Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 17-29

TUNNEL AND RESERVOIR PLAN

CALUMET TUNNEL SYSTEM

ANNUAL GROUNDWATER MONITORING REPORT

FOR 2016

August 2017

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

CECIL LUE-HING RESEARCH AND DEVELOPMENT COMPLEX
6001 WEST PERSHING ROAD CICERO, ILLINOIS 60804-4112

Edward W. Podczerwinski, P.E.
Acting Director of Monitoring and Research

July 26, 2017

Chief
Bureau of Water
Illinois Environmental Protection Agency
P. O. Box 19276
Springfield, IL 62794-9276

Dear Sir or Madam:

Subject: Tunnel and Reservoir Plan, Calumet Tunnel System, Annual Groundwater Monitoring Report for 2016

Attached are three copies of "Tunnel and Reservoir Plan, Calumet Tunnel System, Annual Groundwater Monitoring Report for 2016."

Very truly yours,

Albert E. Cox
Environmental Monitoring and Research Manager
Monitoring and Research Department

AC:PL:cm
cc w/att: Ms. Sally K. Swanson (USEPA Region 5 - WC15J) - (2)
Mr. Podczerwinski
Dr. Zhang
Dr. Cox
Dr. Tian
Dr. Lindo
cc w/o att.: Mr. D. St. Pierre
Mr. J. Murray

Metropolitan Water Reclamation District of Greater Chicago
100 East Erie Street Chicago, Illinois 60611-2803 (312) 751-5600

TUNNEL AND RESERVOIR PLAN
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ANNUAL GROUNDWATER MONITORING REPORT
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Monitoring and Research Department
Ed Podczerwinski, Acting Director

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CFU	colony forming units
ft	feet
IEPA	Illinois Environmental Protection Agency
mL	milliliter
Cl^-	chloride
EC	electrical conductivity
FC	fecal coliform
L	liter
m	meter
mg	milligram
mS	millisiemens
NH_3-N	ammonia nitrogen
SO_4^{2-}	sulfate
TDS	total dissolved solids
TOC	total organic carbon

ANNUAL DATA FOR MONITORING AND OBSERVATION WELLS

Introduction

All monitoring and observation wells are located along the length of the Calumet Tunnel System. Four monitoring wells (QC-1, -2, -2-1, and -2-2) and 11 observation wells (OC-1 through OC-11) are located along the tunnel between Crawford Avenue and the Calumet Water Reclamation Plant. Seventeen monitoring wells (QC-3 through QC-19) are located between 140th Street and Indiana Avenue. Nine monitoring wells (QC-20 through QC-28) are positioned along Torrence Avenue, with the last nine monitoring wells (QC-29 through QC-37) along the Little Calumet River (Figures 1 and 2). Monitoring well QC-3 was abandoned with the approval of the Illinois Environmental Protection Agency (IEPA). Monitoring wells QC-1, -2, and QC-29 through QC-36 are sampled six times per year (IEPA memorandum dated July 9, 2004). Monitoring wells QC-2-1, -2-2, QC-4 through QC-7 and QC-9 through QC-28 are sampled three times per year (IEPA memoranda July 9, 2004 and February 23, 2006).

During 2016, most wells were sampled as scheduled, and almost all of the required number of samples were obtained. Only two samples each were retrieved from Wells QC-2-1 and 2-2. No samples were obtained from Wells QC-32, -33, -34, and -37, and only one sample was retrieved from Well QC-36 because these wells are considered dry or intermittently dry. Their pumps were tested and classified as functional. Groundwater elevations in the monitoring wells were measured during each sampling event, while elevations in the observation wells were measured biweekly. The groundwater level in monitoring well QC-8-1 is no longer adequate for sampling. However, this well was converted to an observation well several years ago, and its groundwater elevations are still measured biweekly.

Summary of Data

Monitoring Wells. The analytical data for groundwater sampled during 2016 from monitoring wells QC-2 through QC-36 are presented in Table 1. Physical characteristics, such as elevation, groundwater temperature, and estimated time of recharge for each well between initial drawdown and sampling, are also included. Fecal coliform counts in all wells at this site were undetectable (<1 CFU/100 mL) throughout the year. Table 2 lists the descriptive statistics for groundwater data of monitoring wells QC-2 through QC-36 for the year 2016.

Observation Wells. Groundwater elevations for observation wells OC-1 through -11 were measured at the required frequencies. Adjusted elevations were calculated relative to the Chicago City Datum (579.48 ft. above mean sea level) at the intersection of Madison and State Streets (Table 3). The minimum, mean, and maximum values for each well were calculated and plotted to determine fluctuations in groundwater elevations during the year (Figure 3). Generally, these fluctuations appeared to be minimal or within expected ranges throughout the year in most wells. During the year, notable fluctuations in groundwater elevations of 13 to 19 ft were evident at Wells OC-1, -3, -4, -8.1, -9, and -10.

FIGURE 1: MAP OF MONITORING WELLS IN THE CALUMET TUNNEL SYSTEM

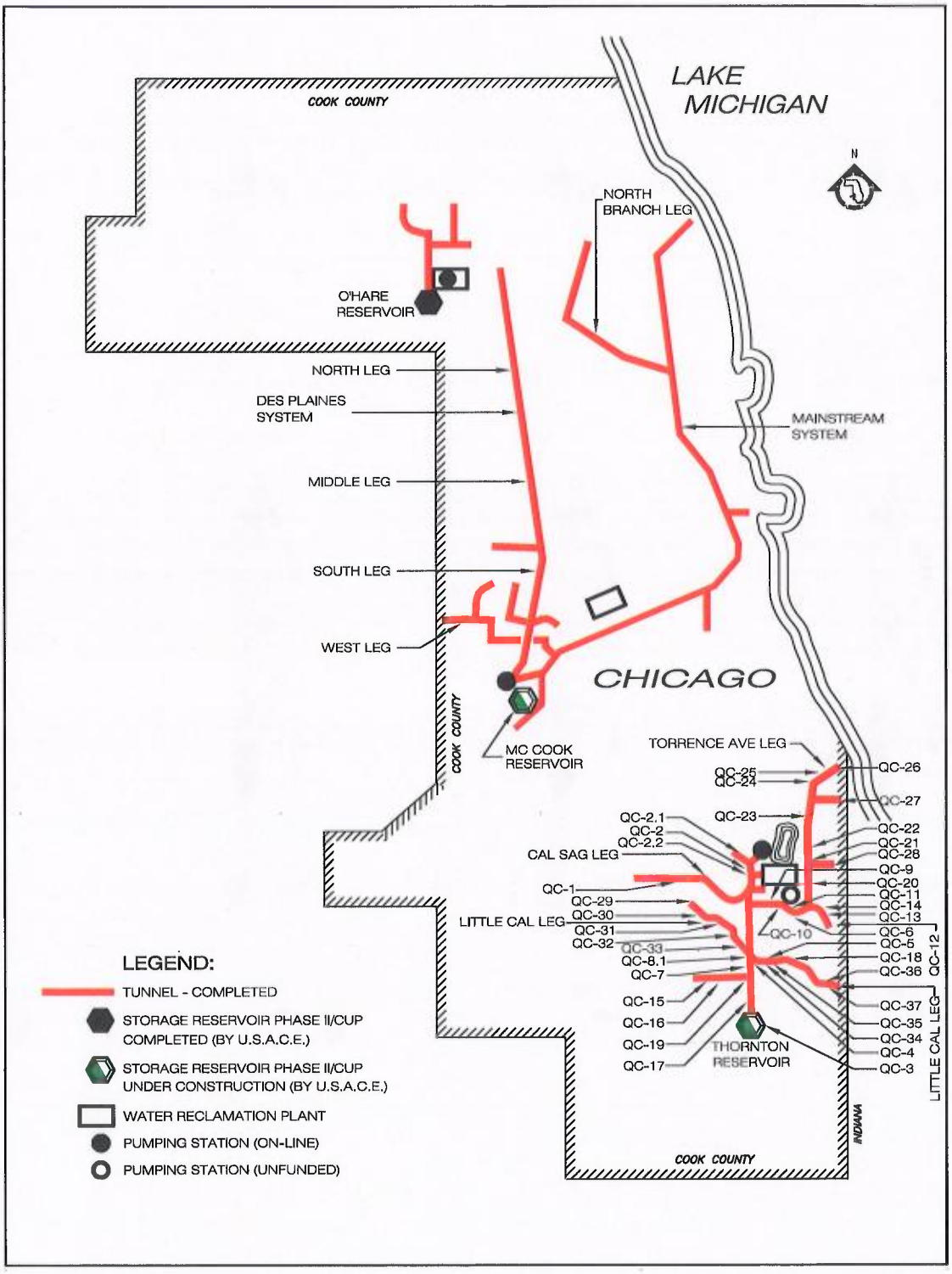

FIGURE 2: MAP OF OBSERVATION WELLS IN THE CALUMET TUNNEL SYSTEM

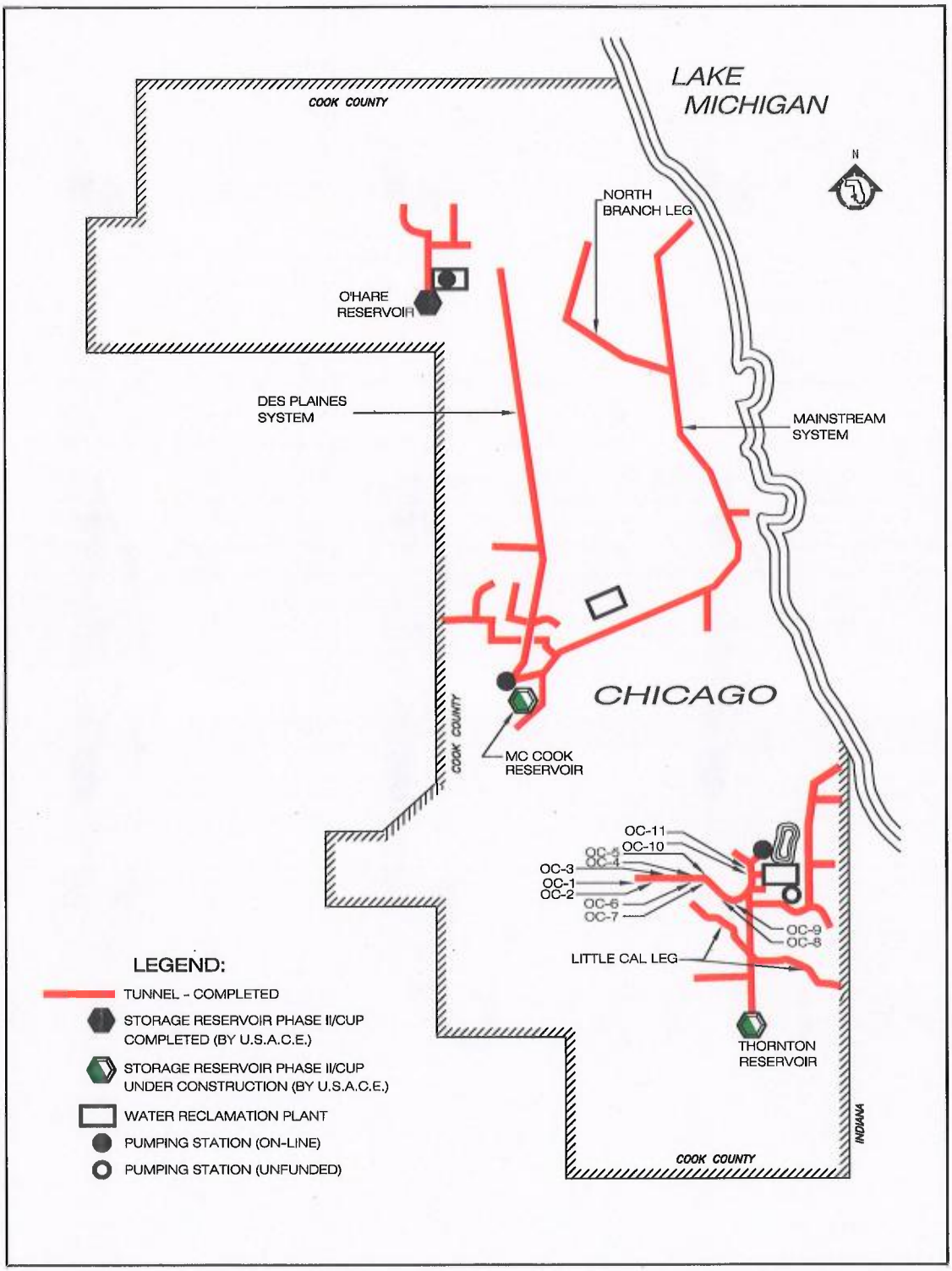

TABLE 1: ANALYSIS OF GROUNDWATER FROM MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	^{0}C	ft	hr
QC-2	01/14/16	7.5	54	334	1.4	28	28	0.18	84	<1	10.9	-279	<48
QC-2	03/31/16	8.3	51	370	1.6	28	25	0.20	87	<1	15.0	-264	<48
QC-2	06/15/16	7.9	57	354	<1.0	28	25	0.22	79	<1	14.6	-260	<48
QC-2	07/07/16	7.7	55	388	1.0	27	33	0.14	92	<1	15.8	-281	<48
QC-2	09/15/16	7.3	56	374	1.4	25	25	0.30	84	<1	15.6	-266	<48
QC-2-1	02/04/16	7.8	85	506	<1.0	30	<5	0.61	59	<1	12.3	-298	<48
QC-2-1	06/15/16	8.1	82	530	<1.0	35	<5	0.63	57	<1	15.0	-295	<48
QC-2-2	02/04/16	8.7	59	356	<1.0	16	29	0.36	41	<1	12.1	-278	<48
QC-2-2	06/15/16	8.6	56	342	<1.0	13	24	0.43	42	<1	14.8	-277	<48
QC-4	05/04/16	8.6	65	420	<1.0	11	12	0.14	11	<1	11.9	-229	<48
QC-4	08/04/16	8.9	70	460	<1.0	9	16	0.13	11	<1	12.7	-223	<48
QC-4	11/03/16	8.7	69	416	<1.0	9	16	<0.10	10	<1	12.3	-226	<48
QC-5	05/04/16	8.4	85	514	1.0	41	13	0.10	8	<1	12.1	-131	<48
QC-5	08/04/16	8.7	70	568	1.1	43	13	<0.10	8	<1	13.2	-206	<48
QC-5	11/03/16	8.7	89	538	1.4	42	15	0.10	8	<1	12.5	-209	<48
QC-6	05/04/16	8.4	70	438	1.2	17	8	0.31	16	<1	12.2	-212	<48
QC-6	08/04/16	8.6	73	478	1.3	15	8	0.30	16	<1	13.4	-209	<48
QC-6	11/03/16	8.6	73	462	1.5	15	7	0.34	15	<1	13.0	-209	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	^{0}C	ft	hr
QC-7	05/04/16	8.5	65	390	1.1	11	<5	0.24	10	<1	12.4	-164	<48
QC-7	08/04/16	8.3	70	432	1.3	10	<5	0.26	11	<1	13.1	-162	<48
QC-7	11/03/16	8.1	66	400	4.1	10	<5	0.27	10	<1	12.6	-165	<48
QC-9	02/04/16	7.9	58	308	<1.0	<10	42	<0.10	60	<1	12.5	-253	<48
QC-9	06/15/16	8.5	52	326	<1.0	9	38	0.35	62	<1	14.4	-249	<48
QC-9	09/15/16	8.0	50	352	1.0	9	37	0.41	65	<1	14.3	-246	<48
QC-10	05/25/16	8.5	67	420	<1.0	31	<5	<0.10	10	<1	14.8	-168	<4
QC-10	08/25/16	8.7	66	474	<1.0	31	<5	0.12	10	<1	13.5	-167	<4
QC-10	11/21/16	8.8	64	382	<1.0	28	<5	0.11	10	<1	12.4	-170	<4
QC-11	03/16/16	7.9	44	310	<1.0	22	<5	<0.10	21	<1	12.1	-199	<4
QC-11	06/23/16	8.6	46	312	<1.0	22	<5	0.11	21	<1	13.4	-220	<4
QC-11	09/07/16	8.6	47	292	<1.0	21	<5	0.19	20	<1	14.0	-197	<4
QC-12	03/16/16	7.3	128	838	<1.0	35	318	1.0	162	<1	12.6	-206	<4
QC-12	06/23/16	7.5	129	894	<1.0	36	311	0.46	169	<1	12.9	-228	<4
QC-12	09/07/16	7.7	127	858	<1.0	35	287	0.60	173	<1	13.6	-225	<4
QC-13	03/16/16	7.9	65	412	<1.0	54	24	0.14	35	<1	12.6	-240	<48
QC-13	06/23/16	8.1	65	448	<1.0	57	22	0.18	34	<1	13.2	-238	<48
QC-13	09/07/16	8.2	62	410	<1.0	56	21	0.19	39	<1	14.4	-237	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	^{0}C	ft	hr
QC-14	02/18/16	7.3	140	686	3.0	140	<5	0.33	157	<1	13.4	-209	<48
QC-14	07/07/16	7.7	120	748	1.9	144	9	0.25	156	<1	13.8	-208	<48
QC-14	09/15/16	7.6	119	732	2.7	132	<5	0.33	14	<1	14.5	-206	<48
QC-15	02/18/16	8.3	47	298	1.1	12	<5	0.18	15	<1	15.0	-213	<48
QC-15	07/07/16	8.3	49	336	<1.0	12	<5	0.25	15	<1	13.4	-220	<48
QC-15	09/15/16	8.4	51	328	1.1	12	<5	0.22	157	<1	13.1	-219	<48
QC-16	05/04/16	7.8	78	486	<1.0	24	78	<0.10	90	<1	12.0	-255	<48
QC-16	08/04/16	8.3	82	534	<1.0	23	77	<0.10	80	<1	14.6	-240	<48
QC-16	11/03/16	8.1	80	506	<1.0	23	80	<0.10	81	<1	14.6	-240	<48
QC-17	02/10/16	8.4	65	498	<1.0	<10	200	0.28	147	<1	11.1	-239	<48
QC-17	07/07/16	8.1	74	482	<1.0	<5	194	0.25	145	<1	13.1	-197	<48
QC-17	10/13/16	8.4	74	442	<1.0	8	31	<0.10	12	<1	12.6	-206	<48
QC-18	02/10/16	8.8	58	360	<1.0	<10	33	0.10	7	<1	10.3	-202	<48
QC-18	07/07/16	9.1	60	402	<1.0	<10	30	<0.10	7	<1	12.7	-195	<48
QC-18	10/13/16	9.0	59	534	<1.0	5	166	0.29	150	<1	12.3	-195	<48
QC-19	10/13/16	8.7	67	504	1.0	6	146	0.32	115	<1	12.5	-137	<48
QC-19	11/17/16	8.5	66	396	<1.0	6	154	<0.10	110	<1	12.4	-135	<48
QC-19	12/15/16	7.7	87	440	<1.0	NRR[3]	147	0.33	122	<1	11.5	-135	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	^{0}C	ft	hr
QC-20	05/12/16	8.3	52	256	1.1	18	<5	0.15	23	<1	12.8	-266	<48
QC-20	10/13/16	7.5	44	338	<1.0	19	6	0.20	23	<1	12.1	-260	<48
QC-20	11/17/16	8.4	44	194	<1.0	18	<5	0.13	20	<1	12.3	-261	<48
QC-21	05/12/16	8.1	54	332	2.4	16	9	0.11	37	<1	13.3	-255	<48
QC-21	08/18/16	7.7	54	356	3.2	17	7	0.10	31	<1	14.4	-257	<48
QC-21	11/17/16	8.1	54	270	3.3	17	9	<0.10	29	<1	13.3	-260	<48
QC-22	05/12/16	8.0	43	250	1.4	14	<5	0.25	38	<1	12.5	-257	<48
QC-22	08/18/16	8.2	43	264	1.3	14	6	0.25	38	<1	13.4	-260	<48
QC-22	11/17/16	8.1	43	210	1.4	13	7	0.30	41	<1	13.4	-261	<48
QC-23	05/12/16	9.1	54	330	<1.0	19	<5	0.13	7	<1	12.4	-237	<48
QC-23	08/18/16	9.3	54	342	<1.0	18	<5	<0.10	7	<1	13.3	-239	<48
QC-23	11/30/16	9.0	53	308	<1.0	19	52	<0.10	7	<1	12.7	-243	<48
QC-24	05/25/16	8.6	38	256	<1.0	27	<5	0.14	14	<1	13.7	-243	<48
QC-24	08/18/16	8.7	40	240	<1.0	27	<5	0.12	16	<1	14.2	-242	<48
QC-24	11/30/16	8.6	49	208	<1.0	26	6	0.16	15	<1	13.1	-247	<48
QC-25	05/25/16	8.1	31	254	<1.0	12	6	0.14	31	<1	13.9	-240	<48
QC-25	08/18/16	8.0	37	214	<1.0	13	6	0.14	32	<1	13.6	-238	<48
QC-25	11/30/16	7.8	40	190	<1.0	12	7	0.16	31	<1	12.9	-240	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	^{0}C	ft	hr
QC-26	05/25/16	8.3	40	330	<1.0	13	<5	0.10	6	<1	13.5	-231	<48
QC-26	08/18/16	9.2	43	272	<1.0	11	<5	<0.10	7	<1	13.1	-231	<48
QC-26	11/30/16	9.0	45	246	<1.0	11	<5	<0.10	8	<1	12.7	-231	<48
QC-27	05/25/16	8.5	40	260	<1.0	31	<5	0.15	24	<1	13.7	-216	<48
QC-27	08/18/16	8.2	40	272	1.0	10	<5	<0.10	17	<1	13.5	-213	<48
QC-27	11/30/16	8.3	44	218	<1.0	30	<5	0.16	24	<1	12.8	-213	<48
QC-28	05/25/16	8.2	42	290	3.1	13	<5	<0.10	18	<1	14.1	-251	<48
QC-28	08/18/16	8.9	41	244	<1.0	28	<5	0.14	25	<1	13.7	-251	<48
QC-28	11/17/16	8.8	41	216	<1.0	12	<5	<0.10	15	<1	13.4	-253	<48
QC-29	01/14/16	7.0	146	896	1.1	179	207	0.72	413	<1	11.2	-57	<48
QC-29	03/31/16	7.8	145	786	1.2	155	171	0.64	339	<1	12.5	-50	<48
QC-29	06/30/16	7.1	162	908	<1.0	174	208	0.72	390	<1	12.0	-48	<48
QC-29	08/25/16	7.0	159	1,218	1.2	175	238	0.82	435	<1	12.5	-51	<48
QC-29	09/29/16	7.0	156	936	1.3	167	206	0.74	405	<1	11.9	-49	<48
QC-30	03/31/16	8.4	67	444	1.0	13	96	0.21	67	<1	12.0	-124	<48
QC-30	06/30/16	8.1	69	468	<1.0	13	102	0.21	67	<1	12.5	-124	<48
QC-30	08/25/16	8.1	69	518	<1.0	13	103	0.32	70	<1	12.7	-120	<48
QC-30	09/29/16	8.0	71	458	1.1	13	95	0.22	70	<1	11.9	-120	<48
QC-30	12/15/16	7.9	70	430	<1.0	NRR	92	0.34	73	<1	10.0	-122	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	^{0}C	ft	hr
QC-31	01/14/16	7.2	83	548	<1.0	16	207	1.0	247	<1	12.1	-71	<48
QC-31	03/31/16	8.1	87	564	1.2	17	201	1.0	243	<1	13.3	-50	<48
QC-31	06/30/16	7.4	88	568	<1.0	16	207	1.1	245	<1	13.4	-48	<48
QC-31	08/25/16	7.7	89	608	1.0	16	204	1.0	247	<1	13.2	-46	<48
QC-31	09/29/16	7.7	88	562	2.0	16	195	0.98	241	<1	12.5	-46	<48
QC-31	12/15/16	7.5	88	572	1.1	NRR	182	1.1	245	<1	12.1	-48	<48
QC-35	06/23/16	8.4	142	968	<1.0	33	62	<0.10	18	<1	13.5	-149	<48
QC-35	08/25/16	8.4	145	1,024	<1.0	32	79	<0.10	20	<1	14.3	-150	<48
QC-35	10/19/16	8.1	138	898	1.0	30	62	<0.10	19	NRR	4.5	-149	<48
QC-36	10/19/16	8.6	126	768	1.2	30	14	<0.10	14	NRR	14.6	-136	<48

[1]EC = electrical conductivity; TDS = total dissolved solids; TOC = total organic carbon.
[2]Relative to Chicago City Datum (579.5 ft above mean sea level) at intersection of Madison and State Streets.
[3]No reportable result.

TABLE 2: DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m			mg/L				CFU/100 mL
QC-2	Minimum	7.3	51	334	1.0	25	25	0.14	79	<1
	Median	7.7	55	370	1.4	28	25	0.20	84	<1
	Mean	7.7	55	364	1.3	27	27	0.21	85	<1
	Maximum	8.3	57	388	1.6	28	33	0.30	92	<1
	Std. Dev	0.4	2	21	0.3	1	4	0.06	5	NA[3]
	Coeff. of Var. (%)	5.0	5	6	21.0	5	13	29.0	6	NA
QC-2-1	Minimum	7.8	82	506	<1.0	30	<5	0.61	57	<1
	Median	8.0	84	518	<1.0	32	<5	0.62	58	<1
	Mean	8.0	84	518	<1.0	32	<5	0.62	58	<1
	Maximum	8.1	85	530	<1.0	35	<5	0.63	59	<1
	Std. Dev	0.2	2	17	NA	4	NA	0.01	1	NA
	Coeff. of Var. (%)	2.0	3	3	NA	11	NA	2.0	2	NA
QC-2-2	Minimum	8.6	56	342	<1.0	13	24	0.36	41	<1
	Median	8.7	57	349	<1.0	14	27	0.40	42	<1
	Mean	8.7	57	349	<1.0	14	27	0.40	42	<1
	Maximum	8.7	59	356	<1.0	16	29	0.43	42	<1
	Std. Dev	0.1	3	10	NA	2	3	0.05	1	NA
	Coeff. of Var. (%)	1.0	4	3	NA	15	13	13.0	2	NA
QC-4	Minimum	8.6	65	416	<1.0	9	12	<0.10	10	<1
	Median	8.7	69	420	<1.0	9	16	0.13	11	<1
	Mean	8.7	68	432	<1.0	10	14	0.12	11	<1

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m			mg/L				CFU/100 mL
	Maximum	8.9	70	460	<1.0	11	16	0.14	11	<1
	Std. Dev	0.2	2	24	NA	1	2	0.37	1	NA
	Coeff. of Var. (%)	2.0	3	6	NA	12	15	303	5	NA
QC-5	Minimum	8.4	70	514	1.0	41	13	<0.10	8	<1
	Median	8.7	85	538	1.1	42	13	<0.10	8	<1
	Mean	8.6	81	540	1.2	42	14	0.10	8	<1
	Maximum	8.7	89	568	1.4	43	15	<0.10	8	<1
	Std. Dev	0.1	10	27	0.2	1	1	0.32	0	NA
	Coeff. of Var. (%)	2.0	12	5	18.0	2	7	316	0	NA
QC-6	Minimum	8.4	70	438	1.2	15	7	0.30	15	<1
	Median	8.6	73	462	1.3	15	8	0.31	16	<1
	Mean	8.5	72	459	1.3	16	8	0.32	16	<1
	Maximum	8.6	73	478	1.5	17	8	0.34	16	<1
	Std. Dev	0.1	2	20	0.2	1	0.02	0.02	1	NA
	Coeff. of Var. (%)	2.0	3	4	11.0	7	2.5	7.0	4	NA
QC-7	Minimum	8.1	65	390	1.1	10	<5	0.24	10	<1
	Median	8.3	66	400	1.3	10	<5	0.26	10	<1
	Mean	8.3	67	407	2.2	10	<5	0.26	10	<1
	Maximum	8.5	70	432	4.1	11	<5	0.27	11	<1
	Std. Dev	0.2	3	22	1.7	1	NA	0.02	1	NA
	Coeff. of Var. (%)	2.0	4	5	77.0	6	NA	6.0	6	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m			mg/L				CFU/100 mL
QC-9	Minimum	7.9	50	308	<1.0	<10	37	<0.10	60	<1
	Median	8.0	52	326	<1.0	<10	38	0.35	62	<1
	Mean	8.1	53	329	<1.0	<10	39	0.29	62	<1
	Maximum	8.5	58	352	<0.0	<10	42	0.41	65	<1
	Std. Dev	0.3	4	22	NA	NA	3	0.64	3	NA
	Coeff. of Var. (%)	4.0	8	7	NA	NA	7	223	4	NA
QC-10	Minimum	8.5	64	382	<1.0	28	<5	<0.10	10	<1
	Median	8.7	66	420	<1.0	31	<5	0.11	10	<1
	Mean	8.6	66	425	<1.0	30	<5	0.11	10	<1
	Maximum	8.8	67	474	<1.0	31	<5	0.12	10	<1
	Std. Dev	0.2	2	46	NA	2	NA	0.32	0	NA
	Coeff. of Var. (%)	2.0	2	11	NA	6	NA	287	0	NA
QC-11	Minimum	7.9	44	292	<1.0	21	<5	<0.10	20	<1
	Median	8.6	46	310	<1.0	22	<5	0.11	21	<1
	Mean	8.4	46	305	<1.0	22	<5	0.13	21	<1
	Maximum	8.6	47	312	<1.0	22	<5	0.19	21	<1
	Std. Dev	0.4	1	11	NA	1	NA	0.33	1	NA
	Coeff. of Var. (%)	5.0	3	4	NA	3	NA	249	3	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QC-12	Minimum	7.3	127	838	<1.0	35	287	0.46	162	<1
	Median	7.5	128	858	<1.0	35	310	0.60	169	<1
	Mean	7.5	128	863	<1.0	35	305	0.70	168	<1
	Maximum	7.7	129	894	<1.0	36	318	1.0	173	<1
	Std. Dev	0.2	1	28	NA	1	16	0.30	6	NA
	Coeff. of Var. (%)	3.0	1	3	NA	2	5	43.0	3	NA
QC-13	Minimum	7.9	62	410	<1.0	54	21	0.14	34	<1
	Median	8.1	65	412	<1.0	56	22	0.18	35	<1
	Mean	8.0	64	423	<1.0	56	22	0.17	36	<1
	Maximum	8.2	65	448	<1.0	57	24	0.19	39	<1
	Std. Dev	0.2	2	21	NA	2	2	0.03	3	NA
	Coeff. of Var. (%)	2.0	3	5	NA	3	8	16.0	7	NA
QC-14	Minimum	7.3	119	686	1.9	132	<5	0.25	14	<1
	Median	7.6	120	732	2.7	140	<5	0.33	156	<1
	Mean	7.5	126	722	2.5	139	6	0.30	109	<1
	Maximum	7.7	140	748	3.0	144	9	0.33	157	<1
	Std. Dev	0.2	12	32	0.6	6	2	0.05	82	NA
	Coeff. of Var. (%)	3.0	10	4	22.0	4	36	15.0	75	NA
QC-15	Minimum	8.3	47	298	<1.0	12	<5	0.18	15	<1
	Median	8.3	49	328	1.1	12	<5	0.22	15	<1
	Mean	8.3	49	321	1.1	12	<5	0.22	62	<1

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
	Maximum	8.4	51	336	1.1	12	<5	0.25	157	<1
	Std. Dev	0.1	2	20	1.0	0	NA	0.04	82	NA
	Coeff. of Var. (%)	1.0	4	6	98.0	0	NA	16.0	132	NA
QC-16	Minimum	7.8	78	486	<1.0	23	77	<0.10	80	<1
	Median	8.1	80	506	<1.0	23	78	<0.10	81	<1
	Mean	8.1	80	509	<1.0	23	78	0.10	84	<1
	Maximum	8.3	82	534	<1.0	24	80	<0.10	90	<1
	Std. Dev	0.3	2	24	NA	1	1	0.32	6	NA
	Coeff. of Var. (%)	3.0	3	5	NA	2	2	316	7	NA
QC-17	Minimum	8.1	65	442	<1.0	<5	31	<0.10	12	<1
	Median	8.4	74	482	<1.0	8	194	0.25	145	<1
	Mean	8.3	71	474	<1.0	8	142	0.21	101	<1
	Maximum	8.4	74	498	<1.0	10	200	0.28	147	<1
	Std. Dev	0.2	5	29	NA	2	96	0.32	77	NA
	Coeff. of Var. (%)	2.0	7	6	NA	30	68	151	76	NA
QC-18	Minimum	8.8	58	360	<1.0	<10	30	<0.10	7	<1
	Median	9.0	58	402	<1.0	<10	33	<0.10	7	<1
	Mean	9.0	59	432	<1.0	<10	76	0.16	55	<1
	Maximum	9.1	60	534	<1.0	<10	166	0.29	150	<1
	Std. Dev	0.2	1	91	NA	NA	78	0.54	83	NA
	Coeff. of Var. (%)	2.0	2	21	NA	NA	102	330	151	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QC-19	Minimum	7.7	66	396	<1.0	6	146	<0.10	110	<1
	Median	8.4	67	440	<1.0	6	147	0.32	115	<1
	Mean	8.3	73	447	<1.0	6	149	0.25	116	<1
	Maximum	8.7	87	504	<1.0	6	154	0.33	122	<1
	Std. Dev	0.5	12	54	NA	0	4	0.32	6	NA
	Coeff. of Var. (%)	6.0	16	12	NA	0	3	126	5	NA
QC-20	Minimum	7.5	44	194	<1.0	18	<5	0.13	20	<1
	Median	8.3	44	256	<1.0	18	<5	0.15	23	<1
	Mean	8.1	46	263	1.0	18	5	0.16	22	<1
	Maximum	8.4	52	338	1.1	19	6	0.20	23	<1
	Std. Dev	0.5	5	72	0.04	1	1	0.04	2	NA
	Coeff. of Var. (%)	6.0	10	28	4.4	3	11	23.0	8	NA
QC-21	Minimum	7.7	54	270	2.4	16	7	<0.10	29	<1
	Median	8.0	54	332	3.2	17	9	<0.10	31	<1
	Mean	7.9	54	319	3.0	17	8	0.10	32	<1
	Maximum	8.1	54	356	3.3	17	9	0.11	37	<1
	Std. Dev	0.2	0	44	0.5	1	1	0.33	4	NA
	Coeff. of Var. (%)	3.0	1	14	17.0	3	16	321	13	NA
QC-22	Minimum	8.0	43	210	1.3	13	<5	0.25	38	<1
	Median	8.1	43	250	1.4	14	6	0.25	38	<1
	Mean	8.1	43	241	1.4	14	6	0.27	39	<1

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
	Maximum	8.2	43	264	1.4	14	7	0.30	41	<1
	Std. Dev	0.1	0	28	0.1	1	1	0.03	2	NA
	Coeff. of Var. (%)	1.0	1	12	4.0	4	17	11.0	4	NA
QC-23	Minimum	9.0	53	308	<1.0	18	<5	<0.10	7	<1
	Median	9.1	54	330	<1.0	19	<5	<0.10	7	<1
	Mean	9.2	54	327	<1.0	19	21	0.11	7	<1
	Maximum	9.3	54	342	<1.0	19	52	0.13	7	<1
	Std. Dev	0.1	1	17	NA	1	7	0.32	0	NA
	Coeff. of Var. (%)	2.0	1	5	NA	3	35	287	0	NA
QC-24	Minimum	8.6	38	208	<1.0	26	<5	0.12	14	<1
	Median	8.6	40	240	<1.0	27	<5	0.14	15	<1
	Mean	8.6	43	235	<1.0	27	5	0.14	15	<1
	Maximum	8.6	49	256	<1.0	27	6	0.16	16	<1
	Std. Dev	0.1	6	24	NA	1	1	0.02	1	NA
	Coeff. of Var. (%)	1.0	13	10	NA	2	20	14.0	7	NA
QC-25	Minimum	7.8	31	190	<1.0	12	6	0.14	31	<1
	Median	8.0	37	214	<1.0	12	6	0.14	31	<1
	Mean	8.0	36	219	<1.0	12	6	0.15	31	<1
	Maximum	8.1	40	254	<1.0	13	7	0.16	32	<1
	Std. Dev	0.2	5	32	NA	1	1	0.01	1	NA
	Coeff. of Var. (%)	2.0	13	15	NA	5	15	8.0	2	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QC-26	Minimum	8.3	40	246	<1.0	11	<5	<0.10	6	<1
	Median	9.0	43	272	<1.0	11	<5	<0.10	7	<1
	Mean	8.8	43	283	<1.0	12	<5	0.10	7	<1
	Maximum	9.2	45	330	<1.0	13	<5	<0.10	8	<1
	Std. Dev	0.4	2	43	NA	1	NA	0.32	1	NA
	Coeff. of Var. (%)	5.0	6	15	NA	10	NA	316	14	NA
QC-27	Minimum	8.2	40	218	<1.0	10	<5	<0.10	17	<1
	Median	8.3	40	260	<1.0	30	<5	0.15	24	<1
	Mean	8.4	41	250	<1.0	24	<5	0.14	22	<1
	Maximum	8.5	44	272	<1.0	31	<5	0.16	24	<1
	Std. Dev	0.2	3	28	NA	12	NA	0.40	4	NA
	Coeff. of Var. (%)	2.0	6	11	NA	50	NA	293	19	NA
QC-28	Minimum	8.2	41	216	<1.0	12	<5	<0.10	15	<1
	Median	8.8	41	244	<1.0	13	<5	<0.10	18	<1
	Mean	8.6	41	250	1.7	18	<5	0.11	19	<1
	Maximum	8.9	42	290	3.1	28	<5	0.14	25	<1
	Std. Dev	0.4	1	37	1.8	9	NA	0.32	5	NA
	Coeff. of Var. (%)	4.0	1	15	104.0	51	NA	279	27	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QC-29	Minimum	7.0	145	786	1.0	155	171	0.64	339	<1
	Median	7.0	156	908	1.2	174	207	0.72	405	<1
	Mean	7.2	154	949	1.2	170	206	0.73	396	<1
	Maximum	7.8	162	1,218	1.3	179	238	0.82	435	<1
	Std. Dev	0.4	8	161	0.1	9	24	0.06	36	NA
	Coeff. of Var. (%)	5.0	5	17	10.0	6	12	9.0	9	NA
QC-30	Minimum	7.9	66	430	<1.0	13	92	0.21	67	<1
	Median	8.1	69	458	<1.0	13	96	0.22	70	<1
	Mean	8.1	69	464	1.0	13	98	0.26	69	<1
	Maximum	8.4	70	518	1.1	13	103	0.34	73	<1
	Std. Dev	0.2	2	34	0.04	0	5	0.06	3	NA
	Coeff. of Var. (%)	2.0	2	7	4.0	0	5	25.0	4	NA
QC-31	Minimum	7.2	83	548	<1.0	16	182	0.98	241	<1
	Median	7.6	88	566	1.0	16	203	1.0	245	<1
	Mean	7.6	87	570	1.2	16	199	1.0	245	<1
	Maximum	8.1	89	608	2.0	17	207	1.1	247	<1
	Std. Dev	0.3	2	20	1.1	0	10	0.06	2	NA
	Coeff. of Var. (%)	4.0	3	4	90.0	3	5	6.0	1	NA
QC-35	Minimum	8.1	138	898	<1.0	30	62	<0.10	18	<1
	Median	8.4	142	968	<1.0	32	62	<0.10	19	<1
	Mean	8.3	141	963	<1.0	32	68	0.10	19	<1

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QC-2 THROUGH QC-36 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
	Maximum	8.4	145	1,024	<1.0	33	79	<0.10	20	<1
	Std. Dev	0.2	4	63	NA	2	10	0.32	1	NA
	Coeff. of Var. (%)	2.0	3	7	NA	5	14	316	5	NA
QC-36[4]	Minimum	8.6	126	768	1.2	30	14	<0.10	14	NRR[5]
	Median	8.6	126	768	1.2	30	14	<0.10	14	NRR
	Mean	8.6	126	768	1.2	30	14	<0.10	14	NRR
	Maximum	8.6	126	768	1.2	30	14	<0.10	14	NRR
	Std. Dev	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Coeff. of Var. (%)	NA	NA	NA	NA	NA	NA	NA	NA	NA

[1]EC = electrical conductivity; TDS = total dissolved solids; TOC = total organic carbon.
[2]Geometric mean is evaluated since data are assumed to be Log-Normally Distributed.
[3]Not applicable.
[4]Only one sample for Well QC-36.
[5]No reportable result.

TABLE 3: GROUNDWATER ELEVATIONS FOR OBSERVATION WELLS OC-1 THROUGH OC-11 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN MEASURED DURING 2016

Date[1]	Observation Well No.											
	OC-1	OC-2	OC-3	OC-4	OC-5	OC-6	OC-7	OC-8	OC-8.1	OC-9	OC-10	OC-11
	Elevation (ft^2)											
01/08/16	-27.8	-24.6	-161	NA[3]	NA	-70.7	NA	-224.9	-224.9	-201	-228	-222
01/15/16	-35.8	-23.6	-150	-150	-147	-76.7	NA	-219.9	-219.9	NA	-214	-220
02/05/16	-33.8	-25.6	-151	-153	-143	-75.7	-203	-213.9	-213.9	NA	-210	-216
02/23/16	-37.8	-25.6	-161	-157	NA	-76.7	-205	-224.9	-224.9	NA	-227	-221
03/11/16	-36.8	-24.6	-153	-155	-147	-77.7	-205	-217.9	-217.9	-211	-212	-217
03/24/16	-35.8	-23.6	-151	-152	-145	-78.7	-203	-219.9	-219.9	-208	-213	-215
04/08/16	-35.8	-23.6	-151	-153	-148	-74.7	-202	-213.9	-213.9	NA	-213	-215
04/29/16	-39.8	-26.6	-162	NA	NA	-75.7	NA	-223.9	-223.9	NA	-226	-226
05/20/16	-33.8	-26.6	-160	-155	-151	-78.7	-205	-217.9	-217.9	-209	-215	-218
05/31/16	-38.8	-24.6	-156	-147	NA	-74.7	-209	-220.9	-220.9	NA	-224	-220
06/10/16	-39.8	-25.6	-160	NA	NA	-77.7	-204	-226.9	-226.9	NA	-227	NA
06/17/16	-37.8	-24.6	-157	-162	NA	-78.7	-206	-228.9	-228.9	NA	-229	-222
07/01/16	-36.8	-23.6	-155	-160	NA.	-79.7	-203	-226.9	-226.9	-211	-226	-223
07/28/16	-39.8	-27.6	-157	-162	NA	-74.7	NA	-223.9	-223.9	NA	NA	NA
08/12/16	NA	-25.6	-155	-161	NA	-74.7	-210	-223.9	-223.9	-207	-225	-222
08/30/16	-40.8	-24.6	-161	-158	NA	-77.7	-205	NA	NA	NA	-226	-222
09/16/16	NA	-23.6	-152	-159	NA	-76.7	-202	-220.9	-220.9	NA	-224	-219
09/28/16	NA	-25.6	-158	-161	NA	-73.7	-210	-222.9	-222.9	NA	-221	NA
10/14/16	NA	-22.6	-153	-160	NA	-78.7	-203	-221.9	-221.9	NA	-225	-221
10/28/16	NA	-21.6	-148	-165	-149	-77.7	-200	-219.9	-219.9	NA	-221	-223
11/18/16	NA	-23.6	-158	-160	-150	-73.7	-210	-221.9	-221.9	NA	-212	-222
11/23/16	NA	-23.6	-157	-160	-149	-73.7	-210	-221.9	-221.9	-217	-211	-222
12/09/16	-38.8	-25.6	-154	-162	NA	NA	-212	NA	-222.9	NA	-210	-223
12/16/16	NA	-24.6	-156	NA	NA	-76.7	-212	NA	-222.9	-215	-212	-228

[1]Date measurements were taken.
[2]Relative to Chicago City Datum (mean of 579.48' above sea level) at intersection of State and Madison Streets.
[3]Wells inaccessible at various times due to heavy snow, locked gate, muddy road conditions, fallen trees, high weeds, and flooding.

FIGURE 3: MINIMUM, MEAN, AND MAXIMUM OF WATER ELEVATIONS FOR OBSERVATION WELLS OC-1 THROUGH OC-11 IN THE CALUMET TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN MEASURED DURING 2016