease, most specifically at the quarry where groundwater elevations of approximately 15' have been recorded in LaFarge MW-2 (also refered to as LAF-002). As such, it is important to continue to demonstrate that the groundwater mound which separates the power block groundwater from the LaFarge area groundwater remains elevated. As such, transducers should remain in both **MW-40** and **MW-51**. In each of these two installations, both the shallowest and deepest transducers are required to: 1) delineate the range of vertical piezometric elevations with depth and 2) provide a level of redundancy at each location in case one transducer fails. In addition, transducers should be maintained in **MW-43** and **MW-46**. These wells are located in the Unit 3 power block just downgriadient of MW-40 and MW-51 and provide a reference to demonstrate that the gradient is toward the power block area (i.e., to the north).

Groundwater elevations also rise from the power block area to the East. **MW-65** provides an appropriate location to monitor groundwater flow from the East just prior to migration into the power block area. Again both elevations in this monitoring installation should continue to be monitored, primarily to provide a level of redundancy.

Monitoring well **I-2** located to the North of the power block area provides a suitable location to monitor the upgradient groundwater elevations in this direction. Given that a single well screen exists at this location, two transducers should be installed to provide redundancy.

Downgradient Western Boundary

From the upgradient boundaries to the South, East and North, groundwater flows into the power block area and then ultimately exits at the river to the West. Given that the river is the ultimate sink for groundwater flow, and thus the radionuclides within the groundwater, it is important to verify its elevation over time. Stilling well **HR-1** was previously installed for this purpose. It is therefore proposed that this well be maintained as part of the Long Term Monitoring Program. Once again, a second transducer should be installed in this well to provide redundancy.

While the river is the ultimate sink for groundwater flow, the Discharge Canal forms an intermediate groundwater sink on the site. Stilling well **U3-C1** was installed to monitor the Discharge Canal surface water elevation. This well should continue to be monitored and should have an additional transducer installed to provide redundancy.

Groundwater Tritium and Strontium Plumes

The two primary sources of radionuclide release to the groundwater have been the Unit 1 (Strontium) and Unit 2 (Tritium) SFPs. While Unit 3 covers a large portion of the IPEC site, the groundwater data has not shown any significant releases from this unit. Therefore, it is recommended that transducer monitoring internal to the site (i.e., between the above summarized upgradient and downgradient boundaries) be primarily focused on the area of the Unit1/2 plumes.

The historic source area of each plume would be monitored using **MW-30** (Unit 2) and **MW-53**[18] (Unit 1). Both the upper and lower monitoring elevations in these installations should be monitored to: 1) provide vertical gradient information, and 2) provide a level of transducer redundancy.

It is recommended that a location just upgradient of the Discharge Canal also be monitored for each plume. **MW-55** satisfies this criterion for both plumes given that the two plumes converge at this location as a likely result of a preferential flow path (increased bedrock fracturing) in this area. Again, it is recommended that both the upper most and lowest monitoring elevations in this installation be monitored.

Finally, the toe of each plume should also be monitored just prior to where they discharge into the river. Again, this recommendation can be satisfied by one location given the convergence of the two plumes. In this case, the upper and lower levels of **MW-67** are recommended for bedrock monitoring and the upper level of the proximate **MW-66** is recommended to monitor the overburden groundwater levels in this area.

We appreciate the opportunity to be of service to you. Should you have any questions or comments, please feel free to contact Matt or Dave at (781) 278-3805 or (860) 858-3110.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

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Attachments: Figure 1: Long-Term Transducer Monitoring Evaluation Map

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[18] MW-42 was considered as the historic source area monitoring location for Unit 1 given its closer proximity to the SFPs than MW-53. However, MW-42 is also very close to the NCD, which likely controls the groundwater elevations in MW-42 to a large extent. As such, it is judged that MW-53 would likely be more responsive to groundwater elevation variations indicative of changes at the site than would be MW-42.

LONGTERM TRANSDUCER MONITORING EVALUATION MAP

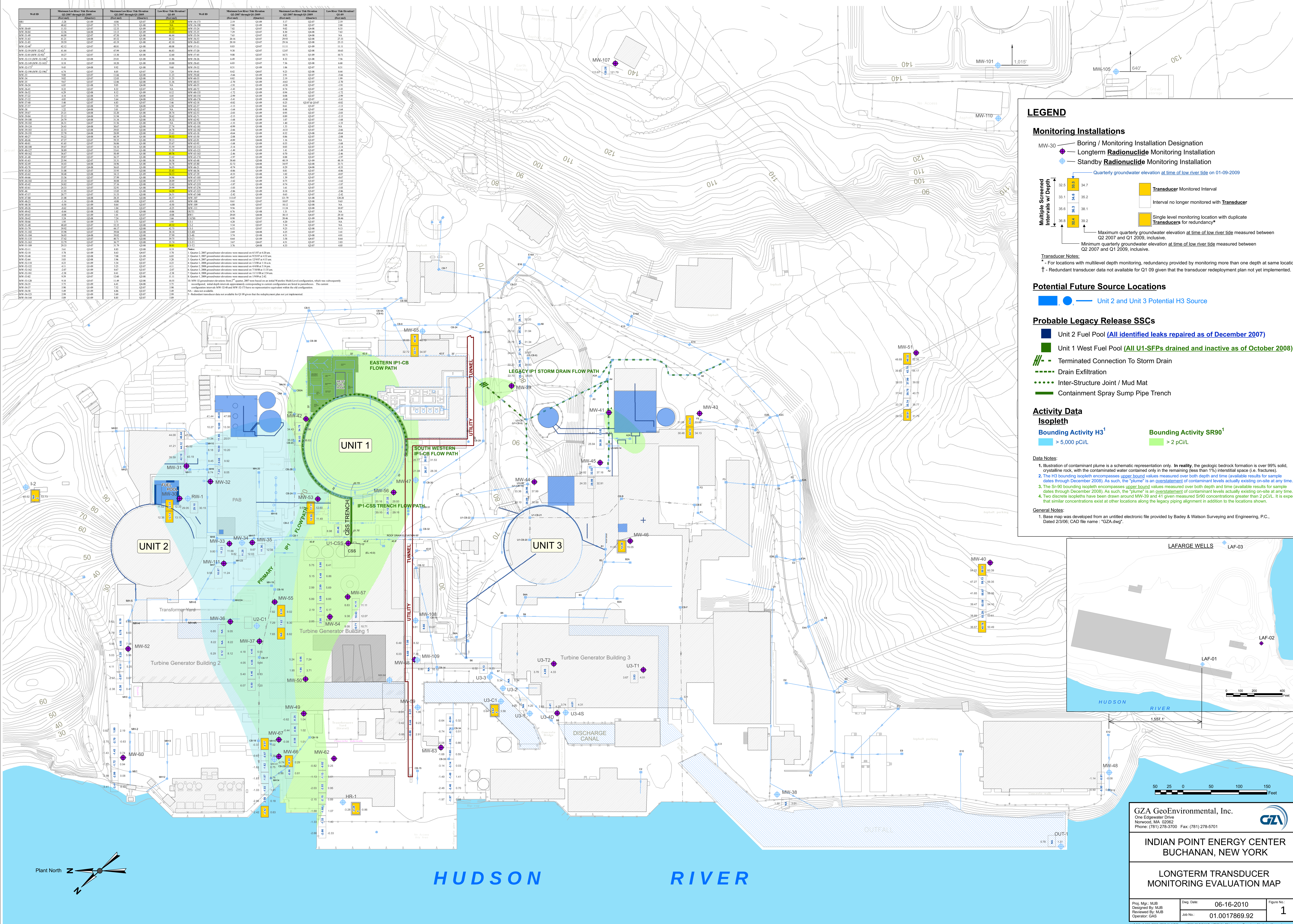
Well ID	Minimum Low River Tide Elevation Q2-2007 through Q1-2009 (Feet msl)	(Quarter)	Maximum Low River Tide Elevation Q2-2007 through Q1-2009 (Feet msl)	(Quarter)	Low River Tide Elevation† Q1-09 (Feet msl)
HR1	-3.28	Q1-09	-0.86	Q3-07	-3.28
I2	48.62	Q3-07	53.73	Q1-08	NA
MW-30-69	11.53	Q3-07	12.33	Q1-09	12.33
MW-30-84	12.36	Q4-08	13.13	Q1-09	13.13
MW-31-49	44.09	Q2-07	47.50	Q1-08	46.44
MW-31-63	41.21	Q4-08	45.52	Q1-08	44.12
MW-31-85	39.59	Q2-07	43.19	Q1-08	42.10
MW-32-48[9]	42.12	Q3-07	48.81	Q1-08	48.08
MW-32-59 (MW-32-62)[9]	41.44	Q3-07	47.99	Q1-08	46.83
MW-32-85 (MW-32-92)[9]	10.27	Q2-07	13.30	Q1-08	12.60
MW-32-131 (MW-32-140)[9]	11.34	Q3-08	25.01	Q1-08	11.86
MW-32-149 (MW-32-165)[9]	8.18	Q2-07	10.20	Q1-08	10.00
MW-32-173[9]	9.45	Q4-08	9.92	Q1-08	9.68
MW-32-190 (MW-32-196)[9]	6.74	Q2-07	8.05	Q3-07	7.24
MW-33	9.80	Q3-07	11.66	Q2-08	11.23
MW-34	9.82	Q3-07	12.03	Q2-08	11.25
MW-35	9.67	Q3-07	12.06	Q2-08	11.36
MW-36-24	6.85	Q1-08	9.05	Q4-08	NA
MW-36-41	8.22	Q2-07	8.22	Q2-07	NA
MW-36-52	6.29	Q2-08	8.12	Q1-09	8.12
MW-37-22	4.18	Q2-08	5.55	Q4-08	4.45
MW-37-32	4.05	Q2-08	5.64	Q4-08	4.55
MW-37-40	5.40	Q2-07	6.83	Q3-07	5.46
MW-37-57	6.07	Q2-08	7.20	Q4-08	6.50
MW-38	1.22	Q4-08	3.01	Q2-07	NA
MW-39-67	25.21	Q4-08	32.20	Q1-08	28.74
MW-39-84	25.12	Q4-08	31.94	Q1-08	28.62
MW-39-100	24.79	Q4-08	31.34	Q2-08	28.32
MW-39-102	26.31	Q4-07	31.56	Q1-08	NA
MW-39-124	24.43	Q4-08	30.67	Q2-08	27.74
MW-39-183	22.33	Q3-08	29.83	Q2-08	26.78
MW-39-195	22.70	Q4-08	28.89	Q2-08	25.63
MW-40-27	54.22	Q4-08	60.39	Q1-08	59.53
MW-40-46	47.27	Q3-07	59.35	Q1-08	59.13
MW-40-81	41.65	Q3-07	56.06	Q1-08	55.67
MW-40-100	39.47	Q3-07	54.10	Q1-08	53.59
MW-40-127	38.89	Q3-07	53.61	Q1-08	53.29
MW-40-162	36.67	Q3-07	50.49	Q1-08	49.76
MW-41-40	29.87	Q2-07	36.57	Q1-08	33.62
MW-41-63	25.94	Q2-07	33.31	Q1-08	30.38
MW-42-49	34.43	Q4-08	34.96	Q1-08	34.78
MW-42-78	35.07	Q4-08	36.63	Q1-08	36.03
MW-43-28	31.08	Q3-07	33.95	Q2-08	33.43
MW-43-62	30.48	Q3-08	34.13	Q1-09	34.13
MW-44-66	33.36	Q2-07	37.99	Q1-08	34.96
MW-44-102	23.10	Q2-07	30.88	Q2-08	28.09
MW-45-42	24.82	Q3-07	37.16	Q2-08	32.02
MW-45-61	24.33	Q3-07	32.91	Q1-08	29.99
MW-46	11.95	Q3-07	15.05	Q1-08	14.29
MW-47-57	20.77	Q3-07	31.53	Q2-08	26.51
MW-47-80	21.08	Q4-08	28.35	Q2-08	26.37
MW-48-23	-1.14	Q1-08	-0.08	Q2-07	-0.91
MW-48-38	-0.50	Q1-09	0.64	Q2-07	-0.50
MW-49-26	-0.62	Q1-08	1.04	Q2-07	-0.25
MW-49-42	-0.44	Q1-08	1.02	Q3-08	-0.06
MW-49-65	-0.08	Q1-09	1.01	Q3-07	-0.08
MW-50-42	5.24	Q2-08	7.24	Q2-07	5.66
MW-50-66	1.95	Q1-09	3.71	Q2-07	1.95
MW-51-40	48.69	Q3-07	52.35	Q2-08	49.32
MW-51-79	39.92	Q3-07	44.17	Q2-08	42.75
MW-51-102	35.98	Q3-07	39.04	Q2-08	38.18
MW-51-104	36.03	Q4-08	39.02	Q2-08	37.99
MW-51-135	37.42	Q3-07	40.71	Q2-08	39.75
MW-51-163	33.79	Q3-07	36.77	Q2-08	35.74
MW-51-189	29.33	Q3-07	31.79	Q2-08	30.81
MW-52-11	5.61	Q3-07	8.85	Q2-08	8.19
MW-52-18	5.78	Q1-09	8.63	Q4-07	5.78
MW-52-48	5.95	Q2-08	7.08	Q1-09	6.05
MW-52-64	5.03	Q2-08	5.96	Q2-07	5.20
MW-52-118	4.23	Q1-09	5.34	Q2-07	4.23
MW-52-122	4.11	Q1-09	5.25	Q2-07	4.11
MW-52-162	-2.07	Q1-09	0.67	Q2-07	-2.07
MW-52-181	-2.38	Q1-09	0.41	Q2-07	-2.38
MW-53-82	9.59	Q3-07	12.60	Q2-08	11.11
MW-53-120	9.18	Q3-07	11.49	Q2-08	10.55
MW-54-35	5.75	Q1-09	6.41	Q4-08	5.75
MW-54-37	5.90	Q1-09	7.52	Q2-07	5.90
MW-54-58	5.49	Q1-09	6.86	Q2-07	5.49
MW-54-123	2.99	Q1-09	5.69	Q2-07	2.99
MW-54-144	5.89	Q1-09	8.85	Q2-07	5.89

Well ID	Minimum Low River Tide Elevation Q2-2007 through Q1-2009 (Feet msl)	(Quarter)	Maximum Low River Tide Elevation Q2-2007 through Q1-2009 (Feet msl)	(Quarter)	Low River Tide Elevation† Q1-09 (Feet msl)
MW-54-173	2.19	Q1-09	5.17	Q2-07	2.19
MW-54-190	2.00	Q1-09	5.08	Q2-07	2.00
MW-55-24	7.82	Q3-07	9.02	Q4-08	8.35
MW-55-35	7.29	Q3-07	8.30	Q4-08	7.63
MW-55-54	7.65	Q3-07	8.82	Q4-08	NA
MW-56-53	20.16	Q3-07	29.93	Q2-08	27.33
MW-56-83	20.10	Q3-07	29.16	Q2-08	25.13
MW-57-11	8.83	Q3-07	11.11	Q1-09	11.11
MW-57-20	9.38	Q2-07	12.07	Q2-08	10.63
MW-57-45	9.08	Q2-07	10.71	Q1-09	10.71
MW-58-26	6.49	Q3-07	8.32	Q1-08	7.56
MW-58-65	6.03	Q3-07	7.36	Q2-08	6.68
MW-59-32	0.31	Q1-09	1.06	Q2-07	0.31
MW-59-45	0.42	Q4-07	9.23	Q2-08	0.44
MW-59-68	-5.66	Q1-09	2.91	Q2-07	-5.66
MW-60-35	0.82	Q3-08	2.19	Q2-07	1.99
MW-60-53	-2.70	Q1-09	-0.63	Q2-07	-2.70
MW-60-55	-1.91	Q1-09	-0.28	Q3-07	-1.91
MW-60-72	-1.43	Q1-09	0.74	Q2-07	-1.43
MW-60-135	-1.72	Q1-09	0.94	Q2-07	-1.72
MW-60-154	-2.99	Q1-09	0.08	Q2-07	-2.99
MW-60-176	-3.41	Q1-09	-0.48	Q2-07	-3.41
MW-62-18	-0.82	Q1-09	0.25	Q2-07 & Q3-07	-0.82
MW-62-37	-1.13	Q1-09	0.61	Q3-07	-1.13
MW-62-52	-1.64	Q1-09	0.48	Q3-07	-1.64
MW-62-53	-2.03	Q1-09	0.95	Q2-07	-2.03
MW-62-71	-2.15	Q1-09	0.89	Q2-07	-2.15
MW-62-92	-1.68	Q1-09	1.07	Q2-07	-1.68
MW-62-138	-1.33	Q1-09	1.40	Q2-07	-1.33
MW-62-181	-0.99	Q1-08	1.33	Q2-07	NA
MW-62-182	-2.66	Q1-09	-0.33	Q3-07	-2.66
MW-63-18	-0.64	Q1-09	0.32	Q3-08	-0.64
MW-63-50	-2.08	Q1-09	0.86	Q2-07	-2.08
MW-63-91	-0.89	Q4-08	1.16	Q2-07	NA
MW-63-93	-1.68	Q1-09	0.55	Q3-07	-1.68
MW-63-112	-3.14	Q1-09	0.03	Q2-07	-3.14
MW-63-121	-1.49	Q1-09	1.41	Q2-07	-1.49
MW-63-163	-2.46	Q1-09	0.70	Q2-07	-2.46
MW-63-174	-1.97	Q1-09	0.88	Q2-07	-1.97
MW-65-48	38.60	Q2-08	48.19	Q1-09	48.19
MW-65-80	32.72	Q4-08	34.97	Q2-08	33.71
MW-66-21	-0.74	Q1-08	0.29	Q4-08	-0.33
MW-66-36	-0.86	Q1-09	0.81	Q2-07	-0.86
MW-67-39	-0.33	Q1-08	1.02	Q3-07	-0.07
MW-67-105	-0.67	Q1-09	1.39	Q3-07	-0.67
MW-67-173	-1.62	Q1-09	0.75	Q3-07	-1.62
MW-67-219	-1.87	Q1-09	0.74	Q3-07	-1.87
MW-67-276	-1.03	Q1-09	1.61	Q3-07	-1.03
MW-67-323	-2.86	Q1-09	0.18	Q3-07	-2.86
MW-67-340	-2.42	Q1-09	0.63	Q3-07	-2.42
MW-107	113.87	Q3-07	121.79	Q1-08	120.28
MW-108	8.61	Q3-07	10.07	Q2-08	9.65
MW-109	6.80	Q3-07	10.12	Q2-08	NA
MW-111	9.56	Q2-07	11.24	Q2-08	10.87
OUT1	0.76	Q1-08	1.31	Q3-07	NA
RW1	29.05	Q4-08	30.15	Q4-07	29.10
U1CSS	8.98	Q3-07	20.46	Q1-09	20.46
U3-1	4.20	Q2-07	4.20	Q2-07	NA
U3-2	5.34	Q2-07	5.34	Q2-07	NA
U3-3	6.52	Q3-07	9.25	Q2-08	9.13
U3-4D	2.69	Q4-08	4.25	Q2-07	3.41
U3-4S	3.74	Q1-08	4.31	Q3-08	4.01
U3-C1	0.64	Q1-09	3.58	Q4-07	0.64
U3-T1	3.67	Q4-07	4.51	Q2-07	3.83
U3-T2	3.76	Q4-08	4.33	Q2-07	4.05

Notes:
1. Quarter 2, 2007 groundwater elevations were measured on 6/1/07 at 6:20 am.
2. Quarter 3, 2007 groundwater elevations were measured on 9/25/07 at 4:32 am.
3. Quarter 4, 2007 groundwater elevations were measured on 12/9/07 at 4:15 am.
4. Quarter 1, 2008 groundwater elevations were measured on 1/3/08 at 1:14 a.m.
5. Quarter 2, 2008 groundwater elevations were measured on 4/4/08 at 5:14 pm.
6. Quarter 3, 2008 groundwater elevations were measured on 7/10/08 at 11:35 am.
7. Quarter 4, 2008 groundwater elevations were measured on 11/11/08 at 2:54 am.
8. Quarter 1, 2009 groundwater elevations were measured on 1/9/09 at 2:42.
10. MW-32 groundwater elevations from 2nd quarter, 2007 were based on an initial Waterloo Multi-Level configuration, which was subsequently reconfigured; initial depth intervals approximately corresponding to current configuration are listed in parentheses. The current configuration intervals MW-32-48 and MW-32-173 have no representative equivalent within the old configuration.

NA – data not available.

† - Redundant transducer data not available for Q1 09 given that the redeployment plan not yet implemented.



LEGEND

Monitoring Installations

MW-30 — Boring / Monitoring Installation Designation

Longterm **Radionuclide** Monitoring Installation

Standby **Radionuclide** Monitoring Installation

Quarterly groundwater elevation at time of low river tide on 01-09-2009

Multiple Screened Intervals w/ Depth

Transducer Monitored Interval

Interval no longer monitored with **Transducer**

Single level monitoring location with duplicate **Transducers** for redundancy*

Maximum quarterly groundwater elevation at time of low river tide measured between Q2 2007 and Q1 2009, inclusive.

Minimum quarterly groundwater elevation at time of low river tide measured between Q2 2007 and Q1 2009, inclusive.

Transducer Notes:
- * - For locations with multilevel depth monitoring, redundancy provided by monitoring more than one depth at same location.
- † - Redundant transducer data not available for Q1 09 given that the transducer redeployment plan not yet implemented.

Potential Future Source Locations

Unit 2 and Unit 3 Potential H3 Source

Probable Legacy Release SSCs

- Unit 2 Fuel Pool (All identified leaks repaired as of December 2007)
- Unit 1 West Fuel Pool (All U1-SFPs drained and inactive as of October 2008)
- Terminated Connection To Storm Drain
- Drain Exfiltration
- Inter-Structure Joint / Mud Mat
- Containment Spray Sump Pipe Trench

Activity Data

Isopleth

Bounding Activity H3[1] > 5,000 pCi/L

Bounding Activity SR90[1] > 2 pCi/L

Data Notes:
1. Illustration of contaminant plume is a schematic representation only. **In reality**, the geologic bedrock formation is over 99% solid, crystalline rock, with the contaminated water contained only in the remaining (less than 1%) interstitial space (i.e. fractures).
2. The H3 bounding isopleth encompasses upper bound values measured over both depth and time (available results for sample dates through December 2008). As such, the "plume" is an overstatement of contaminant levels actually existing on-site at any time.
3. The Sr-90 bounding isopleth encompasses upper bound values measured over both depth and time (available results for sample dates through December 2008). As such, the "plume" is an overstatement of contaminant levels actually existing on-site at any time.
4. Two discrete isopleths have been drawn around MW-39 and 41 given measured Sr90 concentrations greater than 2 pCi/L. It is expected that similar concentrations exist at other locations along the legacy piping alignment in addition to the location shown.

General Notes:
1. Base map was developed from an untitled electronic file provided by Badey & Watson Surveying and Engineering, P.C., Dated 2/3/06; CAD file name : "GZA.dwg".

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INDIAN POINT ENERGY CENTER
BUCHANAN, NEW YORK

LONGTERM TRANSDUCER MONITORING EVALUATION MAP

Proj. Mgr.: MJB
Designed By: MJB
Reviewed By: MJB
Operator: GAS

Dwg. Date: 06-16-2010
Job No.: 01.0017869.92
Figure No.: 1