DOCUMENTATION OF ENVIRONMENTAL INDICATOR DETERMINATION
Interim Final 2/5/99
RCRA Corrective Action
Environmental Indicator (EI) RCRIS code (CA750)

Migration of Contaminated Groundwater Under Control

Facility Name: Honeywell – Chesterfield, VA
Facility Address: 4101 Bermuda Hundred Road, Chester, VA 23836
Facility EPA ID #: VAD023690183

1. Has **all** available relevant/significant information on known and reasonably suspected releases to the groundwater media, subject to RCRA Corrective Action (e.g., from Solid Waste Management Units (SWMU), Regulated Units (RU), and Areas of Concern (AOC)), been **considered** in this EI determination?

   __√__ If yes – check here and continue with #2 below.

   _____ If no – re-evaluate existing data, or

   _____ if data are not available skip to #8 and enter "IN" (more information needed) status code.

BACKGROUND

Definition of Environmental Indicators (for the RCRA Corrective Action)

Environmental Indicators (EI) are measures being used by the RCRA Corrective Action program to go beyond programmatic activity measures (e.g., report received and approved, etc.) to track changes in the quality of the environment. The two EIs developed to-date indicate the quality of the environment in relation to current human exposures to contamination and the migration of contaminated groundwater. An EI for non-human (ecological) receptors is intended to be developed in the future.

Definition of "Current Migration of Contaminated Groundwater Under Control" EI

A positive "Migration of Contaminated Groundwater Under Control" EI determination ("YE" status code) indicates that the migration of "contaminated" groundwater has stabilized, and that monitoring will be conducted to confirm that contaminated groundwater remains within the original "area of contaminated groundwater" (for all groundwater "contamination" subject to RCRA corrective action at or from the identified facility (i.e., site-wide).

Relationship of EI to Final Remedies

While Final remedies remain the long-term objective of the RCRA Corrective Action program, the EI are near-term objectives which are currently being used as Program measures for the Government Performance and Results Act of 1993, (GPRA). The "Migration of Contaminated Groundwater Under Control" EI pertains ONLY to the physical migration (i.e., further spread) of contaminated groundwater and contaminants within groundwater (e.g., non-aqueous phase liquids or NAPLs). Achieving this EI does not substitute for achieving other stabilization or final remedy requirements and expectations associated with sources of contamination and the need to restore, wherever practicable, contaminated groundwater to be suitable for its designated current and future uses.

Duration / Applicability of EI Determinations

EI Determinations status codes should remain in RCRIS national database ONLY as long as they remain true (i.e., RCRIS status codes must be changed when the regulatory authorities become aware of contrary information).

2. Is **groundwater** known or reasonably suspected to be **"contaminated"**[1] above appropriately protective "levels" (i.e., applicable promulgated standards, as well as other appropriate standards, guidelines, guidance, or criteria) from releases subject to RCRA Corrective Action, anywhere at, or from, the facility?

__√__ If yes – continue after identifying key contaminants citing appropriate "levels" and referencing supporting documentation.

_____ If no– skip to #8, and enter "YE," status code after citing appropriate "levels," and referencing supporting documentation to demonstrate that groundwater is not "contaminated".

_____ If unknown - skip to #8 and enter "IN" status code.

The Chesterfield Facility (Facility) is an active nylon resins manufacturing plant located at 4101 Bermuda Hundred Road in the county of Chesterfield, Commonwealth of Virginia. USEPA has identified eleven Solid Waste Management Units (SWMUs) at the Facility, and three are considered to be sources of groundwater impacts. Since January 2000, Honeywell has been conducting RCRA Facility Investigation activities under a Facility Lead Agreement.

The following RCRA Facility Investigation Reports have been produced under the Facility Lead Agreement and form the basis of this EI determination.

[1] "Contamination" and "contaminated" describe media containing contaminants (in any form, NAPL and/or dissolved, vapors, or solids, that are subject to RCRA) in concentrations in excess of appropriate "levels" (appropriate for the protection of the groundwater resource and its beneficial uses).

- *Draft Data Summary Report, RCRA Corrective Action Program Honeywell – Chesterfield, VA Facility;* Montgomery Watson Harza; dated April 2002.

- *RFI Data Summary Report Honeywell Chesterfield Facility Chester, VA;* Montgomery Watson Harza; dated October 2003, revised January 2004.

- *Phase III RFI Data Summary Report Honeywell Chesterfield Facility Chester, VA;* Montgomery Watson Harza; dated March 2005, revised by MACTEC Engineering and Consulting, Inc. October 2006.

- *Final Phase IV RCRA Facility Investigation Report Honeywell Chesterfield Facility Chester, VA;* MACTEC Engineering and Consulting, Inc.; dated January 2007, revised October 2007.

- *Phase V RCRA Facility Investigation Report Honeywell Chesterfield Facility Chester Virginia;* MACTEC Engineering and Consulting, Inc.; dated April 2008.

- *Conceptual Site Model for Dense Non-Aqueous Phase Liquid and Marl, Honeywell Chesterfield Facility, Chester, Virginia*; MACTEC Engineering and Consulting, Inc.; dated September 2009

- *SWMU 4 MIP Investigation, Honeywell Chesterfield Facility, Chesterfield, Virginia*; Letter report to Russell H. Fish (USEPA) from Richard Karr (AMEC); dated June 24, 2013.

- *SWMU 4 Groundwater Investigation*; Letter report to Russell H. Fish (USEPA) from Richard Karr (AMEC); dated June 28, 2013.

- *Chesterfield Groundwater Study, Vertical Plume Delineation*; Letter report to Erich Weissbart (USEPA) from Richard Karr (AMEC); dated January 6, 2014.

- *Chesterfield Groundwater Study, Vertical Plume Delineation*; Letter report to Erich Weissbart (USEPA) from Richard Karr (AMEC); dated February 28, 2014.

- *Chesterfield Groundwater Study, Horizontal and Vertical Plume Delineation*; Letter report to Erich Weissbart (USEPA) from Richard Karr (AMEC); dated July 2, 2014.

- *Solid Waste Management Unit 4, Groundwater Monitoring Plan, Final*; AMEC Environment & Infrastructure, Inc.; dated October 14, 2014.

- *Chesterfield Facility RCRA Groundwater Monitoring Plan, Final;* AMEC Environment & Infrastructure, Inc.; dated October 9, 2014.

- *Solid Waste Management Unit 4 Interim Measure Work Plan*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated January 30, 2015.

- *Groundwater Monitoring Report*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated April 2015.

- *SWMU 4 Groundwater Monitoring Report*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated January 30, 2015.

The key contaminants at the site are volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). The April 2015 Groundwater Monitoring Report and April 2015 SWMU4 Groundwater Monitoring Report document groundwater concentrations of organic parameters exceeding the USEPA Risk Based Screening (RSL) for Tap Water[1] and/or the USEPA Maximum Contaminant Level (MCL) for Groundwater.

Exceedances were identified for the following key parameters in the Recent Alluvium:

Volatile Organic Compounds (VOCs)	**Semi-Volatile Organic Compounds (SVOCs)**
1,1,1-trichloroethane	1,4-dioxane
1,1,2-trichloroethane	N-nitrosodiphenylamine
1,1-dichloroethane	Naphthalene
1,1-dichlorethene	
1,2-dichloroethane	
1,3-dichlorobenzene	
1,4-dichlorobenzene	
benzene	
chloroform	
cis-1,2-dichloroethene	
tetrachloroethene	
trichloroethene	
vinyl chloride	

Exceedances were identified for the following key parameters in the Potomac Unit:

Volatile Organic Compounds (VOCs)	**Semi-Volatile Organic Compounds (SVOCs)**
1,1-dichloroethane	1,1-biphenyl
cis-1,2-dichloroethene	1,4-dioxane
tetrachloroethene	anthracene
	benzo(a)anthracene
	benzo(a)pyrene
	benzo(b)fluoranthene
	benzo(g,h,i)perylene
	benzo(k)fluoranthene

[1] USEPA Risk-based Screening Levels, January 2015

Volatile Organic Compounds (VOCs)	Semi-Volatile Organic Compounds (SVOCs)
	chrysene
	dibenzo(a,h)anthracene
	Indeno(1,2,3-cd)pyrene
	pyrene

The January 2004 RFI Report and the October 2006 Phase III Data Summary Report document groundwater concentrations of inorganic parameters exceeding the RSL for Tap Water and/or the MCL for Groundwater

Non-key parameters are those parameters that are not part of the primary waste stream disposed at this facility. Exceedances were identified for the following non-key parameters in the Recent Alluvium:

Dissolved Metals
antimony
arsenic
cadmium
iron
manganese

Exceedances were identified for the following non-key parameters in the Potomac Aquifer Unit:

Dissolved Metals
arsenic
manganese

3. Has the **migration** of contaminated groundwater **stabilized** (such that contaminated groundwater is expected to remain within “existing area of contaminated groundwater”[2] as defined by the monitoring locations designated at the time of this determination)?

__√__ If yes – continue, after presenting or referencing the physical evidence (e.g., groundwater sampling/measurement/migration barrier data) and rationale why contaminated groundwater is expected to remain within the (horizontal

[2] “existing area of contaminated groundwater” is an area (with horizontal and vertical dimensions) that has been verifiably demonstrated to contain all relevant groundwater contamination for this determination, and is defined by designated (monitoring) locations proximate to the outer perimeter of “contamination” that can and will be sampled/tested in the future to physically verify that all” contaminated” groundwater remains within this area, and that the further migration of “contaminated” groundwater is not occurring. Reasonable allowances in the proximity of the monitoring locations are permissible to incorporate formal remedy decisions (i.e., including public participation) allowing a limited area for natural attenuation.

or vertical) dimensions of the "existing area of groundwater contamination").

_____ If no (contaminated groundwater is observed or expected to migrate beyond the designated locations defining the "existing area of groundwater contamination") – skip to #8, and enter "NO" status code after providing an explanation.

_____ If unknown - skip to #8 and enter "IN" status code.

Rationale and Reference(s):

The delineation of groundwater impacts to the north of the Chesterfield Facility along Bermuda Hundred Road and to the east along the James River was completed in 2014[2]. This also completed the delineation of groundwater impacts for the entire site completing the database to assess the migration of impacts.

The stability of the contaminated groundwater migration at the Site within the Recent Alluvium and Potomac Unit was evaluated by compiling the historical database of groundwater contaminant concentrations around the boundaries of the Site and plotting available analyte concentration data through November 2014. Historical data was compiled from monitoring wells positioned along boundaries where migration offsite could occur (see Figure 1):

1. Along the James River.
   a. MW-119, MW-110D, MW-111S, MW-111D, MW-7, MW-9, MW-118D, and MW-118DD

2. Monitoring wells to the north of the Site.
   a. NW12-1, MW-131S, MW-131D, MW-131DD, TMP-131, MW-132D, MW-132DD, MW-133D, and MW-133DD.

Groundwater data for the above monitoring wells and sampling locations were screened to focus on usable data. This screening removed data from consideration meeting these criteria:

- Non-detections and other data with quality assurance qualifiers of R, U, UJ, and UL;
- General water quality analytes such as salts, major ions, etc.;
- Compounds reported as totals of multiple isomers (i.e., total xylenes); and,

[2] *Chesterfield Groundwater Study, Horizontal and Vertical Plume Delineation*; Letter report to Erich Weissbart (USEPA) from Richard Karr (AMEC); dated July 2, 2014.

- Most tentatively identified compounds (TICs) or generally identified compounds (i.e., x-carbon chain hydrocarbon) not normally reported under SW846 8260 or 8270 analytical methods[3].

Because the historical data groundwater show that the key compounds of concern (COCs) are VOCs and SVOC, dissolved metal analytes were not considered further in the evaluation.

Data from a total of 17 monitoring wells screened in the Recent Alluvium or Potomac Unit were evaluated to assess stability of groundwater migration. Data were available from multiple historical sampling events dating back to 2001. However, no single sampling event included all 17 wells. This was because a number of the site wells, particularly those north of SWMU 4, were not installed and available for sampling during the Phase I and II RCRA Facility Investigation (RFI). Several monitoring wells north of SWMU 3 and 4 were installed during the subsequent Phase III, IV and V RFI work, and a number were only installed and sampled during the RFI activities conducted in 2013-2014.

To facilitate the evaluation of key COC stability from the data sets for the wells identified above, two types of analyses were performed:

- In monitoring wells where data from four (4) or more sampling events were available, stability was assessed with Mann-Kendall statistical trend analyses[4] at the 95% confidence level on select key parameters in data sets for individual wells. The individual wells where data from four (4) or more sampling events were available were NW12-1 and MW-7.

- In monitoring wells where data from less than four (4) sampling events were available, stability was assessed by comparing the concentrations of individual parameters from the earliest sampling event to those of the most recent (in most cases November 2014). For each individual well, the percentage of parameters with increased or decreased concentrations over the period of observation was noted. Monitoring wells evaluated in this manner included MW- 9, MW-111S, MW-119, MW-131S, MW-131D, MW-131DD, TMP-131, MW-132D, MW-132DD, MW-133D, and MW-133DD.

Mann-Kendall trend analyses identified no significant trend in the data sets at the 95% significance level for any parameter examined in either NW12-1 or MW-7 (See Attachment 1 for individual output). Monitoring well NW-12-1 located near SWMU 4 and installed in 1988 in the Recent Alluvium, has a robust data set reflecting six (6) separate monitoring events. Concentrations of individual analytes varied from beginning to end of the time series, likely attributable to production of degradation daughter products of tetrachloroethene and the close proximity to the SWMU where DNAPL is present. However, Mann-Kendall trend analyses indicates no significant concentration trends and

[3] If a TIC or other compound not normally reported under SW846 Method 8260 or Method 8270 analyses was detected in multiple events, it was included in the analysis.
[4] Mann-Kendal trend analyses were performed using USEPA ProUCL v.4.1 software.

suggests stability. SWMU 4 is scheduled to be addressed by a containment Interim Measure to be constructed in early 2016, which is designed to immediately reduce loading to groundwater from the SWMU. A summary of the parameters tested in both wells and the conclusions are provided in Table 1:

Table 1

Monitoring Well	Parameter	Number of Data Points	Significance Level	Evidence of Trend
NW12-1	1,1,1-trichloroethane	6	0.05	Neutral
	1,1-dichloroethane	6	0.05	Neutral
	1,2-dichloroethane	6	0.05	Neutral
	benzene	6	0.05	Neutral
	chloroethane	6	0.05	Neutral
	cis-1,2-dichloroethene	6	0.05	Neutral
	m,p-xylene	6	0.05	Neutral
	toluene	6	0.05	Neutral
	vinyl chloride	6	0.05	Neutral
	trichloroethene	6	0.05	Neutral
	1,1-biphenyl	5	0.05	Neutral
	1,4-dioxane	4	0.05	Neutral
	naphthalene	6	0.05	Neutral
	tetrachloroethene	6	0.05	Neutral
MW-7	caprolactam	4	0.05	Neutral
	carbazole	4	0.05	Neutral
	n-nitrosdiphenylamine	4	0.05	Neutral
	chloroethane	4	0.05	Neutral

Stability evaluation for the monitoring wells with less than four (4) sampling events indicate concentrations of the majority of the parameters detected have actually declined from the initial sampling event to most recent sampling event in the majority of individual wells. Many of the declines are attributable to parameter concentrations marginally above detection limit in the initial sampling event followed by non-detect values (i.e., one-time detections) in the subsequent event(s).

If these wells are viewed as a population, the scarcity of wells with increasing trends (only three out of eleven) is strong evidence that the contaminant concentrations in the wells are declining. If the wells with increases are examined individually, the increases can be seen to be either one-time detections in 2014 but not detected previously and/or down gradient of SWMU 4, which is scheduled to be addressed by a containment Interim Measure to be constructed in early 2016. A summary of these analyses is presented in Table 2 and Table 3:

Table 2

Monitoring Well	Concentration Change Over the History of Sampling Events	
	Percentage of Detected Parameters where Concentrations Increased Between First and Last Measurement	Percentage of Detected Parameters where Concentrations Decreased Between First and Last Measurement
MW-9	60%	40%
MW-111S	57%	43%
MW-119	33%	67%
MW-131S	50%	50%
MW-131D	17%	83%
MW-131DD	0%	100%
TMP-131	75%	25%
MW-132D	46%	54%
MW-132DD	23%	78%
MW-133D	11%	89%
MW-133DD	14%	86%
Average:	**35%**	**65%**

Table 3

Monitoring Well	Reason for Increase in Concentration
MW-9	Three parameters detected in only one event, in 2014. All but caprolactam were <10 µg/L
MW-111S	Two parameters detected in only one event, in 2014. These were caprolactam and diphenyl ether. Phenol, 1,4 dioxane, and n-nitrosodiphenylamine detected in two events and increased in second event.
TMP-131	Down gradient of SWMU 4. Most detections occurred in only one event.

Along the James River, the monitoring well data typically exhibited non-detect to nominal (i.e., below RSL) concentrations of only four analytes or less, with the exception of data from MW-7 which is screened in the Recent Alluvium at a depth of 17 feet. Well MW-7 is likely monitoring groundwater impacted by SWMU 12. However, Mann-Kendall trend analyses indicates no significant concentration trends and stability.

Along the northern boundary of the Site, Bermuda Hundred Road, the monitoring wells in the network were installed in 2014. These include the MW-131S/D/DD, MW-TMP-131, MW-132D/DD, MW-133D/DD, all screened within the Potomac Unit. Available data from these monitoring wells only reflect two sampling events conducted in 2014. Within this dataset, a number of VOC and SVOC analytes were detected at each monitoring well.

Overall, the extent and magnitude of groundwater impacts within the Recent Alluvium and the Potomac Unit by VOCs and SVOCs, as observed in key monitoring wells along the Site boundaries, appears to be quantitatively stable or declining. Consequently, the data suggest that impacted groundwater remains within the original "area of contaminated groundwater" subject to RCRA corrective action and defined by the existing monitoring network.

4. Does "contaminated" groundwater **discharge** into **surface water** bodies?

__√__ If yes – continue after identifying potentially affected surface water bodies.

_____ If no skip to #7 (and enter "YE" status code in #8, if #7 = yes) after providing an explanation and/or referencing documentation supporting that groundwater "contamination" does not enter surface water bodies.

_____ If unknown - skip to #8 and enter "IN" status code.

Rationale and Reference(s): Within the Recent Alluvium, groundwater elevation data suggest that groundwater discharges to three surface water bodies: Portions of the Western Cooling Water Ditch (WCWD) and portions of the Eastern Cooling Water Ditch (ECWD) which flow through the Chesterfield Facility; and, to the James River.

Within the Potomac Unit, groundwater discharges only to the James River along subaqueous outcrops.

References:

1. *Groundwater Monitoring Report*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated April 2015.

2. *SWMU 4 Groundwater Monitoring Report*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated January 30, 2015.

5. Is the **discharge** of "contaminated" groundwater into surface water likely to be **"insignificant"** (i.e., the maximum concentration[3] of each contaminant discharging into surface water is less than 10 times their appropriate groundwater "level", and there are no other conditions (e.g., the nature, and number, of discharging contaminants, or environmental setting), which significantly increase the potential

[3] As measured in groundwater prior to entry to the groundwater-surface water/sediment interaction (e.g., hyporheic) zone.

for unacceptable impacts to surface water, sediments, or eco-systems at these concentrations)?

_____If yes – skip to #7 (and enter "YE" status code in #8 if #7 = yes), after documenting: 1) the maximum known or reasonably suspected concentration of key contaminants discharged above their groundwater "level," the value of the appropriate "level(s)," and if there is evidence that the concentrations are increasing; and 2) provide a statement of professional judgement/explanation (or reference documentation) supporting that the discharge of groundwater contaminants into the surface water is not anticipated to have unacceptable impacts to the receiving surface water, sediments, or eco-system.

__√__ If no – (the discharge of "contaminated" groundwater into surface water is potentially significant) – continue after documenting: 1) the maximum known or reasonably suspected concentration of each contaminant discharged above its groundwater "level," the value of the appropriate "level(s)," and if there is evidence that the concentrations are increasing; and 2) for any contaminants discharging into surface water in concentrations greater than 100 times their appropriate groundwater "levels," the estimated total amount (mass in kg/yr) of each of these contaminants that are being discharged (loaded) into the surface water body (at the time of the determination), and identify if there is evidence that the amount of discharging contaminants is increasing.

_____ If unknown - enter "IN" status code in #8.

Rationale and Reference(s): In November 2014, synoptic groundwater elevation measurements were collected in over 40 onsite wells during the most recent groundwater sampling event. These data were used to construct groundwater elevation contour maps for both the Recent Alluvium and Potomac Unit (see Figures 2 and 3). Groundwater flow paths were then evaluated based on these contours to construct discrete flow tubes that define discharge flux planes adjacent to the WCWD, ECWD, and James River. Groundwater contaminant data for VOCs and SVOCs, collected during the November 2014 sampling event from monitoring wells positioned within the respective units and representative of groundwater quality discharging to these surface water bodies, were evaluated to identify the maximum known or reasonably suspected concentration of each contaminant discharged above its respective Maximum Contaminant Level (MCL) or Tap Water Risk-based Screening Level (RSL). Generally the monitoring well or wells closest to the discharge boundary was judged to be representative of groundwater quality. The following were the wells selected as representative (Refer to Figures 2 and 3):

Aquifer	Flow Tube and Flux Plane Section	Representative Monitoring Wells	Discharge to:
Recent Alluvium	1A	NW-12-1	WCWD
Recent Alluvium	1B	MW-106S	WCWD
Recent Alluvium	1C	MW-107S	WCWD
Recent Alluvium	2A	MW-119S	James River
Recent Alluvium	2B	MW-110S	James River
Recent Alluvium	2C	MW-111S, MW-7	James River
Recent Alluvium	2D	MW-9	James River
Recent Alluvium	3A	MW-8	ECWD
Potomac Unit	1A	NW9-1, MW-110D	James River
Potomac Unit	1B	MW-111D	James River
Potomac Unit	1C	MW-118D, MW-118DD, NW5-1	James River
Potomac Unit	1D	NW-1-3	James River

Where multiple wells were representative, their analytical results were averaged[5] for these evaluations. If only one detection of an analyte existed within multiple representative wells in one flow section, then that value was used in these evaluations.

Recent Alluvium

Within the Recent Alluvium, the maximum concentration of each VOC and SVOC analyte in any flow tube was identified and compared to its respective MCL, or Tap Water RSL (if no MCL has been established). The identified maximum concentrations were evaluated to identify those greater than 100 times their respective groundwater level. The results of this evaluation are presented in tabular format with those analytes greater than 100 times their respective groundwater level highlighted in yellow:

VOC Analyte	Jan 2015 MCL or Tap Water RSL (µg/L)	Max Conc. (µg/L)	Max Conc. Multiple of GW Level
1,1,1-Trichloroethane	200.0	21.6	0.1
1,1-Dichloroethane	2.7	72.2	26.7
1,1-Dichloroethene	7.0	1.7	0.2
1,2-Dichlorobenzene	600.0	1.4	0.0
1,2-Dichloroethane	5.0	5.3	1.1
1,4-Dichlorobenzene	75.0	0.25	0.0
Acetone	14,000.0	25.3	0.0
Benzene	5.0	27.7	5.5
Carbon tetrachloride	5.0	4.1	0.8
Chlorobenzene	100.0	0.4	0.0

[5] Non-detects were treated as a concentration of zero.

VOC Analyte	Jan 2015 MCL or Tap Water RSL (µg/L)	Max Conc. (µg/L)	Max Conc. Multiple of GW Level
Chloroethane	21,000.0	1,810.0	0.1
cis-1,2-dichloroethylene	70.0	188.0	2.7
Ethylbenzene	700.0	14.0	0.0
m,p-Xylene	190.0	32.5	0.2
Methyl Acetate	20,000.0	5	0.0
Methylene Chloride	5.0	16.1	3.2
o-Xylene	190.0	10.8	0.1
Tetrachloroethene	5.0	2.5	0.5
Toluene	1,000.0	91.3	0.1
trans-1,2-Dichloroethene	100.0	10.4	0.1
Trichloroethylene (TCE)	5.0	10.6	2.1
Vinyl chloride	2.0	548.0	274.0

SVOC Analyte	Jan. 2015 MCL or Tap Water RSL (µg/L)	Max Conc. (µg/L)	Max Conc. Multiple of GW Level
1,4-Dioxane	0.8	484	620.5
2-Chlorophenol	91.0	1.5	0.0
2-Methylphenol (o-cresol)	930.0	1.5	0.0
3&4-Methylphenol	1,900.0	6.1	0.0
1,1 Biphenyl (diphenyl)	0.8	33.4	40.2
Caprolactam	9,900.0	162	0.0
Carbazole	none	17.9	NA
Cyclohexane	13,000.0	1.7	0.0
Diphenyl ether	none	525	N/A
Naphthalene	0.2	0.265	1.6
N-Nitrosodiphenylamine	12.0	328	27.3
Phenanthrene	none	0.209	N/A
Phenol	5,800.0	23.7	0.0
Tetrahydrofuran	3,400.0	11	0.0

As indicated in the tables above, the maximum observed concentrations of vinyl chloride and 1,4-dioxane exceed their respective groundwater levels by a multiple of greater than 100 times in the Recent Alluvium monitoring wells representative of groundwater that discharges to surface waters at the site. Using data from the November 2014 groundwater sampling event, the estimated mass flux of compounds greater than 100 x the RSL being discharged to surface water bodies was computed (see Attachment 2 for detailed calculations). The result of this estimate on an annualized basis is summarized in the following table:

Annual Loading From Recent Alluvium				
Surface Water Body	**Parameter**	**Flow Tube and Flux Plane Section**	**Estimated Flux (mg/sec)**	**Annual Flux (kg/yr)**
WCWD	Vinyl Chloride	1A	7.97E-03	0.25
ECWD	Vinyl Chloride	3A	7.94E-05	0.003
WCWD	1,4-Dioxane	1A	3.58E-04	0.01
WCWD	1,4-Dioxane	1B	1.38E-03	0.04
WCWD	1,4-Dioxane	1C	1.88E-03	0.06
James River	1,4-Dioxane	2A	5.85E-05	0.002
James River	1,4-Dioxane	2C	5.71E-02	1.80
James River	1,4-Dioxane	2D	1.22E-04	0.004
ECWD	1,4-Dioxane	3A	6.14E-07	0.00002

Potomac Unit

In a similar fashion within the Potomac Unit, the maximum concentration of each VOC and SVOC analyte in any flow tube was identified and compared to its respective MCL, or Tap Water RSL if no MCL has been established. As with the data for the Recent Alluvium, the maximum concentrations of each analyte were evaluated and compared to 100 times their respective groundwater level (MCL or Tap Water RSL if not MCL was available). The results of this evaluation are presented in tabular format below. None of the analyte maximum concentrations were greater than 100 times their respective groundwater level (MCL or RSL if no MCL has been established).

VOC Analyte	**Jan 2015 MCL or Tap Water RSL (µg/L)**	**Max Conc. (µg/L)**	**Max Conc. Multiple of GW Level**
1,1,1-Trichloroethane	200.0	1.1	0.006
1,1-Dichloroethane	2.7	42.3	15.7
1,2-Dichloroethane	5.0	1.0	0.2
Acetone	14,000.0	3.8	0.0003
Chloroethane	21,000.0	84.0	0.004
cis-1,2-dichloroethylene	70.0	1.4	0.02
m,p-Xylene	190.0	1.0	0.01
Methylene Chloride	5.0	1.0	0.2
Tetrachloroethene	5.0	1.3	0.3
Trichloroethylene (TCE)	5.0	2.6	0.5

SVOC Analyte	Jan. 2015 MCL or Tap Water RSL (µg/L)	Max Conc. (µg/L)	Max Conc. times GW Level
1,4-Dioxane (p-dioxane)	0.8	35	44.9
1,1-Biphenyl (diphenyl)	0.8	0.44	0.5
Caprolactam	9,900.0	6.45	0.001
Di-n-butyl phthalate	None	0.48	N/A
Bis(2-ethylhexyl) phthalate	6.0	1.7	0.3
Butyl benzyl phthalate	61.0	0.25	0.004
Pyrene	120.0	0.284	0.002
Benzo(b)fluoranthene	0.034	0.161	4.7
Fluoranthene	800.0	0.3	0.0004
Benzo(k)fluoranthene	0.34	0.109	0.3
Chrysene	3.4	0.171	0.1
Benzo(a)anthracene	0.034	0.207	6.1
Hexachlorobenzene	1.0	0.199	0.2
Anthracene	1,800.0	0.192	0.0001
Phenanthrene	None	0.162	N/A
Tetrahydrofuran	3,400.0	1	0.0003

6. Can the **discharge** of "contaminated" groundwater into surface water be shown to be **"currently acceptable"** (i.e., not cause impacts to surface water, sediments, or eco-systems that should not be allowed to continue until a final remedy decision can be made and implemented[4])?

__√__ If yes – continue after either: 1) identifying the Final Remedy decision incorporating these conditions, or other site-specific criteria (developed for the protection of the site's surface water, sediments, and eco-systems), and referencing supporting documentation demonstrating that these criteria are not exceeded by the discharging groundwater; OR
2) providing or referencing an interim-assessment[5], appropriate to the potential for impact, that shows the discharge of groundwater contaminants into the surface water is (in the opinion of trained specialists, including ecologist) adequately protective of receiving surface water, sediments, and

[4] Because areas of inflowing groundwater can be critical habitats (e.g., nurseries or thermal refugia) for many species, appropriate specialist (e.g., ecologist) should be included in management decisions that could eliminate these areas by significantly altering or reversing groundwater flow pathways near surface water bodies.

[5] The understanding of the impacts of contaminated groundwater discharges into surface water bodies is a rapidly developing field and reviewers are encouraged to look to the latest guidance for the appropriate methods and scale of demonstration to be reasonably certain that discharges are not causing currently unacceptable impacts to the surface waters, sediments or ecosystems.

eco-systems, until such time when a full assessment and final remedy decision can be made. Factors which should be considered in the interim-assessment (where appropriate to help identify the impact associated with discharging groundwater) include: surface water body size, flow, us/classification/habitats and contaminant loading limits, other sources of surface water/sediment contamination, surface water and sediment sample results and comparisons to available and appropriate surface water and sediment "levels," as well as any other factors, such as effects on ecological receptors (e.g., via bio-assays/benthic surveys or site-specific ecological Risk Assessments), that the overseeing regulatory agency would deem appropriate for making the EI determination.

_____ If no – (the discharge of "contaminated" groundwater can not be shown to be **"currently acceptable"**) – skip to #8 and enter "NO" status code, after documenting the currently unacceptable impacts to the surface water body, sediments, and/or eco-systems.

_____ If unknown – skip to #8 and enter "IN" status code.

Rationale and Reference(s):

The two surface water bodies that flow through the Site are the cooling water ditches WCWD and ECWD. Each of these receives groundwater discharge along at least a portion of its length from the Recent Alluvium, and discharging groundwater is impacted by Site COCs. Additionally, the Site is bounded on its down gradient perimeter by the James River. The James River receives ground water discharge along its entire length adjacent to the Site from the Recent Alluvium and subaqueous outcrops of the Potomac Unit. Groundwater discharging directly to the James River from each of these units is impacted by Site COCs. The James River receives all surface water flow from both the WCWD and the ECWD.

Figures 2 and 3 depict the Recent Alluvium and Potomac Unit groundwater contours interpolated from head data collected during the November 2014 sampling event. Also depicted on Figures 2 and 3 are flow tubes representing groundwater flow paths terminating in a flux plane section parallel to the receiving surface water body. The horizontal dimension of the flux planes are equivalent to the length of the flux section lines shown on Figure 2 and 3. The vertical dimension in the Recent Alluvium is the thickness of the saturated section at the monitoring well nearest to the section and within the flow tube, as measured in November 2014. The vertical dimension of the flux plan for the Potomac Unit is the saturated thickness from the bottom of the Potomac Confining Unit to the bottom of the well screen at the monitoring well nearest to the section and within the flow tube, as indicated by boring and well installation logs.

Contaminant loading as mass flux for Site key COCs (VOCs and SVOCs) was estimated for the WCWD, ECWD and the James River for discharge from the Recent Alluvium and from the Potomac Unit. Attachment 2 provides individual calculation sheets estimating the Site COC mass flux for each flow section discharging to the WCWD, ECWD, and James River. These estimates are based on analytical data and groundwater elevation data collected during the November 2014 sampling event[6,7]. The mass flux of Site COCs from the Recent alluvium and/or Potomac Unit to the respective surface water body was calculated using the following input terms and equations:

- Hydraulic conductivity (K) measurement for one or more wells within a flow tube near to a given flux section line.

- Saturated cross-sectional area (A) of the flux plane terminus of a flow tube adjacent to the surface water body.

- Gradient (i) along a given flow tube.

- Concentration (C) of each analyte identified above detection limits in monitoring wells within a flow tube and near to the surface water body.

- NPDES permit flow rate in the WCWD, ECWD and the estimated flow rate of the James River at the Site.

The flow component along each flux section line was calculated using Equation 1:

Equation 1 $Q = KiA$

where:

Q_{gw} = Discharge (ft^3/sec and converted to L/sec – 28.316 L/ft^3)

K = hydraulic conductivity (ft/sec).

i =groundwater flow gradient (ft/ft).

A = Flow tube flux section cross-sectional area (ft^2).

Upon calculation of the discharge (Q_{gw}) along each flux section line, the mass flux was calculated along each section line using Equation 2:

Equation 2 $F = CQ_{gw}$

[6] *Groundwater Monitoring Report*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated April 2015.

[7] *SWMU 4 Groundwater Monitoring Report*; Amec Foster Wheeler Environment & Infrastructure, Inc.; dated January 30, 2015

where:

F = Mass flux (mg/sec)

C = concentration of contaminant analytes within flow tube (mg/L)

Q_{gw} = groundwater discharge rate as determined using Equation 1 (L/sec).

Following calculation of the mass flux for individual flux section lines, an estimate of analyte concentrations in the surface water body due to that mass flux was calculated using Equation 3:

<u>Equation 3</u> $C_{sw} = F/Q_{sw}$

Where:

C_{sw} = Estimated concentration in surface water body being considered (mg/L)

F = Calculated mass flux entering the surface water body (mg/sec)

Q_{sw} = Flow in surface water body (L/sec)

Hydraulic gradients used in the estimate were evaluated from the groundwater contours depicted on Figure 2 and 3, and groundwater elevations measured in individual monitoring wells during the November 2014 event. Where head data from two wells were not available from the November 2014 event, the gradient was estimated from groundwater contours.

Hydraulic conductivities were measured by slug testing during the Phase II and Phase III RFI work. These data were most recently presented as Table 1 in each of the groundwater sampling work plans approved by USEPA in 2014[8,9].

Analyte concentration data for VOCs and SVOCs was used from the November 2014 sampling event from monitoring wells positioned within the respective units and near to the flux section so as to be representative of groundwater quality discharging to these surface water bodies. If multiple wells within a flow tube met this criteria, then the average value of individual analyte concentrations were used. Average values were not used if an analytes was only above detection limits in one well. In those instances, the reported concentration was used.

[8] *Solid Waste Management Unit 4, Groundwater Monitoring Plan, Final*; Prepared by AMEC Environment & Infrastructure, Inc.; dated October 12, 2014.
[9] *Chesterfield Facility RCRA Groundwater Monitoring Plan, Final*; Prepared by AMEC Environment & Infrastructure, Inc.; dated October 9, 2014.

Surface water flow rates for the WCWD and ECWD were provided by the Chesterfield Facility NPDES permit flows as 14 million gallons per day (mgd) and 4.5 mgd, respectively. Prior investigators[10] have conservatively estimated the flow in the James River at the Site to be approximately 24,000 cubic feet per second (ft^3/sec).

Loading Estimate Results

Mass flux estimates and resulting surface water concentrations are summarized in the tables that follow. They reflect direct mass loading of individual analytes to the individual surface water bodies (WCWD, ECWD and James River) from groundwater discharging from the Recent Alluvium and Potomac Unit into these surface water bodies, and in the case of the James River, also due to discharge from the WCWD and ECWD. Also presented is the resulting estimated concentration of the analyte (mg/L) in the water body. Results have been sorted from the greatest estimated concentration to least in each table.

VOC mass flux to the WCWD from the Recent Alluvium and estimated surface water concentrations at its James River outfall is summarized in the following table:

Summary of VOC Load to WCWD - Recent Alluvium					
VOC Parameter	From Section 1A Flux (mg/sec)	From Section 1B Flux (mg/sec)	From Section 1C Flux (mg/sec)	Total Load to WCWD (mg/sec)	Est. Resulting WCWD Surface Water Conc. (mg/L)
Chloroethane	2.6E-02	—	1.2E-04	2.6E-02	4.3E-05
Vinyl chloride	8.0E-03	—	—	8.0E-03	1.3E-05
1,1-Dichloroethane	7.3E-04	—	4.0E-03	4.8E-03	7.8E-06
1,2-Dichloroethane	7.7E-05	—	4.1E-03	4.2E-03	6.9E-06
cis-1,2-Dichloroethylene	2.7E-03	—	5.2E-04	3.3E-03	5.3E-06
Toluene	1.3E-03	—	—	1.3E-03	2.2E-06
Trichloroethylene	1.2E-04	—	5.8E-04	6.9E-04	1.1E-06
m,p-Xylene	4.7E-04	—	—	4.7E-04	7.7E-07
Benzene	4.0E-04	—	—	4.0E-04	6.6E-07
Acetone	3.7E-04	—	—	3.7E-04	6.0E-07
1,1,1-Trichloroethane	3.1E-04	—	3.8E-05	3.5E-04	5.7E-07
Tetrachloroethene	1.4E-04	—	1.4E-04	2.8E-04	4.6E-07
Methyl Acetate	—	—	2.8E-04	2.8E-04	4.6E-07
Methylene Chloride	2.3E-04	—	—	2.3E-04	3.8E-07
Ethylbenzene	2.0E-04	—	—	2.0E-04	3.3E-07
o-Xylene	1.6E-04	—	—	1.6E-04	2.6E-07
trans-1,2-Dichloroethene	1.5E-04	—	—	1.5E-04	2.5E-07
1,1-Dichloroethene	2.5E-05	—	6.7E-05	9.2E-05	1.5E-07

[10] *Phase II RFI Report, Volume 1, - Text, Tables and Appendices, Honeywell Chesterfield Facility, Chester, VA*; Prepared by MWH Americas, Inc.; Dated January 2004.

Summary of VOC Load to WCWD - Recent Alluvium					
VOC Parameter	**From Section 1A Flux (mg/sec)**	**From Section 1B Flux (mg/sec)**	**From Section 1C Flux (mg/sec)**	**Total Load to WCWD (mg/sec)**	**Est. Resulting WCWD Surface Water Conc. (mg/L)**
Carbon tetrachloride	6.0E-05	—	—	6.0E-05	9.7E-08
1,2-Dichlorobenzene	2.0E-05	—		2.0E-05	3.3E-08
1,4-Dichlorobenzene	—	—	1.4E-05	1.4E-05	2.3E-08
Chlorobenzene	5.4E-06	—	—	5.4E-06	8.8E-09

SVOC mass flux to the WCWD from the Recent Alluvium and estimated surface water concentrations at its James River outfall is summarized in the following table:

Summary of SVOC Load to WCWD - Recent Alluvium					
SVOC Parameter	**From Section 1A Flux (mg/sec)**	**From Section 1B Flux (mg/sec)**	**From Section 1C Flux (mg/sec)**	**Total Load to WCWD (mg/sec)**	**Est. Resulting WCWD Surface Water Conc. (mg/L)**
1,4-Dioxane	3.6E-04	1.4E-03	1.9E-03	3.6E-03	5.9E-06
Diphenyl ether	1.9E-03	—	—	1.9E-03	3.1E-06
1,1-Biphenyl	4.9E-04	—	—	4.9E-04	7.9E-07
3&4-Methylphenol	8.9E-05	—	—	8.9E-05	1.4E-07
Phenanthrene	—	4.3E-05	—	4.3E-05	7.0E-08
Phenol	3.5E-05	—	—	3.5E-05	5.7E-08
Caprolactam	3.2E-05	—	—	3.2E-05	5.2E-08
Cyclohexane	2.5E-05	—	—	2.5E-05	4.0E-08
2-Methylphenol (o-cresol)	2.2E-05	—	—	2.2E-05	3.6E-08
2-Chlorophenol	2.2E-05	—	—	2.2E-05	3.6E-08
Naphthalene	2.7E-06	—	—	2.7E-06	4.3E-09

Total VOC mass flux to the ECWD from the Recent Alluvium estimated surface water concentrations at its James River outfall is summarized in the following table:

Summary of VOC Load to ECWD - Recent Alluvium			
VOC Parameter	**From Section 3A Flux (mg/sec)**	**Total Load to ECWD (mg/sec)**	**Est. Resulting ECWD Surface Water Conc. (mg/L)**
cis-1,2-Dichloroethylene	7.5E-04	7.5E-04	3.8E-06
Trichloroethylene	2.9E-04	2.9E-04	1.5E-06
Tetrachloroethene	1.7E-04	1.7E-04	8.8E-07
1,1-Dichloroethane	9.1E-05	9.1E-05	4.6E-07
Vinyl chloride	7.9E-05	7.9E-05	4.0E-07
1,1-Dichloroethene	4.5E-05	4.5E-05	2.3E-07
1,1,1-Trichloroethane	3.8E-05	3.8E-05	1.9E-07

Total SVOC mass flux to the ECWD from the Recent Alluvium and estimated surface water concentrations at its James River outfall is summarized in the following table:

Summary of SVOC Load to ECWD - Recent Alluvium			
SVOC Parameter	**From Section 3A Flux (mg/sec)**	**Total Load to ECWD (mg/sec)**	**Est. Resulting ECWD Surface Water Conc. (mg/L)**
Diphenyl ether	6.1E-04	6.1E-04	3.1E-06
1,4-Dioxane	1.2E-04	1.2E-04	6.1E-07
Phenol	3.8E-05	3.8E-05	1.9E-07

Total VOC mass flux to the James River directly from the Recent Alluvium, directly from the Potomac Unit, and by discharge of the WCWD and ECWD is summarized in the following table[11]:

[11] This estimate assumes that the concentration is being measured in the James River immediately downstream of the western property boundary of the Site.

Summary of VOC Load to James River						
VOC Parameter	**From WCWD (mg/sec)**	**From ECWD (mg/sec)**	**Direct From Recent Alluvium Section 2A, 2B, 2C, 2D Flux (mg/sec)**	**Direct From Potomac Unit Section 1A, 1B, 1C, 1D Flux (mg/sec)**	**Total Load All Sources (mg/sec)**	**Est. Resulting James River Surface Water Conc. (mg/L)**
Chloroethane	2.6E-02	—	1.8E-02	2.3E-03	4.7E-02	6.9E-08
Vinyl chloride	8.0E-03	8.2E-03	—	—	1.6E-02	2.4E-08
1,1-Dichloroethane	4.8E-03	7.5E-04	—	1.7E-03	7.3E-03	1.1E-08
cis-1,2-Dichloroethylene	3.3E-03	2.8E-03	—	5.7E-05	6.1E-03	9.0E-09
1,2-Dichloroethane	4.2E-03	—	—	2.8E-05	4.2E-03	6.2E-09
Toluene	1.3E-03	—	4.6E-05	—	1.4E-03	2.0E-09
Trichloroethylene	6.9E-04	1.2E-04	—	1.1E-04	9.2E-04	1.3E-09
1,1,1-Trichloroethane	3.5E-04	3.2E-04	—	3.1E-05	7.0E-04	1.0E-09
Acetone	3.7E-04	—	—	2.4E-04	6.0E-04	8.9E-10
m,p-Xylene	4.7E-04	—	6.7E-05	2.8E-05	5.7E-04	8.4E-10
Benzene	4.0E-04	—	9.4E-05	—	5.0E-04	7.3E-10
Tetrachloroethene	1.4E-04	1.4E-04	—	5.3E-05	3.4E-04	5.0E-10
Methyl Acetate	2.9E-04	—	—	—	2.9E-04	4.2E-10
Methylene Chloride	2.3E-04	—	—	2.8E-05	2.6E-04	3.8E-10
Ethylbenzene	2.0E-04	—	5.5E-05	—	2.6E-04	3.8E-10
o-Xylene	1.6E-04	—	—	—	1.6E-04	2.3E-10
trans-1,2-Dichloroethene	1.5E-04	—	—	—	1.5E-04	2.2E-10
1,1-Dichloroethene	9.2E-05	2.5E-05	—	—	1.2E-04	1.7E-10
Carbon tetrachloride	6.0E-05	—	—	—	6.0E-05	8.8E-11
1,2-Dichlorobenzene	2.0E-05	2.1E-05	—	—	4.1E-05	6.1E-11
1,4-Dichlorobenzene	1.4E-05	—	—	—	1.4E-05	2.1E-11
Chlorobenzene	5.4E-06	—	—	—	5.4E-06	7.9E-12

Total SVOC mass flux to the James River directly from the Recent Alluvium, directly from the Potomac Unit, and by discharge of the WCWD and ECWD is summarized in the following table:

Summary of SVOC Load to James River						
SVOC Parameter	From WCWD (mg/sec)	From ECWD (mg/sec)	Direct From Recent Alluvium Section 2A, 2B, 2C, 2D Flux (mg/sec)	Direct From Potomac Unit Section 1A, 1B, 1C, 1D Flux (mg/sec)	Total Load All Sources (mg/sec)	Est. Resulting James River Surface Water Conc. (mg/L)
Diphenyl ether	1.9E-03	1.9E-03	6.2E-02	—	6.6E-02	9.7E-08
1,4-Dioxane	3.6E-03	3.7E-04	5.7E-02	1.4E-03	6.3E-02	9.2E-08
N-Nitrosodiphenylamine	—	—	3.9E-02	—	3.9E-02	5.7E-08
Caprolactam	3.2E-05	—	1.7E-02	2.6E-04	1.7E-02	2.6E-08
Phenol	3.5E-05	3.6E-05	2.8E-03	—	2.9E-03	4.2E-09
Carbazole	—	—	2.1E-03	—	2.1E-03	3.1E-09
Tetrahydrofuran	—	—	4.9E-04	4.7E-05	5.4E-04	8.0E-10
1,1-Biphenyl	4.9E-04	—	—	1.8E-05	5.0E-04	7.4E-10
3&4-Methylphenol	8.9E-05	—	—	—	8.9E-05	1.3E-10
Phenanthrene	4.3E-05	—	—	6.6E-06	5.0E-05	7.3E-11
Bis(2-ethylhexyl) phthalate	—	—	—	4.7E-05	4.7E-05	7.0E-11
Naphthalene	2.7E-06	—	3.1E-05	—	3.4E-05	5.0E-11
Cyclohexane	2.5E-05	—	—	—	2.5E-05	3.6E-11
2-Chlorophenol	2.2E-05	—	—	—	2.2E-05	3.2E-11
2-Methylphenol (o-cresol)	2.2E-05	—	—	—	2.2E-05	3.2E-11
Di-n-butyl phthalate	—	—	—	1.3E-05	1.3E-05	2.0E-11
Fluoranthene	—	—	—	1.2E-05	1.2E-05	1.8E-11
Pyrene	—	—	—	1.2E-05	1.2E-05	1.7E-11
Benzo(a)anthracene	—	—	—	8.5E-06	8.5E-06	1.2E-11
Hexachlorobenzene	—	—	—	8.2E-06	8.2E-06	1.2E-11
Anthracene	—	—	—	7.9E-06	7.9E-06	1.2E-11
Chrysene	—	—	—	7.0E-06	7.0E-06	1.0E-11
Butyl benzyl phthalate	—	—	—	7.0E-06	7.0E-06	1.0E-11
Benzo(b)fluoranthene	—	—	—	6.6E-06	6.6E-06	9.7E-12
Benzo(k)fluoranthene	—	—	—	4.5E-06	4.5E-06	6.6E-12

The results of loading calculations to all three surface water bodies and estimated concentrations of individual analytes were evaluated by an ecologic risk assessor to assess the ecologic risk in all three surface water bodies. The modeled concentrations of VOCs and SVOCs in surface water were compared to ecological risk screening levels to determine if groundwater discharges could be adversely affecting aquatic communities in the Western Cooling Water Ditch (WCWD), Eastern Cooling Water Ditch (ECWD), and the James River. Ecological screening benchmarks were selected from the following sources in the order presented:

1) Reg III - EPA Region III BTAG Freshwater Screening Benchmarks for Freshwater (USEPA, 2005).
2) Reg V - EPA Region V Ecological Screening Levels (ESLs) for surface water (USEPA, 2003).
3) ORNL SCV - Oak Ridge National Laboratory Secondary Chronic Values (Suter & Tsao, 1996)
4) Ecological screening benchmarks developed in the Screening Level Ecological Risk Assessment (SLERA) (AMEC, 2007).

As shown in the following tables, modeled concentrations of VOCs and SVOCs in all three water bodies are below screening level benchmarks by several orders of magnitude, indicating that adverse effects to populations and communities of aquatic receptors are unlikely.

Applicable VOC Surface Water Screening Levels (all units mg/L)							
VOC Parameter	**Freshwater chronic AWQC[a]**	**USEPA Region III Freshwater**	**USEPA Region V**	**ORNL Tier II Secondary Chronic Values (SCV)[b]**	**Est. Conc. WCWD**	**Est. Conc. ECWD**	**Est. Conc. James River**
Chloroethane	NA	N/A	N/A	N/A	4.3E-05	N/A	6.9E-08
Vinyl Chloride	N/A	9.3E-01	9.3E-01	N/A	1.3E-05	4.0E-07	2.4E-08
1,1-Dichloroethane	N/A	4.7E-02	4.7E-02	4.7E-02	7.8E-06	4.6E-07	1.1E-08
1,2-Dichloroethane	N/A	1.0E-01	9.1E-01	9.1E-01	6.9E-06	N/A	9.0E-09
1,2-Dichloroethene (cis)	N/A	N/A	N/A	5.9E-01	5.3E-06	3.8E-06	6.2E-09
Toluene	N/A	2.0E-03	2.5E-01	9.8E-03	2.2E-06	N/A	2.0E-09
Trichloroethene	N/A	2.1E-02	4.7E-02	4.7E-02	1.1E-06	1.5E-06	1.3E-09
m&p-Xylene	N/A	N/A	N/A	1.8E-03	7.7E-07	N/A	1.0E-09
Benzene	N/A	3.7E-01	N/A	N/A	6.6E-07	N/A	8.9E-10
Acetone	N/A	1.5E+00	N/A	N/A	6.0E-07	N/A	8.4E-10
1,1,1-Trichloroethane	N/A	1.1E-02	7.6E-02	1.1E-02	5.7E-07	1.9E-07	7.3E-10
Tetrachloroethene	N/A	1.1E-01	4.5E-02	9.8E-02	4.6E-07	8.8E-07	5.0E-10
Methyl Acetate	N/A	N/A	N/A	N/A	4.6E-07	N/A	4.2E-10
Methylene Chloride	N/A	9.8E-02	9.4E-01	2.2E+00	3.8E-07	N/A	3.8E-10
Ethylbenzene	N/A	9.0E-02	N/A	N/A	3.3E-07	N/A	3.8E-10
o-Xylene	N/A	N/A	N/A	N/A	2.6E-07	N/A	2.3E-10
trans-1,2-Dichloroethene	N/A	9.7E-01	N/A	N/A	2.5E-07	N/A	2.2E-10
1,1-Dichloroethene	N/A	2.5E-02	6.5E-02	2.5E-02	1.5E-07	2.3E-07	1.7E-10
Carbon tetrachloride	N/A	1.3E-02	2.4E-01	9.8E-03	9.7E-08	N/A	8.8E-11
1,2-Dichlorobenzene	N/A	7.0E-04	1.4E-02	1.4E-02	3.3E-08	N/A	6.1E-11
1,4-Dichlorobenzene	N/A	N/A	N/A	N/A	2.3E-08	N/A	2.1E-11
Chlorobenzene	N/A	N/A	N/A	N/A	8.8E-09	N/A	7.9E-12

Applicable SVOC Surface Water Screening Levels (all units mg/L)							
SVOC Parameter	Freshwater chronic AWQC[a]	USEPA Region III Freshwater	USEPA Region V	ORNL Tier II Secondary Chronic Values (SCV)[b]	Est. Conc. WCWD	Est. Conc. ECWD	Est. Conc. James River
1,4-Dioxane	N/A	N/A	2.2E+01	N/A	5.9E-06	6.1E-07	9.2E-08
1,1'-Biphenyl	N/A	N/A	N/A	N/A	7.9E-07	N/A	7.4E-10
3+4-Methylphenols	N/A	N/A	N/A	N/A	1.4E-07	N/A	1.3E-10
3-Methylphenol	N/A	N/A	N/A	N/A	1.4E-07	N/A	1.3E-10
4-Methylphenol	N/A	N/A	N/A	N/A	1.4E-07	N/A	1.3E-10
Phenanthrene	N/A	4.0E-04	N/A	N/A	7.0E-08	N/A	7.3E-11
Phenol	N/A	N/A	N/A	N/A	5.7E-08	1.9E-07	4.2E-09
Caprolactam	N/A	N/A	N/A	N/A	5.2E-08		2.6E-08
Cyclohexane	N/A	N/A	N/A	N/A	4.0E-08	N/A	3.6E-11
2-Methylphenol	N/A	1.3E-02	N/A	N/A	3.6E-08	N/A	3.2E-11
2-Chlorophenol	N/A	N/A	N/A	N/A	3.6E-08	N/A	3.2E-11
Naphthalene	N/A	1.1E-03	N/A	N/A	4.3E-09	N/A	5.0E-11
N-Nitroso-diphenylamine	N/A	2.1E-01	N/A	N/A	N/A	N/A	5.7E-08
Carbazole	N/A	N/A	N/A	N/A	N/A	N/A	3.1E-09
Tetrahydrofuran	N/A	N/A	N/A	N/A	N/A	N/A	8.0E-10
Phenanthrene	N/A	4.0E-04	N/A	N/A	N/A	N/A	7.3E-11
Bis(2-ethylhexyl)phthalate	N/A	1.6E-02	N/A	N/A	N/A	N/A	7.0E-11
Di-n-Butylphthalate	N/A	1.9E-02	N/A	N/A	N/A	N/A	2.0E-11
Fluoranthene	N/A	4.0E-05	1.9E-03	N/A	N/A	N/A	1.8E-11
Pyrene	N/A	2.5E-05	3.0E-04	N/A	N/A	N/A	1.7E-11
Benzo(a)anthracene	N/A	1.8E-05	N/A	N/A	N/A	N/A	1.2E-11
Hexachlorobenzene	N/A	3.0E-07	N/A	N/A	N/A	N/A	1.2E-11
Anthracene	N/A	N/A	N/A	N/A	N/A	N/A	1.2E-11
Chrysene	N/A	N/A	N/A	N/A	N/A	N/A	1.0E-11
Butylbenzylphthalate	N/A	1.9E-02	2.3E-02	1.9E-02	N/A	N/A	1.0E-11
Benzo(b)fluoranthene	N/A	N/A	9.1E-03	N/A	N/A	N/A	9.7E-12
Benzo(k)fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A	6.6E-12

Notes:

[a] National Chronic Ambient Water Quality Criteria for Freshwater (AWQC) (USEPA, 2002; 2004; 2006). An estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. Value is equal to the 4-day average concentration that should not be exceeded more than once every 3 years.

[b] Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for Screening Potential Contaminants of Concern (COCs) for effects on aquatic biota (Suter and Tsao, 1996). Values presented is secondary chronic value.

Consequently, the discharge of groundwater contaminants into the surface water currently is adequately protective of receiving surface water, sediments, and eco-systems.

7. Will groundwater **monitoring** / measurement data (and surface water/sediment/ecological data, as necessary) be collected in the future to verify that contaminated groundwater has remained within the horizontal (or vertical, as necessary) dimensions of the "existing area of contaminated groundwater?"

__√__ If yes – continue after providing or citing documentation for planned activities or future sampling/measurement events. Specifically identify the well/measurement locations which will be tested in the future to verify the expectation (identified in #3) that groundwater contamination will not be migrating horizontally (or vertically, as necessary) beyond the "existing area of groundwater contamination."

____ If no – enter "NO" status code in #8.

_____ If unknown - enter "IN" status code in #8.

Rationale and Reference(s):

Currently a groundwater monitoring plan has been approved by USEPA for the network of monitoring wells associated with SWMU 4. An Interim Remedy has been approved by USEPA and is under design with the expected construction completion in mid-2016. The sampling frequency in the SWMU 4 monitoring network will be subject to completion of the SWMU 4 remediation.

Time Period	Frequency
Prior to IM Construction	Semi-annually. Sampling events to be schedule during spring and fall.
Following IM Construction	Sampling event frequency will be as determined to be appropriate in consultation with USEPA. A post-remediation sampling frequency will be proposed as part of the remediation work plan.

The monitoring wells that make up the SWMU 4 monitoring network and the rationale for including them are as follows:

Well ID	Rationale
MW-9	Sentinel – Recent Alluvium
NW12-1	Upgradient – Recent Alluvium
MW-104S	Source – Recent Alluvium

Well ID	Rationale
MW-105S	Upgradient – Recent Alluvium
MW-118D	Sentinel – Potomac Unit
MW-118DD	Sentinel – Potomac Unit
MW-123S	Down gradient – Recent Alluvium
MW-124S	Down gradient – Recent Alluvium
MW-125S	Down gradient – Recent Alluvium
MW-126S	Down gradient – Recent Alluvium
MW-127S	Down gradient – Recent Alluvium
MW-128S	Down gradient – Recent Alluvium
MW-128D	Down gradient – Potomac Unit
MW-131S	Down gradient – Recent Alluvium
MW-131D	Down gradient – Potomac Unit
MW-131DD	Down gradient – Potomac Unit
TMP-131	Down gradient – Potomac Unit
MW-132D	Sentinel – Potomac Unit
MW-132DD	Sentinel – Potomac Unit
MW-133D	Sentinel – Potomac Unit
MW-133DD	Sentinel – Potomac Unit

Reference: *Solid Waste Management Unit 4 Groundwater Monitoring Plan Final, Honeywell Chesterfield Facility, Chester, VA*; Prepared by AMEC Environment & Infrastructure, Inc.; Dated October 14, 2014.

8. Check the appropriate RCRIS status codes for the Migration of Contaminated Groundwater Under Control EI event code (CA750), and obtain Supervisor (or appropriate Manager) signature and date on the EI determination below (attach appropriate supporting documentation as well as a map of the facility):

__√__ YE – Yes, "Migration of Contaminated Groundwater Under Control" has been verified. Based on a review of the information contained in this EI Determination, "Migration of Contaminated Groundwater" is "Under Control" at the Honeywell Chesterfield Facility, EPA ID # VAD023690183, located at 4101 Bermuda Hundred Road, Chester, VA under current and reasonably expected conditions. Specifically, this determination indicates that the migration of "contaminated" groundwater is under control, and that monitoring will be conducted to confirm that contaminated groundwater remains within the "existing area of contaminated groundwater". This determination will be re-evaluated when the Agency/State becomes aware of significant changes at the facility.

____ NO – Unacceptable migration of contaminated groundwater is observed or expected.

_____ IN – More information is needed to make a determination.

Completed by: Erich Weissbart
Signature
Date: 7/21/15

Erich Weissbart
Printed Name

Project Manager
Title

Supervisor: [signature]
Signature
Date: 7/21/15

Luis Pizarro
Printed Name

Associate Director
Title

Contact telephone and e-mail numbers

Name: Erich Weissbart

Phone #: 410 305-2779

e-Mail: weissbart.erich@epa.gov

FIGURES

Amec Foster Wheeler
Environment & Infrastructure, Inc.
751 Arbor Way, Suite 180
Blue Bell, PA 19422
Tel. 610-828-8100
www.amecfw.com

CLIENT

PROJECT
GROUNDWATER ENVIRONMENTAL INDICATOR
HONEYWELL CHESTERFIELD
CHESTERFIELD, VIRGINIA

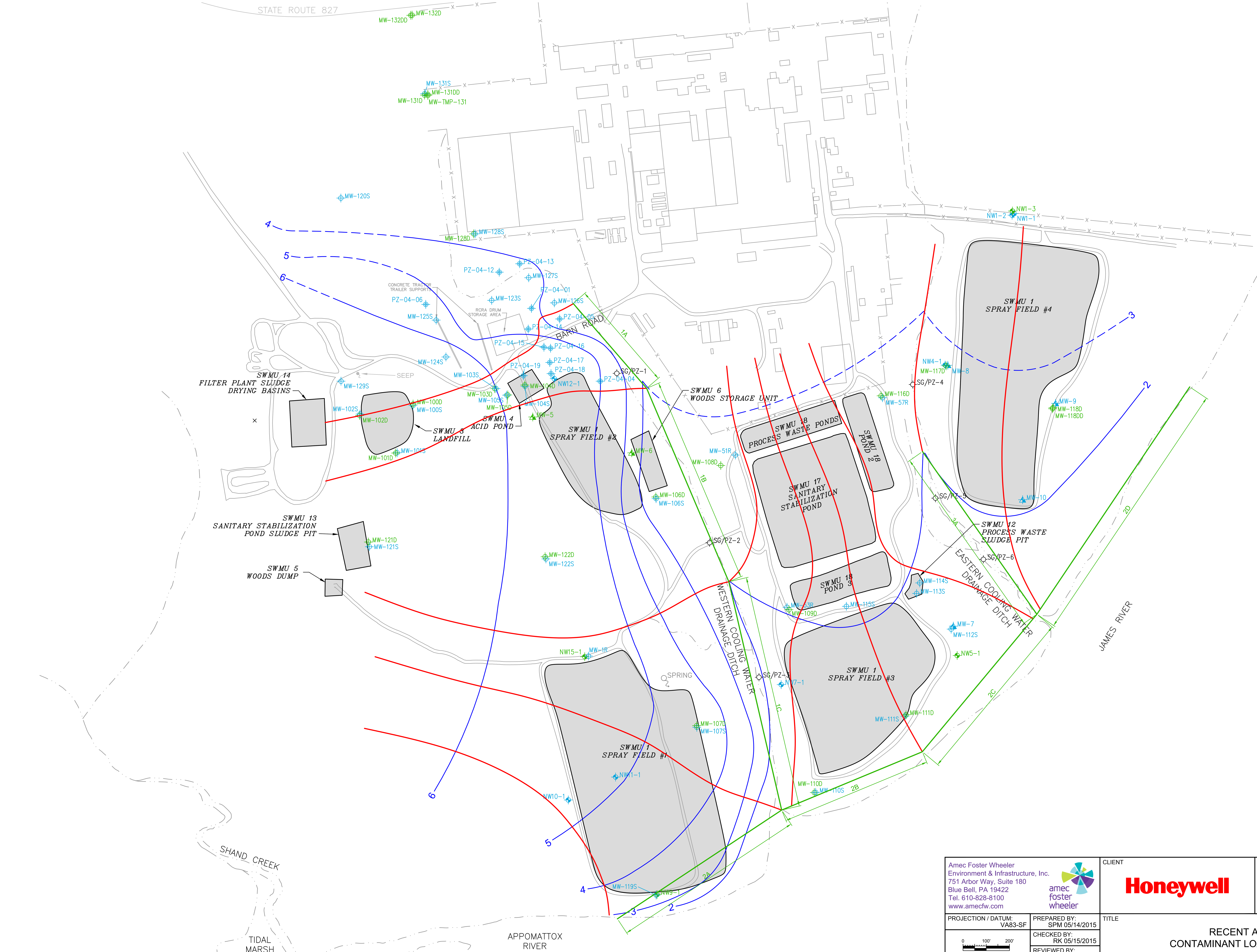
PROJECT NO.: 7772140016
REVISION NO.: 0
DATE: 25 JUNE 2015

PROJECTION / DATUM: VA State Plane South, NAD83

PREPARED BY: JP 06/25/2015
CHECKED BY: AC 06/25/2015
REVIEWED BY: RK 06/25/2015

TITLE
MONITORING WELL LOCATIONS

FIGURE NO.: 1



LEGEND

- STREAM, DITCH, OR EDGE OF WATER
- FENCE
- SWMU 5 — SOLID WASTE MANAGEMENT UNIT AND ID
- MW-120S — WELL INSTALLED IN THE UPPER AQUIFER
- MW-120D — WELL INSTALLED IN THE LOWER AQUIFER
- SG/PZ-2 — STAFF GAUGE/PIEZOMETER LOCATION
- SW-05 — SURFACE WATER SAMPLE LOCATION
- LINE OF EQUAL WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL - NOVEMBER 2014 (DASHED WHERE INFERRED) (CONTOUR INTERVAL SHOWN)
- FLOW ZONE BOUNDARY (DASHED WHERE INFERRED)
- FLUX PLANE

REFERENCES

1. MAP ENTITLED "CHESTERFIELD PLANT BOUNDARY PLOT", CAD DWG 001A1095, BY AUSTIN BROCKENBROUGH AND ASSOCIATES, CHESTER, VA, UPDATED 2/16/94.
2. TOPO.DWG AND STREAM.DWG FILES EXTRACTED FROM CHESTERFIELD COUNTY, WA GIS SYSTEM DATED 5/22/00.

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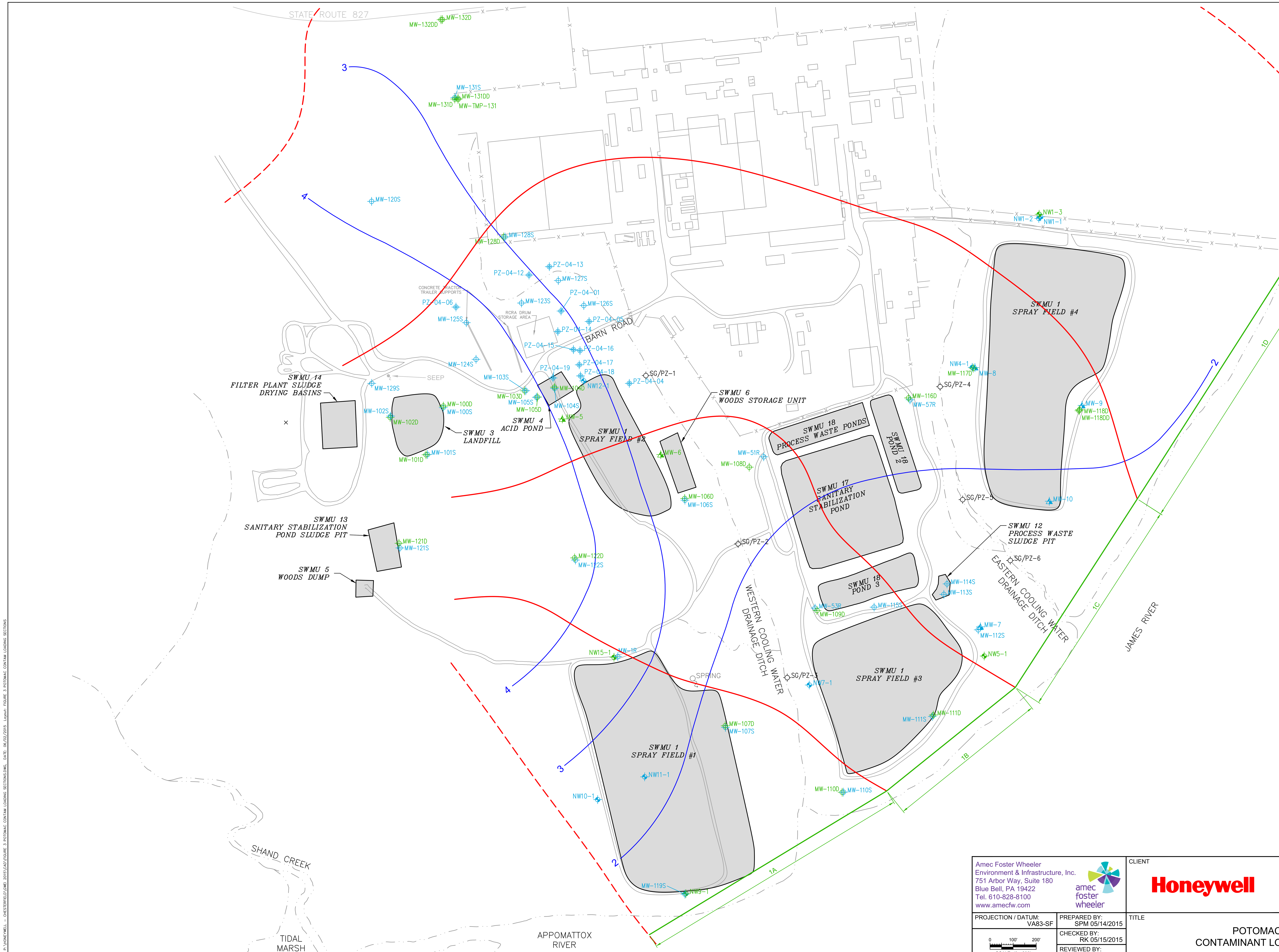
www.amecfw.com

CLIENT: Honeywell	PROJECT: GROUNDWATER MONITORING, CHESTERFIELD FACILITY, CHESTER, VIRGINIA	PROJECT NO.: 7772140016	REV. NO.: 0
PROJECTION / DATUM: VA83-SF	PREPARED BY: SPM 05/14/2015	DATE: MAY 2015	
SCALE: 1" = 200'	CHECKED BY: RK 05/15/2015		
	REVIEWED BY: RK 05/15/2015		

TITLE: RECENT ALLUVIUM CONTAMINANT LOADING SECTIONS

FIGURE NO.: 2



LEGEND

— · · —	STREAM, DITCH, OR EDGE OF WATER
—x—	FENCE
SWMU 5	SOLID WASTE MANAGEMENT UNIT AND ID
MW-120S	WELL INSTALLED IN THE UPPER AQUIFER
MW-120D	WELL INSTALLED IN THE LOWER AQUIFER
SG/PZ-2	STAFF GAUGE/PIEZOMETER LOCATION
SW-05	SURFACE WATER SAMPLE LOCATION
2	LINE OF EQUAL WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL - NOVEMBER 2014 (DASHED WHERE INFERRED) (CONTOUR INTERVAL SHOWN)
	FLOW ZONE BOUNDARY (DASHED WHERE INFERRED)
	FLUX PLANE

REFERENCES

1. MAP ENTITLED "CHESTERFIELD PLANT BOUNDARY PLOT", CAD DWG 001A1095, BY AUSTIN BROCKENBROUGH AND ASSOCIATES, CHESTER, VA, UPDATED 2/16/94.
2. TOPO.DWG AND STREAM.DWG FILES EXTRACTED FROM CHESTERFIELD COUNTY, WA GIS SYSTEM DATED 5/22/00.

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CLIENT: Honeywell	PROJECT: GROUNDWATER MONITORING, CHESTERFIELD FACILITY, CHESTER, VIRGINIA	PROJECT NO.: 7772140016	REV. NO.: 0
PROJECTION / DATUM: VA83-SF	PREPARED BY: SPM 05/14/2015	DATE: MAY 2015	FIGURE NO.: 3
SCALE: 1" = 200'	CHECKED BY: RK 05/15/2015	REVIEWED BY: RK 05/15/2015	

TITLE

POTOMAC AQUIFER
CONTAMINANT LOADING SECTIONS

3

ATTACHMENT 1
MANN-KENDALL TREND ANALYSES OUTPUT

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	6/25/2015 1:39:46 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

111TCA

General Statistics

Number of Values	6
Minimum	0
Maximum	28
Mean	11.33
Geometric Mean	0
Median	9.2
Standard Deviation	12.18
SEM	4.972

Mann-Kendall Test

Test Value (S)	0
Tabulated p-value	0.5
Standard Deviation of S	5.228
Standardized Value of S	N/A
Approximate p-value	N/A

Insufficient evidence to identify a significant trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	6/25/2015 1:49:01 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

11DCA

General Statistics

Number of Values	6
Minimum	0
Maximum	170
Mean	66.2
Geometric Mean	0
Median	33.1
Standard Deviation	78.72
SEM	32.14

Mann-Kendall Test

Test Value (S)	-3
Tabulated p-value	0.36
Standard Deviation of S	5.323
Standardized Value of S	-0.376
Approximate p-value	0.354

Insufficient evidence to identify a significant trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	6/25/2015 1:50:14 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

12DCA

General Statistics

Number of Values	6
Minimum	0
Maximum	5.3
Mean	2.9
Geometric Mean	0
Median	3.55
Standard Deviation	2.42
SEM	0.988

Mann-Kendall Test

Test Value (S)	4
Tabulated p-value	0.235
Standard Deviation of S	5.228
Standardized Value of S	0.574
Approximate p-value	0.283

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 1:51:12 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Benzene	
General Statistics	
Number of Values	6
Minimum	0
Maximum	27.7
Mean	9.217
Geometric Mean	0
Median	5.65
Standard Deviation	10.38
SEM	4.239
Mann-Kendall Test	
Test Value (S)	5
Tabulated p-value	0.235
Standard Deviation of S	5.323
Standardized Value of S	0.751
Approximate p-value	0.226

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 1:51:46 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Chloroethane

General Statistics

Number of Values	6
Minimum	2
Maximum	1810
Mean	568.2
Geometric Mean	160.4
Median	400
Standard Deviation	679.2
SEM	277.3

Mann-Kendall Test

Test Value (S)	5
Tabulated p-value	0.235
Standard Deviation of S	5.323
Standardized Value of S	0.751
Approximate p-value	0.226

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:31:09 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

cis12DCE

General Statistics

Number of Values	6
Minimum	0
Maximum	470
Mean	141.7
Geometric Mean	0
Median	88.5
Standard Deviation	178.5
SEM	72.87

Mann-Kendall Test

Test Value (S)	3
Tabulated p-value	0.36
Standard Deviation of S	5.323
Standardized Value of S	0.376
Approximate p-value	0.354

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:32:10 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

mpXylene

General Statistics

Number of Values	6
Minimum	0
Maximum	32.5
Mean	8.9
Geometric Mean	0
Median	1.95
Standard Deviation	13.26
SEM	5.412

Mann-Kendall Test

Test Value (S)	0
Tabulated p-value	0.5
Standard Deviation of S	5.228
Standardized Value of S	N/A
Approximate p-value	N/A

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:32:43 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Toluene

General Statistics

Number of Values	6
Minimum	0
Maximum	91.3
Mean	29.22
Geometric Mean	0
Median	16.7
Standard Deviation	35.37
SEM	14.44

Mann-Kendall Test

Test Value (S)	5
Tabulated p-value	0.235
Standard Deviation of S	5.323
Standardized Value of S	0.751
Approximate p-value	0.226

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:33:28 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

VC

General Statistics

Number of Values	6
Minimum	0
Maximum	548
Mean	152.8
Geometric Mean	0
Median	88.5
Standard Deviation	205.8
SEM	84.03

Mann-Kendall Test

Test Value (S)	5
Tabulated p-value	0.235
Standard Deviation of S	5.323
Standardized Value of S	0.751
Approximate p-value	0.226

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:34:02 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

TCE

General Statistics

Number of Values	6
Minimum	0
Maximum	8
Mean	1.783
Geometric Mean	0
Median	0.5
Standard Deviation	3.124
SEM	1.276

Mann-Kendall Test

Test Value (S)	6
Tabulated p-value	0.136
Standard Deviation of S	4.967
Standardized Value of S	1.007
Approximate p-value	0.157

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:35:02 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Biphenyl (diphenyl)	
General Statistics	
Number of Values	5
Minimum	3.3
Maximum	33
Mean	12.54
Geometric Mean	8.313
Median	5.5
Standard Deviation	12.73
SEM	5.693
Mann-Kendall Test	
Test Value (S)	0
Tabulated p-value	0.592
Standard Deviation of S	4.082
Standardized Value of S	N/A
Approximate p-value	N/A

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:35:32 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

1,4-Dioxane (p-dioxane)

General Statistics

Number of Values	4
Minimum	24.6
Maximum	220
Mean	105.9
Geometric Mean	78.68
Median	89.5
Standard Deviation	85.69
SEM	42.84

Mann-Kendall Test

Test Value (S)	-4
Tabulated p-value	0.167
Standard Deviation of S	2.944
Standardized Value of S	-1.019
Approximate p-value	0.154

Insufficient evidence to identify a significant trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	6/25/2015 2:35:59 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Naphthalene

General Statistics

Number of Values	6
Minimum	0
Maximum	0.99
Mean	0.196
Geometric Mean	0
Median	0
Standard Deviation	0.396
SEM	0.162

Mann-Kendall Test

Test Value (S)	5
Tabulated p-value	0.235
Standard Deviation of S	4.435
Standardized Value of S	0.902
Approximate p-value	0.184

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 2:34:27 PM
From File	NW12-1.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

PCE

General Statistics

Number of Values	6
Minimum	0
Maximum	16.1
Mean	3.55
Geometric Mean	0
Median	0
Standard Deviation	6.491
SEM	2.65

Mann-Kendall Test

Test Value (S)	9
Tabulated p-value	0.068
Standard Deviation of S	4.435
Standardized Value of S	1.804
Approximate p-value	0.0356

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 3:02:02 PM
From File	MW-7.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Caprolactam

General Statistics

Number of Values	4
Minimum	5
Maximum	14
Mean	8.7
Geometric Mean	7.982
Median	7.9
Standard Deviation	4.159
SEM	2.079

Mann-Kendall Test

Test Value (S)	-2
Tabulated p-value	0.375
Standard Deviation of S	2.944
Standardized Value of S	-0.34
Approximate p-value	0.367

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 3:02:42 PM
From File	MW-7.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Carbazole

General Statistics

Number of Values	4
Minimum	17.9
Maximum	140
Mean	96.98
Geometric Mean	75.55
Median	115
Standard Deviation	55.39
SEM	27.69

Mann-Kendall Test

Test Value (S)	-2
Tabulated p-value	0.375
Standard Deviation of S	2.944
Standardized Value of S	-0.34
Approximate p-value	0.367

Insufficient evidence to identify a significant trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis
User Selected Options	
Date/Time of Computation	6/25/2015 3:03:10 PM
From File	MW-7.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

n-Nitrosodiphenylamine

General Statistics

Number of Values	4
Minimum	590
Maximum	740
Mean	634
Geometric Mean	631.2
Median	603
Standard Deviation	71.16
SEM	35.58

Mann-Kendall Test

Test Value (S)	0
Tabulated p-value	0.625
Standard Deviation of S	2.944
Standardized Value of S	N/A
Approximate p-value	N/A

Insufficient evidence to identify a significant trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	6/25/2015 3:03:42 PM
From File	MW-7.wst
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Chloroethane

General Statistics

Number of Values	4
Minimum	1.9
Maximum	156
Mean	65.98
Geometric Mean	30.2
Median	53
Standard Deviation	64.68
SEM	32.34

Mann-Kendall Test

Test Value (S)	2
Tabulated p-value	0.375
Standard Deviation of S	2.944
Standardized Value of S	0.34
Approximate p-value	0.367

Insufficient evidence to identify a significant trend at the specified level of significance.

ATTACHMENT 2
LOADING CALCULATION DETAILS

Calculation sheet for Recent Alluvium Aquifer Section Line 1A

MW-101S (cm/sec)	MW-105S cm/sec)
3.86E-03	3.08E-03
MW-101S (ft/sec)	MW-105S (ft/sec)
1.27E-04	1.01E-04

Input Parameters

i (MW-5S to NW-12-1)* =	0.0015	ft/ft	Nov-14
A (X-Sect Area) ** =	3101.7	ft^2	at NW-12-1
Q *** =	5.14E-04	ft^3/sec	
Q =	**1.45E-02**	**L/sec**	

Denotes User Data Input Cell (yellow)

Average VOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In WCWD**
Parameter	**NW12-1**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
1,1,1-Trichloroethane	21.6	21.6	0.022	1.45E-02	3.14E-04	5.1E-07
1,1-Dichloroethane	50.2	50.2	0.050	1.45E-02	7.30E-04	1.2E-06
1,2-Dichloroethane	5.3	5.3	0.005	1.45E-02	7.71E-05	1.3E-07
Acetone	25.3	25.3	0.025	1.45E-02	3.68E-04	6.0E-07
Benzene	27.7	27.7	0.028	1.45E-02	4.03E-04	6.6E-07
Chloroethane	1,810.0	1810	1.810	1.45E-02	2.63E-02	4.3E-05
cis-1,2-Dichloroethylene	188.0	188	0.188	1.45E-02	2.73E-03	4.5E-06
Ethylbenzene	14.0	14	0.014	1.45E-02	2.04E-04	3.3E-07
m,p-Xylene	32.5	32.5	0.033	1.45E-02	4.73E-04	7.7E-07
o-Xylene	10.8	10.8	0.011	1.45E-02	1.57E-04	2.6E-07
Toluene	91.3	91.3	0.091	1.45E-02	1.33E-03	2.2E-06
Vinyl chloride	548.0	548	0.548	1.45E-02	7.97E-03	1.3E-05
Trichloroethylene (TCE)	8.0	8	0.008	1.45E-02	1.16E-04	1.9E-07
trans-1,2-Dichloroethene	10.4	10.4	0.010	1.45E-02	1.51E-04	2.5E-07
Methylene Chloride	16.1	16.1	0.016	1.45E-02	2.34E-04	3.8E-07
Chlorobenzene	0.4	0.37	0.000	1.45E-02	5.38E-06	8.8E-09
Carbon tetrachloride	4.1	4.1	0.004	1.45E-02	5.96E-05	9.7E-08
1,1-Dichloroethene	1.7	1.7	0.002	1.45E-02	2.47E-05	4.0E-08
1,2-Dichlorobenzene	1.4	1.4	0.001	1.45E-02	2.04E-05	3.3E-08
	Total VOCs:	**2,866.8**	**2.867**		**4.17E-02**	**6.8E-05**

Average SVOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In WCWD**
Parameter	**NW12-1**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
Caprolactam	2.2	2.2	0.0022	1.45E-02	3.20E-05	5.2E-08
Biphenyl (diphenyl)	33.4	33.4	0.0334	1.45E-02	4.86E-04	7.9E-07
2-Methylphenol (o-cresol)	1.5	1.5	0.0015	1.45E-02	2.18E-05	3.6E-08
1,4-Dioxane (p-dioxane)	24.6	24.6	0.0246	1.45E-02	3.58E-04	5.8E-07
Naphthalene	0.183	0.183	0.000183	1.45E-02	2.66E-06	4.3E-09
Diphenylether	130	130	0.13	1.45E-02	1.89E-03	3.1E-06
Phenol	2.4	2.4	0.0024	1.45E-02	3.49E-05	5.7E-08
Cyclohexane	1.7	1.7	0.0017	1.45E-02	2.47E-05	4.0E-08
3&4-Methylphenol	6.1	6.1	0.0061	1.45E-02	8.87E-05	1.4E-07
2-Chlorophenol	1.5	1.5	0.0015	1.45E-02	2.18E-05	3.6E-08
	Total SVOCs:	**203.6**	**0.204**		**2.96E-03**	**4.8E-06**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in WCWD is assumed to be 14.0 mgd (low end of NPDES permitted flow rate).

Calculation sheet for Recent Alluvium Aquifer Section Line 1B

MW-122S (cm/sec)	MW-106S cm/sec)
6.47E-04	6.05E-02
MW-122S (ft/sec)	MW-106S (ft/sec)
2.12E-05	1.98E-03

Input Parameters

i (MW-122S to MW-106S)* =	0.0015	ft/ft	Nov-14
A (X-Sect Area) ** =	5043.5	ft^2	at MW-106S
Q *** =	7.36E-03	ft^3/sec	
Q =	**2.08E-01**	**L/sec**	

(Yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In WCWD**
Parameter	**MW-106S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
None Detected	0.0	0	0.000	2.08E-01	0.00E+00	0.0E+00
	Total VOCs:	**0.0**	**0.000**		**0.00E+00**	**0.0E+00**

Average SVOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In WCWD**
Parameter	**MW-106S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
1,4-Dioxane	6.6	6.6	0.0066	2.08E-01	1.38E-03	2.2E-06
Phenanthrene	0.209	0.209	0.000209	2.08E-01	4.35E-05	7.1E-08
	Total SVOCs:	**6.8**	**0.007**		**1.42E-03**	**2.3E-06**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in WCWD is assumed to be 14.0 mgd (low end of NPDES permitted flow rate).

Calculation sheet for Recent Alluvium Aquifer Section Line 1C

MW-107S (cm/sec)
3.28E-03
MW-107S (ft/sec)
1.08E-04

Input Parameters

i (Estimated from contours) =	0.0033	ft/ft	Nov-14
A (X-Sect Area) ** =	5644.4	ft^2	at MW-107S
Q *** =	1.98E-03	ft^3/sec	
Q =	**5.59E-02**	**L/sec**	

Denotes User Data Input Cell (yellow)

Average VOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In WCWD
Parameter	**MW-107S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
Tetrachloroethene	2.5	2.5	0.003	5.59E-02	1.40E-04	2.3E-07
Chloroethane	2	2	0.002	5.59E-02	1.12E-04	1.8E-07
1,1-Dichloroethane	72.2	72.2	0.072	5.59E-02	4.04E-03	6.6E-06
Methyl Acetate	5	5	0.005	5.59E-02	2.80E-04	4.6E-07
cis-1,2-Dichloroethylene	9.3	9.3	0.009	5.59E-02	5.20E-04	8.5E-07
1,4-Dichlorobenzene	0.25	0.25	0.000	5.59E-02	1.40E-05	2.3E-08
1,1,1-Trichloroethane	0.67	0.67	0.001	5.59E-02	3.75E-05	6.1E-08
1,1-Dichloroethene	1.2	1.2	0.001	5.59E-02	6.71E-05	1.1E-07
Trichloroethene	10.3	10.3	0.010	5.59E-02	5.76E-04	9.4E-07
	Total VOCs:	**103.4**	**0.103**		**5.78E-03**	**9.4E-06**

Average SVOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In WCWD
Parameter	**MW-107S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
1,4-Dioxane (p-dioxane)	33.6	33.6	0.0336	5.59E-02	1.88E-03	3.1E-06
	Total SVOCs:	**33.6**	**0.034**		**1.88E-03**	**3.1E-06**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in WCWD is assumed to be 14.0 mgd (low end of NPDES permitted flow rate).

Calculation sheet for Recent Alluvium Aquifer Section Line 2A

Use 107S (cm/sec)
3.28E-03
Use 107S (ft/sec)
1.08E-04

Input Parameters

i (estimated from contours) =	0.0039	ft/ft	Nov-14
A (X-Sect Area) ** =	3765.5	ft^2	at MW-119S
Q *** =	1.59E-03	ft^3/sec	
Q =	**4.50E-02**	**L/sec**	

(yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In James
Parameter	**MW-119S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**R. (mg/L)**
None Detected	0	0	0.000	4.50E-02	0.00E+00	0.0E+00
	Total VOCs:	**0.0**	**0.000**		**0.00E+00**	**0.0E+00**

Average SVOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In James
Parameter	**MW-119S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**R. (mg/L)**
1,4-Dioxane	1.3	1.3	0.0013	4.50E-02	5.85E-05	8.6E-11
Tetrahydrofuran	11	11	0.011	4.50E-02	4.95E-04	7.3E-10
	Total SVOCs:	**11.0**	**0.011**		**4.95E-04**	**7.3E-10**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Recent Alluvium Aquifer Section Line 2B

MW-110S (cm/sec)	
7.03E-03	
MW-110S (ft/sec)	
2.31E-04	

Input Parameters

i (MW-115S to MW-110S) =	0.0012	ft/ft	Nov-14
A (X-Sect Area) ** =	4446	ft^2	at MW-110S
Q *** =	1.19E-03	ft^3/sec	
Q =	**3.37E-02**	**L/sec**	

(Yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In James**
Parameter	**MW-110S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**R. (mg/L)**
None Detected	0	0	0.000	3.37E-02	0.00E+00	0.0E+00
	Total VOCs:	**0.0**	**0.000**		**0.00E+00**	**0.0E+00**

Average SVOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In James**
Parameter	**MW-110S**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**R. (mg/L)**
None Detected	0	0	0.000	3.37E-02	0.00E+00	0.0E+00
	Total SVOCs:	**0.0**	**0.000**		**0.00E+00**	**0.00E+00**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Recent Alluvium Aquifer Section Line 2C

MW-111S (cm/sec)	MW-112S (cm/sec)	MW-114S (cm/sec)
1.55E-02	1.93E-02	1.17E-02
MW-111S (ft/sec)	MW-112S (ft/sec)	MW-114S (ft/sec)
5.09E-04	6.33E-04	3.84E-04

Input Parameters

i (MW-113S to MW-7) =	0.0016	ft/ft	Nov-14
A (X-Sect Area) ** =	5184.75	ft^2	at MW-111S
Q *** =	4.17E-03	ft^3/sec	
Q =	**1.18E-01**	**L/sec**	

Denotes User Data Input Cell (yellow)

Average VOC Concentration by Constituent					Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	MW-111S	MW-7	Ave. Conc.(ug/L)	Ave. Conc. (mg/L)	Q (L/sec)	Flux (mg/sec)	James R. (mg/L)
Ethylbenzene	ND	0.47	0.47	0.000	1.18E-01	5.55E-05	8.2E-11
Toluene	ND	0.39	0.39	0.000	1.18E-01	4.60E-05	6.8E-11
Benzene	ND	0.8	0.8	0.001	1.18E-01	9.45E-05	1.4E-10
Chloroethane	ND	156	156	0.156	1.18E-01	1.84E-02	2.7E-08
m,p-Xylene	ND	0.57	0.57	0.001	1.18E-01	6.73E-05	9.9E-11
		Total VOCs:	**158.2**	**0.158**		**1.87E-02**	**2.7E-08**

Average SVOC Concentration by Constituent					Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	MW-111S	MW-7	Ave. Conc.(ug/L)	Ave. Conc. (mg/L)	Q (L/sec)	Flux (mg/sec)	James R. (mg/L)
Phenol	45.5	1.9	23.7	0.024	1.18E-01	2.80E-03	4.1E-09
1,4-Dioxane	ND	484	484	0.484	1.18E-01	5.71E-02	8.4E-08
N-Nitrosodiphenylamine	60.9	596	328.45	0.328	1.18E-01	3.88E-02	5.7E-08
Caprolactam	5.6	5.8	5.7	0.006	1.18E-01	6.73E-04	9.9E-10
Diphenyl ether	330	720	525	0.525	1.18E-01	6.20E-02	9.1E-08
Naphthalene	ND	0.265	0.265	0.000	1.18E-01	3.13E-05	4.6E-11
Carbazole	ND	17.9	17.9	0.018	1.18E-01	2.11E-03	3.1E-09
		Total SVOCs:	**1,385.0**	**1.385**		**1.64E-01**	**2.41E-07**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Recent Alluvium Aquifer Section Line 2D

Use MW-111S (cm/sec)
1.55E-02
Use MW-111S (ft/sec)
5.09E-04

Input Parameters

i (MW-9 to 2' Contour) =	0.0006	ft/ft	Nov-14
A (X-Sect Area) ** =	11788.2	ft^2	at MW-9
Q *** =	3.60E-03	ft^3/sec	
Q =	**1.02E-01**	**L/sec**	

(yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In James**
Parameter	**MW-9**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**R. (mg/L)**
None Detected	0	0	0.000	1.02E-01	0.00E+00	0.0E+00
	Total VOCs:	**0.0**	**0.000**		**0.00E+00**	**0.0E+00**

Average SVOC Concentration by Constituent				**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In James**
Parameter	**MW-9**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**R. (mg/L)**
1,4-Dioxane	1.2	1.2	0.001	1.02E-01	1.22E-04	1.8E-10
Caprolactam	162	162	0.162	1.02E-01	1.65E-02	2.4E-08
	Total SVOCs:	**163.2**	**0.163**		**1.66E-02**	**2.45E-08**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Recent Alluvium Aquifer Section Line 3A

Use MW-111S (cm/sec)
1.55E-02
Use MW-111S (ft/sec)
5.09E-04

Input Parameters

i (MW-8 to 2' Contour) =	0.0003	ft/ft	Nov-14
A (X-Sect Area) ** =	10500.6	ft^2	at MW-117D
Q *** =	1.33E-03	ft^3/sec	
Q =	**3.78E-02**	**L/sec**	

Denotes User Data Input Cell (yellow)

Average VOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In ECWD.
Parameter	**MW-8**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
Tetrachloroethene	4.6	4.6	0.005	3.78E-02	1.74E-04	8.8E-07
cis-1,2-Dichloroethene	19.7	19.7	0.020	3.78E-02	7.45E-04	3.8E-06
1,1,1-Trichloroethane	1	1	0.001	3.78E-02	3.78E-05	1.9E-07
Vinyl chloride	2.1	2.1	0.002	3.78E-02	7.94E-05	4.0E-07
1,1-Dichloroethane	2.4	2.4	0.002	3.78E-02	9.07E-05	4.6E-07
1,1-Dichloroethene	1.2	1.2	0.001	3.78E-02	4.54E-05	2.3E-07
Trichloroethene	7.7	7.7	0.008	3.78E-02	2.91E-04	1.5E-06
	Total VOCs:	**38.7**	**0.039**		**1.46E-03**	**7.4E-06**

Average SVOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In ECWD.
Parameter	**MW-8**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**(mg/L)**
Phenol	1	1	0.001	3.78E-02	3.78E-05	1.9E-07
1,4-Dioxane	3.2	3.2	0.003	3.78E-02	1.21E-04	6.1E-07
Diphenyl ether	16	16	0.016	3.78E-02	6.05E-04	3.1E-06
	Total SVOCs:	**20.2**	**0.020**		**7.64E-04**	**3.87E-06**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in ECWD is assumed to be 4.5 mgd.

Calculation sheet for Potomac Aquifer Section Line 1A

MW-110D (cm/sec)	MW-107D (cm/sec)
0.01000	0.00085
MW-110D (ft/sec)	MW-107D (ft/sec)
3.28E-04	2.78E-05

Input Parameters

i (MW-107D to MW-110D) =	0.0004	ft/ft	Nov-14
A (X-Sect Area) ** =	19200	ft^2	at NW9-1
Q *** =	1.45E-03	ft^3/sec	
Q =	**4.10E-02**	**L/sec**	

(Yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent					**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In**
Parameter	**NW9-1**	**MW-110D**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
1,1-Dichloroethane	42.3	ND	42.3	0.042	4.10E-02	1.73E-03	2.6E-09
Trichloroethene	2.6	ND	2.6	0.003	4.10E-02	1.07E-04	1.6E-10
Tetrachloroethene	1.3	ND	1.3	0.001	4.10E-02	5.33E-05	7.8E-11
cis-1,2-Dichloroethene	1.4	ND	1.4	0.001	4.10E-02	5.74E-05	8.4E-11
Acetone	ND	3.8	3.8	0.004	4.10E-02	1.56E-04	2.3E-10
		Total VOCs:	**51.4**	**0.051**		**2.11E-03**	**3.1E-09**

Average SVOC Concentration by Constituent					**Est. Flux = Q x C (Avg. Conc.)**		**Est. Conc. In**
Parameter	**NW9-1**	**MW-110D**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
1,4-Dioxane	35	ND	35	0.035	4.10E-02	1.43E-03	2.1E-09
1,1'-Biphenyl	0.44	ND	0.44	0.000	4.10E-02	1.80E-05	2.7E-11
Pyrene	0.284	ND	0.284	0.000	4.10E-02	1.16E-05	1.7E-11
Benzo(b)fluoranthene	0.161	ND	0.161	0.000	4.10E-02	6.60E-06	9.7E-12
Fluoranthene	0.3	ND	0.3	0.000	4.10E-02	1.23E-05	1.8E-11
Benzo(k)fluoranthene	0.109	ND	0.109	0.000	4.10E-02	4.47E-06	6.6E-12
Chrysene	0.171	ND	0.171	0.000	4.10E-02	7.01E-06	1.0E-11
Benzo(a)anthracene	0.207	ND	0.207	0.000	4.10E-02	8.49E-06	1.2E-11
Hexachlorobenzene	0.199	ND	0.199	0.000	4.10E-02	8.16E-06	1.2E-11
Anthracene	0.192	ND	0.192	0.000	4.10E-02	7.87E-06	1.2E-11
Phenanthrene	0.162	ND	0.162	0.000	4.10E-02	6.64E-06	9.8E-12
		Total SVOCs:	**37.2**	**0.037**		**1.53E-03**	**2.25E-09**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Potomac Aquifer Section Line 1B

MW-111D (cm/sec)	MW-109D (cm/sec)
0.00774	0.00330
MW-111D (ft/sec)	MW-109D (ft/sec)
2.54E-04	1.08E-04

Input Parameters

i (MW-109D to MW-111D) =	0.0006	ft/ft	Nov-14
A (X-Sect Area) ** =	12240	ft^2	at MW-109D
Q *** =	1.43E-03	ft^3/sec	
Q =	**4.06E-02**	**L/sec**	

(Yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	**MW-111D**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
None Detected	0	0	0.000	4.06E-02	0.00E+00	0.0E+00
	Total VOCs:	**0.0**	**0.000**		**0.00E+00**	**0.0E+00**

Average SVOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	**MW-111D**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
Caprolactam	6.45	6.45	0.006	4.06E-02	2.62E-04	3.9E-10
	Total SVOCs:	**6.5**	**0.006**		**2.62E-04**	**3.85E-10**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Potomac Aquifer Section Line 1C

MW-118D (cm/sec)	MW-117D (cm/sec)	MW-116D (cm/sec)
0.00450	0.00067	0.00036
MW-118D (ft/sec)	MW-117D (ft/sec)	MW-116D (ft/sec)
1.48E-04	2.20E-05	1.16E-05

Input Parameters

i (MW-117D to MW-118D) =	0.0006	ft/ft	Nov-14
A (X-Sect Area) ** =	27160	ft^2	at MW-118D
Q *** =	9.85E-04	ft^3/sec	
Q =	**2.79E-02**	**L/sec**	

(Yellow cell) **Denotes User Data Input Cell**

Average VOC Concentration by Constituent						Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	**MW-118D**	**MW-118DD**	**NW5-1**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
Acetone	2.7	ND	3.1	2.9	0.003	2.79E-02	8.09E-05	1.2E-10
1,1,1-Trichloroethane	1.1	ND	ND	1.1	0.001	2.79E-02	3.07E-05	4.5E-11
1,2-Dichloroethane	ND	ND	1	1	0.001	2.79E-02	2.79E-05	4.1E-11
Chloroethane	ND	ND	84	84	0.084	2.79E-02	2.34E-03	3.4E-09
Methylene chloride	ND	ND	1	1	0.001	2.79E-02	2.79E-05	4.1E-11
m,p-Xylene	ND	ND	1	1	0.001	2.79E-02	2.79E-05	4.1E-11
Total VOCs:				**91.0**	**0.091**		**2.54E-03**	**3.7E-09**

Average SVOC Concentration by Constituent						Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	**MW-118D**	**MW-118DD**	**NW5-1**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
Di-n-butyl phthalate	0.48	ND	ND	0.48	0.000	2.79E-02	1.34E-05	2.0E-11
Bis(2-ethylhexyl) phthalate	ND	1.7	ND	1.7	0.002	2.79E-02	4.74E-05	7.0E-11
Butyl benzyl phthalate	ND	0.25	ND	0.25	0.000	2.79E-02	6.97E-06	1.0E-11
Tetrahydrofuran	ND	1.7	27	1.7	0.002	2.79E-02	4.74E-05	7.0E-11
1,4-Dioxane (p-dioxane)	ND	0.25	5100	0.25	0.000	2.79E-02	6.97E-06	1.0E-11
Total SVOCs:				**4.4**	**0.004**		**1.22E-04**	**1.80E-10**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.

Calculation sheet for Potomac Aquifer Section Line 1D

MW-118D (cm/sec)	MW-117D (cm/sec)
0.00450	0.00067
MW-118D (ft/sec)	MW-117D (ft/sec)
1.48E-04	2.20E-05

Input Parameters

i (MW-117D to MW-118D) =	0.0006	ft/ft	Nov-14
A (X-Sect Area) ** =	27421.9	ft^2	at MW-118D
Q *** =	1.40E-03	ft^3/sec	
Q =	**3.95E-02**	**L/sec**	

[yellow cell] **Denotes User Data Input Cell**

Average VOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	**NW1-3**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
None Detected	0	0	0.000	3.95E-02	0.00E+00	0.0E+00
	Total VOCs:	**0.0**	**0.000**		**0.00E+00**	**0.0E+00**

Average SVOC Concentration by Constituent				Est. Flux = Q x C (Avg. Conc.)		Est. Conc. In
Parameter	**NW1-3**	**Ave. Conc.(ug/L)**	**Ave. Conc. (mg/L)**	**Q (L/sec)**	**Flux (mg/sec)**	**James R. (mg/L)**
None Detected	0	0	0.000	3.95E-02	0.00E+00	0.0E+00
	Total SVOCs:	**0.0**	**0.000**		**0.00E+00**	**0.00E+00**

Notes:

1) * = Groundwater gradient between wells
2) ** = Cross sectional area (A) is calculated using (length of section line) x (saturated thickness at nearest well, Nov. 2014)
3) *** = Discharge (Q) is equal to k (the average hydraulic conductivity) x I (the groundwater gradient) x A (the cross sectional) area)
4) Flow in James River is assumed to be 24,000 ft^3/sec at Chesterfield facility.