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January 16, 2018

Ms. Amy Boley
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794

Groundwater Management Zone
Roxana, Illinois
1191150002 – Madison County
Equilon Enterprises LLC d/b/a Shell Oil Products US
Log No. B-43R-M-32

Dear Amy:

On behalf of Shell Oil Products US (SOPUS), AECOM is submitting the enclosed response to questions on the GMZ package, which was originally issued on January 2, 2018 as an attachment to an email. In a phone call with you on January 10, 2018, you asked for a paper copy of the response.

If you have any further questions during your review, please contact Kevin Dyer, SOPUS Senior Principal Program Manager, at kevin.dyer@shell.com (618/288-7237), or Bob Billman at bob.billman@aecom.com (314/743-4108).

Sincerely,

AECOM, on behalf of Shell Oil Products US

Robert B. Billman, PG
Senior Project Manager

Enclosures: Response package (2 copies)

cc: Kevin Dyer, SOPUS
       Eric Petersen, Phillips 66
       Gina Search, IEPA, Collinsville
       Repositories –Roxana Public Library, website

IEPA Comment 1

For the WRR benzene analysis, wells P-15, P-56, and P-66 were selected. The MAROS Attachment identifies P-56 as a source well. What is the rationale for choosing P-56 when several boundary wells have higher benzene concentrations?

Similarly, the benzene evaluation for the Study Area identified wells MW-8, MW-25, P-56 and ROST-3-MW as source wells, and the remaining wells were considered tail wells. Why were those wells selected as source wells when there are other wells in the Study Area that have higher benzene concentrations and seem like more logical choices.

SOPUS Response

In MAROS evaluations, source/tail/delineation wells are selected based on their location with respect to the plume and their concentration. For the MAROS evaluation of benzene, source wells were identified as those with concentrations >0.005 mg/L. Tail wells are those with detections, but at lower concentrations (<0.005 mg/L). These designations are not used for the Mann-Kendall trend analysis for benzene concentrations. This designation is relevant for the moment analysis module, which considers the spatial distribution of wells along with groundwater flow. The monitoring wells and source/tail identification are shown on the attached Figure 1.

In developing the GMZ submittal, MAROS trend analysis was performed for 52 monitoring wells to identify trends in the groundwater conditions in the refinery and Study Area (Figure 1). The results of this evaluation are summarized in Table 1. Additional information on the evaluation process is included in the response to IEPA Comment 2. Wells P-56, P-15 and P-66 were selected as examples for discussing results because of their long history of sampling and consistent trending data. Well P-56 was selected as a source well for plume evaluation for the following reasons:

- Trend data (regression and Mann-Kendall) for P-56 show a decreasing trend at a 100% confidence level (GMZ, MAROS Attachments).
- Located between higher concentration wells located to the north and south (e.g., P-57, -59, -74) that either show decreasing, stable or no trend.

For the Study Area, wells MW-8, MW-25, P-56 and ROST-3-MW were selected as representative of the dissolved phase impact for the following reasons:

- Located within and along the periphery of the dissolved phase impact in the village (mainly outside the refinery).
- Representative of the distribution of higher and lower concentration areas within this footprint.
- Trend data (regression and Mann-Kendall) for these wells show decreasing trends with confidence levels >96% (GMZ, MAROS Attachments).

Other MAROS source wells in the study area either show similar trends or a trend is less or has lower confidence.

IEPA Comment 2

Why was the evaluation limited to 3 wells? You note that the non-detect wells were excluded and why, but there is no discussion why other wells with detections were excluded.

SOPUS Response

The evaluation was not limited to three wells, as described below.

The MAROS evaluation for the GMZ submittal began with an assessment of the monitoring wells in the RCRA monitoring program for North and Main properties and the Study Area. Wells were excluded if they did not monitor the same interval of the aquifer (e.g., relatively deeper "B," "C," and "D" level wells were excluded).

MAROS trend analysis was then performed for 52 monitoring wells to identify trends in the groundwater conditions in the refinery and Study Area. Information for 19 of the 52 wells was included in the GMZ, as examples for the refinery and Study Area. For the purposes of presentation in the GMZ, three wells in the refinery (P-15, P-56 and P-66) and four wells in the Study Area (MW-8, MW-25, P-56, ROST-3-MW) were identified as representative for describing overall plume attributes.

This evaluation for the 52 wells is summarized on Table 1; the key findings are listed below.

- Twenty-six (26) wells indicated decreasing[1] or stable trends. One well indicated a potentially increasing trend; however the data set was limited. One well indicated an increasing trend; however the well typically contains LNAPL.
- Trends could not be established for 24 wells. This represented conditions such as: >30% non-detects; if well was not sampled in the last 4 monitoring periods; if a well did not have a history of being sampled; or trend confidence levels <90%.

10/4/17, 1:42 pm Email from Amy Boley (IEPA Comment 3)

IEPA Comment 3

Could you elaborate more about the Second Moment Analysis also? I'm having a hard time seeing the change with the scale on the chart in the MAROS Attachment.

SOPUS Response

The second moment describes the relative distribution ("spread") of the plume around the center of mass over time in the x and y directions. The x-axis is defined as the groundwater flow direction and can be interpreted as the direction of migration of the plume (east-west in this case). A decreasing trend in the y-direction indicates that the plume is becoming narrower relative to the groundwater flow direction; whereas a decreasing trend in the x-direction indicates that the overall length of the plume is decreasing. The second moment describes a change in the size of the footprint. Another line of evidence, is the plume footprints shown in Figure 15, which also demonstrate overall shrinkage of the plume.

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[1] Based on Mann-Kendall and/or linear regression tests showing a trend.

Attachment 1 contains the Second Moment Analysis presented on a linear rather than a log scale for improved readability. The decreasing trends in the x (east-west) and y (north-south) directions demonstrates the plume is shrinking.

10/23/17, 11:22 am Email from Amy Boley (IEPA Comments 4 and 5)

IEPA Comment 4

Please provide more detail for the following portions of the GMZ Proposal:

1. *Section 5.5 (last paragraph) identifies the trend analyses included in the proposal. For explanations it refers to Appendix C. Section 3 of Appendix C gives a description of the Mann-Kendall and Linear Regression trend analysis, but it doesn't describe how those are combined to establish a concentration trend (increasing, decreasing, etc). I do see both analyses are on the MAROS Statistical Trend Analysis Summary sheets in Attachment C-1 to Appendix C. Figure 14 also says the analyses have been combined to create the map. It is not clear how they are combined. Please provide more detail.*

SOPUS Response

Mann-Kendall and linear regression are two distinct tests that return a trend result for each well. The result of either the Mann-Kendall test or the linear regression test for each well was depicted on Figure 14, whichever test yielded a definitive trend. An explanation of how each test determines a trend result is presented in the response to IEPA Comment 5.

IEPA Comment 5

2. *Table C-1 in Appendix C identifies the lines of evidence that will be used to support study area improvement. It states the MAROS individual trend analyses will demonstrate decreasing trends at >90%. How was this percentage selected? Is the MAROS plume stability analysis also considered decreasing if >90%?*

SOPUS Response

For Mann-Kendall, the trend result is determined according to relationship between the Mann-Kendall statistic "S", which measures the trend in concentrations over time at a given well location, and the confidence in trend, which is the statistical confidence that the concentration is increasing or decreasing. For linear regression, trends are determined through estimation of the log slope of the line comparing concentrations over time. For both tests, the coefficient of variation (COV) is a statistical measure of how individual data points vary around the mean value; the smaller the COV, the closer the data are grouped around the mean value.

The Air Force Center for Environmental Excellence (AFCEE) Monitoring and Remediation Optimization System (MAROS) Technical Manual, Version 3.0, summarizes the analysis decision matrices that the software uses for Mann-Kendall analysis (Table 2.1, page 23) and linear regression analysis (Table 2.2, page 27). These tables from the software technical manual are reproduced below this text and show that a 90% confidence in trend is a threshold for increasing or decreasing trends in concentration.

Table 2.1 MAROS Mann-Kendall Analysis Decision Matrix

Mann-Kendall Statistic	Confidence in Trend	Trend Result
S>0	>95%	Increasing
S>0	90-95%	Probably Increasing
S>0	<90%	No Trend
S≥0	<90% and COV≥1	No Trend
S≤0	<90% and COV<1	Stable
S<0	90-95%	Probably Decreasing
S<0	>95%	Decreasing

Table 2.2 MAROS Linear Regression Analysis Decision Matrix

Confidence in Trend	Positive Ln Slope	Negative Ln Slope
<90%	No Trend	COV < 1 Stable COV > 1 No Trend
90-95%	Probably Increasing	Probably Decreasing
>95%	Increasing	Decreasing

The plume stability module applies the Mann-Kendall test to the group of wells in each moment analysis:

- The zeroth moment demonstrates changes in mass over time and the trend is determined by applying the Mann-Kendall test to the overall mass of the plume.
- The first moment demonstrates change in location of the center of mass over time and the trend is based on the distance from the source area to the center of mass.
- The second moment demonstrates the change in plume spread over time and the trend is based on the spread of the plume footprint.

As with the individual well Mann-Kendall trends, when using the MAROS software, a confidence in trend >90% is considered the minimum value for which trends can be demonstrated as either increasing or decreasing.

Table 1
MAROS Statistical Trend Analysis Summary

Well	Source/Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND"?	Mann-Kendall Trend	Linear Regression Trend
BENZENE								
Wood River Refinery Wells								
P-14	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-15*	S	62	54	5.0E-02	3 3E-02	No	D	D
P-16	S	11	9	2.6E-03	2.1E-03	No	S	S
P-17	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-55	S	9	8	4.5E-01	5.7E-01	No	I	I
P-56*	S	21	21	1.5E-01	1 3E-01	No	D	D
P-57	S	18	18	1 9E+02	1.4E+02	No	NT	NT
P-58	S	19	19	4 6E+02	4.8E+02	No	S	S
P-59	S	20	20	1.1E+01	1.0E+01	No	NT	S
P-66*	T	20	19	2.9E-01	3 2E-02	No	D	D
P-74	S	19	17	2 0E+00	3.4E-01	No	D	D
P-81A	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-82A	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-83A	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-84A	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-86A	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-88A	T	11	1	5.0E-04	5 0E-04	No	S	S
P-93A	S	22	22	2 8E+02	2.4E+02	No	S	S
P-94	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-95	T	11	0	5.0E-04	5 0E-04	Yes	ND	ND
P-99	T	1	0	5.0E-04	5 0E-04	Yes	ND	ND
T-1	T	11	8	6.7E-03	1 2E-03	No	NT	NT
T-12	S	20	20	2.1E+00	2.0E+00	No	NT	S
T-13	T	11	2	9.1E-04	5 0E-04	No	NT	NT
T-42	T	1	0	5.0E-04	5 0E-04	Yes	ND	ND
T-43	T	1	1	8.0E-04	8 0E-04	No	N/A	N/A
T-44	T	1	0	5.0E-04	5 0E-04	Yes	ND	ND
T-51	T	1	0	5.0E-04	5 0E-04	Yes	ND	ND
T-52	T	1	0	5.0E-04	5 0E-04	Yes	ND	ND
T-6	S	1	1	1.4E+02	1.4E+02	No	N/A	N/A
Study Area Wells								
MW-01	T	22	7	3.0E-03	2 5E-04	No	NT	D
MW-02	T	22	22	1.9E-01	2 0E-02	No	NT	D
MW-03	T	22	15	2.3E-03	5 6E-04	No	D	D
MW-04	S	22	22	5 2E+00	1 2E-01	No	NT	NT
MW-05	T	22	19	1.8E-02	6 3E-03	No	PD	D
MW-06A	T	22	10	3.2E-03	6.1E-04	No	D	D
MW-07	S	22	22	1.1E+03	1.0E+03	No	NT	NT
MW-08	S	22	22	8.1E+02	8.2E+02	No	D	D
MW-09	T	22	6	1.0E-03	2 5E-04	No	PD	D
MW-10	T	22	7	8.2E-04	2 5E-04	No	NT	PD
MW-11	T	22	6	6.6E-04	2 5E-04	No	PD	D
MW-12	T	22	5	6.8E-04	2 5E-04	No	D	D
MW-14	T	17	7	2.5E-03	5 0E-04	No	D	D
MW-16	T	13	3	3.6E-04	2 5E-04	No	S	NT
MW-22	S	13	13	1 6E+00	1.6E+00	No	S	S
MW-24	T	12	1	5.1E-04	2 5E-04	No	NT	NT
MW-25	S	6	6	1 2E+02	6.7E+01	No	D	D
MW-26	T	6	0	3.3E-04	2 5E-04	Yes	ND	ND
MW-27	T	6	2	3.6E-04	3.4E-04	No	NT	PI
MW-28	T	6	4	2.5E-02	1.4E-02	No	NT	PD
ROST-3-MW	S	16	14	8.0E-03	4 6E-03	No	D	D
ROST-4-PZ(C)	S	17	15	4.4E-02	3 9E-02	No	NT	NT

Notes for Trends: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)
Notes for sampling period: Samples collected between 2010 and 2016 except where noted by (*) data from 1991 through 2016.
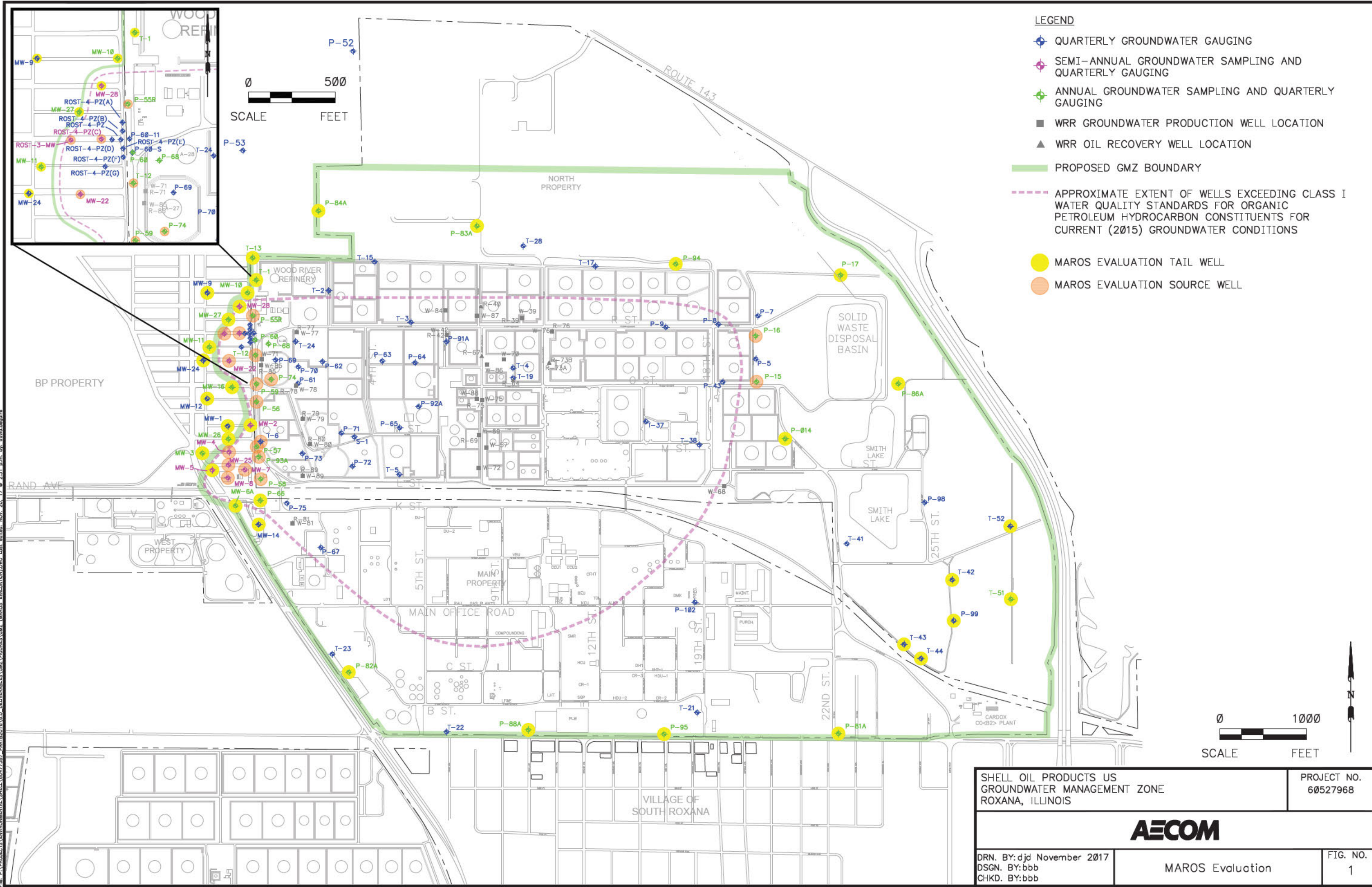
LEGEND

◈ QUARTERLY GROUNDWATER GAUGING

◈ SEMI—ANNUAL GROUNDWATER SAMPLING AND QUARTERLY GAUGING

◈ ANNUAL GROUNDWATER SAMPLING AND QUARTERLY GAUGING

■ WRR GROUNDWATER PRODUCTION WELL LOCATION

▲ WRR OIL RECOVERY WELL LOCATION

━━ PROPOSED GMZ BOUNDARY

┉┉ APPROXIMATE EXTENT OF WELLS EXCEEDING CLASS I WATER QUALITY STANDARDS FOR ORGANIC PETROLEUM HYDROCARBON CONSTITUENTS FOR CURRENT (2015) GROUNDWATER CONDITIONS

● MAROS EVALUATION TAIL WELL

● MAROS EVALUATION SOURCE WELL

SHELL OIL PRODUCTS US
GROUNDWATER MANAGEMENT ZONE
ROXANA, ILLINOIS

PROJECT NO.
60527968

AECOM

DRN. BY: djd November 2017
DSGN. BY: bbb
CHKD. BY: bbb

MAROS Evaluation
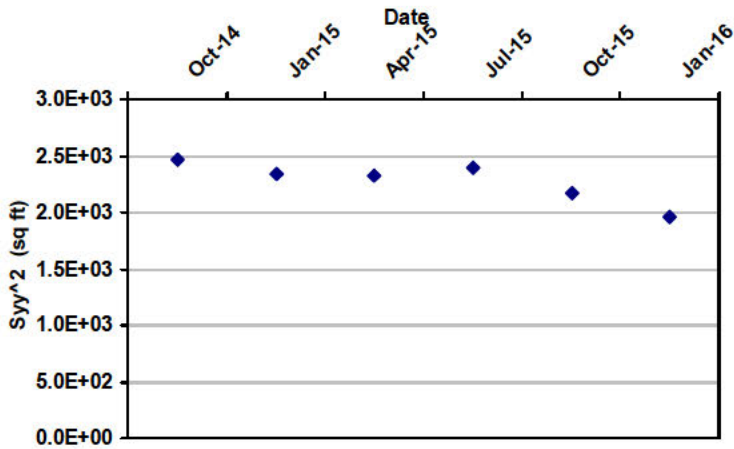
FIG. NO.
1

MAROS Second Moment Analysis

Project: Roxana   **User Name:** AECOM

Location: St Louis   **State:** Illinois

Change in Plume Spread Over Time

COC: BENZENE

Mann-Kendall S Statistic:

-11

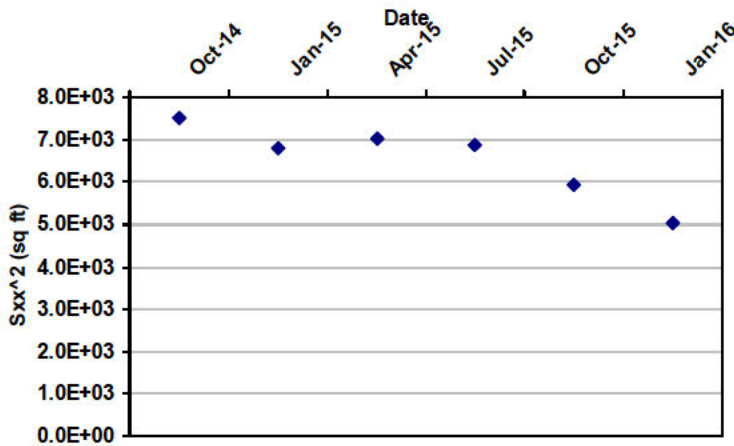**Confidence in Trend:**

97.2%

Coefficient of Variation:

0.08

Second Moment Trend:

D

Mann-Kendall S Statistic:

-11

Confidence in Trend:

97.2%

Coefficient of Variation:

0.14

Second Moment Trend:

D

Data Table:

Effective Date	Constituent	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
10/6/2014	BENZENE	7,497	2,466	6
1/12/2015	BENZENE	6,807	2,335	6
4/6/2015	BENZENE	7,030	2,329	6
7/8/2015	BENZENE	6,871	2,395	6

MAROS Second Moment Analysis

Project: Roxana		**User Name:** AECOM
Location: St Louis		**State:** Illinois

Data Table:

Effective Date	Constituent	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
10/5/2015	BENZENE	5,948	2,162	6
1/7/2016	BENZENE	5,019	1,959	6

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events)

The Sigma XX and Sigma YY components are estimated using the given field coordinate system and then rotated to align with the estimated groundwater flow direction. Moments are not calculated for sample events with less than 6 wells.