Mann Kendall Automation with Power BI

Woodard & Curran

September 21, 2022

Mann-Kendall Trend Test

Mann-Kendall Trend Test - Overview

- Statistical test used to evaluate trends over time
  - Commonly used for groundwater contaminants
- Calculated by examining all possible pairs of measurements in the data set and scoring each pair as follows:
  - $z_k = 1 \; when \; y_t > y_{t'}$ **Increasing**
  - $z_k = 0 \; when \; y_t = y_{t'}$ **No Trend**
  - $z_k = -1 \; when \; y_t < y_{t'}$ **Decreasing**
- Sum of all z_k = Mann-Kendall Statistic (**S**)
  - Positive S suggests **increasing** trend

Woodard & Curran

Mann-Kendall Trend Test - Overview

- Once the S value is calculated, probability (p) is quantified based on
  - n = number of samples
  - sd(s) = standard deviation of S
  - z = standardized Z-statistic

Woodard & Curran

Mann-Kendall Trend Test - Visual Example

	A	B	C
1	Sample No.	Sampling Date (yr.mon)	Sulfate Conc. (ppm)
2	1	89.6	480
3	2	89.8	450
4	3	90.1	490
5	4	90.3	520
6	5	90.6	485
7	6	90.8	510
8	7	91.1	510
9	8	91.3	530
10	9	91.6	510
11	10	91.8	560
12	11	92.1	560
13	12	92.6	540
14	13	93.1	590
15	14	93.6	550
16	15	94.1	600
17	16	94.6	700
18	17	95.1	570
19	18	95.6	610
20	19	95.8	650
21	20	96.1	620
22	21	96.3	830
23	22	96.6	720
24	23	96.8	590

Example 17-6 United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

Woodard & Curran

Mann-Kendall Trend Test - Visual Example

Example 17-6 United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	S	194		SD[S]	37.79		n	23		Z	5.107322		p	1.633787E-07								
	480	450	490	520	485	510	510	530	510	560	560	540	590	550	600	700	570	610	650	620	830	720
480																						
450	-1																					
490	1	1																				
520	1	1	1																			
485	1	1	-1	-1																		
510	1	1	1	-1	1																	
510	1	1	1	-1	1	0																
530	1	1	1	1	1	1	1															
510	1	1	1	-1	1	0	0	-1														
560	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1													
560	1	1	1	1	1	1	1	1	1	0												
540	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1	-1	-1											
590	1	1	1	1	1	1	1	1	1	1	1	1										
550	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1	1	-1	-1	1	-1									
600	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
700	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
570	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	-1	-1						
610	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1					
650	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1				
620	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	-1			
830	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
720	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	
590	1	1	1	1	1	1	1	1	1	1	1	1	0	1	-1	-1	1	-1	-1	-1	-1	-1

United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

Mann-Kendall Trend Test - Visual Example

Example 17-6 United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	S	194		SD[S]	37.79		n	23		Z	5.107322		p	1.633787E-07								
	480	450	490	520	485	510	510	530	510	560	560	540	590	550	600	700	570	610	650	620	830	720
480																						
450	-1																					
490	1	1																				
520	1	1	1																			
485	1	1	-1	-1																		
510	1	1	1	-1	1																	
510	1	1	1	-1	1	0																
530	1	1	1	1	1	1	1															
510	1	1	1	-1	1	0	0	-1														
560	1	1	1	1	1	1	1	1	1													
560	1	1	1	1	1	1	1	1	1	0												
540	1	1	1	1	1	1	1	1	1	-1	-1											
590	1	1	1	1	1	1	1	1	1	1	1	1										
550	1	1	1	1	1	1	1	1	1	-1	-1	1	-1									
600	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
700	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
570	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	-1	-1						
610	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1					
650	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1				
620	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	-1			
830	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
720	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	
590	1	1	1	1	1	1	1	1	1	1	1	1	0	1	-1	-1	1	-1	-1	-1	-1	-1

United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

Mann-Kendall Trend Test - Visual Example

Example 17-6 United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	S	194		SD[S]	37.79		n	23		Z	5.107322		p	1.633787E-07								
	480	450	490	520	485	510	510	530	510	560	560	540	590	550	600	700	570	610	650	620	830	720
480																						
450	-1																					
490	1	1																				
520	1	1	1																			
485	1	1	-1	-1																		
510	1	1	1	-1	1																	
510	1	1	1	-1	1	0																
530	1	1	1	1	1	1	1															
510	1	1	1	-1	1	0	0	-1														
560	1	1	1	1	1	1	1	1	1													
560	1	1	1	1	1	1	1	1	1	0												
540	1	1	1	1	1	1	1	1	1	-1	-1											
590	1	1	1	1	1	1	1	1	1	1	1	1										
550	1	1	1	1	1	1	1	1	1	-1	-1	1	-1									
600	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
700	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
570	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	-1	-1						
610	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1					
650	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1				
620	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	-1			
830	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
720	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	
590	1	1	1	1	1	1	1	1	1	1	1	1	0	1	-1	-1	1	-1	-1	-1	-1	-1

$$SD[S] = \sqrt{\frac{1}{18}\left[n(n-1)(2n+5) - \sum_{j=1}^{g} t_j (t_j - 1)(2t_j + 5)\right]}$$

United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

Mann-Kendall Trend Test - Visual Example

Example 17-6 United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	S	194		SD[S]	37.79		n	23		Z	5.107322		p	1.633787E-07								
	480	450	490	520	485	510	510	530	510	560	560	540	590	550	600	700	570	610	650	620	830	720
480																						
450	-1																					
490	1	1																				
520	1	1	1																			
485	1	1	-1	-1																		
510	1	1	1	-1	1																	
510	1	1	1	-1	1	0																
530	1	1	1	1	1	1	1															
510	1	1	1	-1	1	0	0	-1														
560	1	1	1	1	1	1	1	1	1													
560	1	1	1	1	1	1	1	1	1	0												
540	1	1	1	1	1	1	1	1	1	-1	-1											
590	1	1	1	1	1	1	1	1	1	1	1	1										
550	1	1	1	1	1	1	1	1	1	-1	-1	1	-1									
600	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
700	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
570	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	-1	-1						
610	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1					
650	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1				
620	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	-1			
830	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
720	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	
590	1	1	1	1	1	1	1	1	1	1	1	1	0	1	-1	-1	1	-1	-1	-1	-1	-1

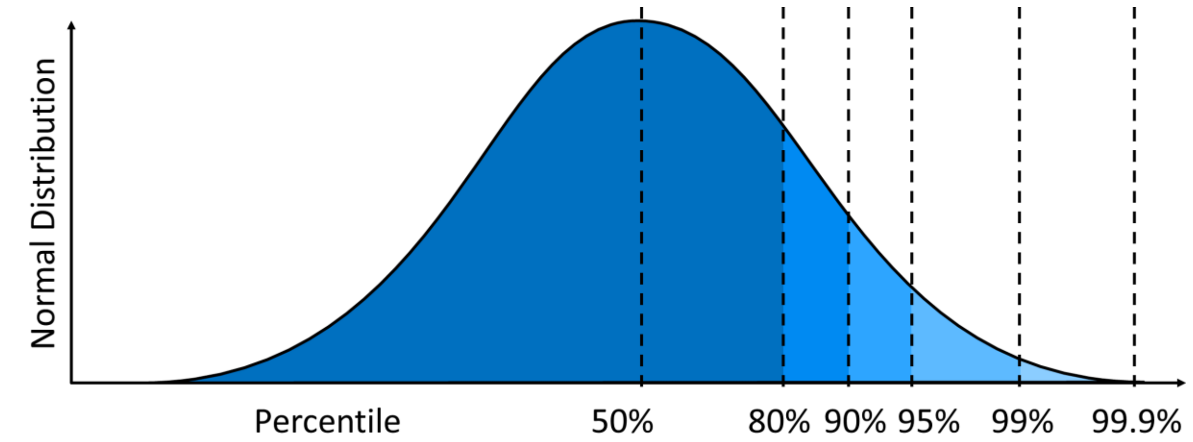
$$Z = \left(|S| - 1\right) / SD[S]$$

United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

Mann-Kendall Trend Test - Visual Example

Example 17-6 United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	S	194		SD[S]	37.79		n	23		Z	5.107322		p	1.633787E-07								
	480	450	490	520	485	510	510	530	510	560	560	540	590	550	600	700	570	610	650	620	830	720
480																						
450	-1																					
490	1	1																				
520	1	1	1																			
485	1	1	-1	-1																		
510	1	1	1	-1	1																	
510	1	1	1	-1	1	0																
530	1	1	1	1	1	1	1															
510	1	1	1	-1	1	0	0	-1														
560	1	1	1	1	1	1	1	1	1													
560	1	1	1	1	1	1	1	1	1	0												
540	1	1	1	1	1	1	1	1	1	-1												
590	1	1	1	1	1	1	1	1	1	1												
550	1	1	1	1	1	1	1	1	1	-1												
600	1	1	1	1	1	1	1	1	1	1												
700	1	1	1	1	1	1	1	1	1	1												
570	1	1	1	1	1	1	1	1	1	1												
610	1	1	1	1	1	1	1	1	1	1												
650	1	1	1	1	1	1	1	1	1	1												
620	1	1	1	1	1	1	1	1	1	1												
830	1	1	1	1	1	1	1	1	1	1												
720	1	1	1	1	1	1	1	1	1	1												
590	1	1	1	1	1	1	1	1	1	1												1



**Central Tendency Theorem can be applied only once n ≥ 10*

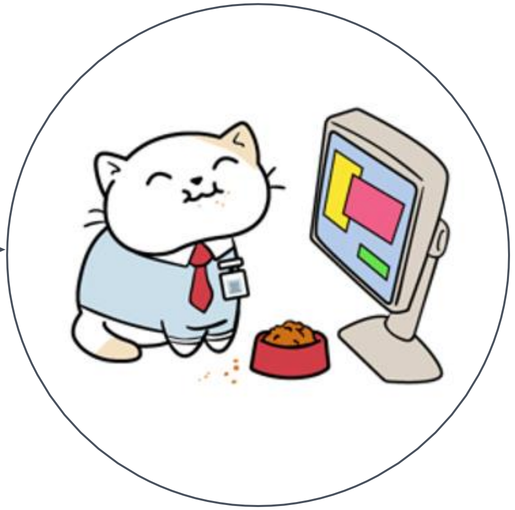
United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.

R-Based Approach to Automating Mann-Kendall

Woodard & Curran

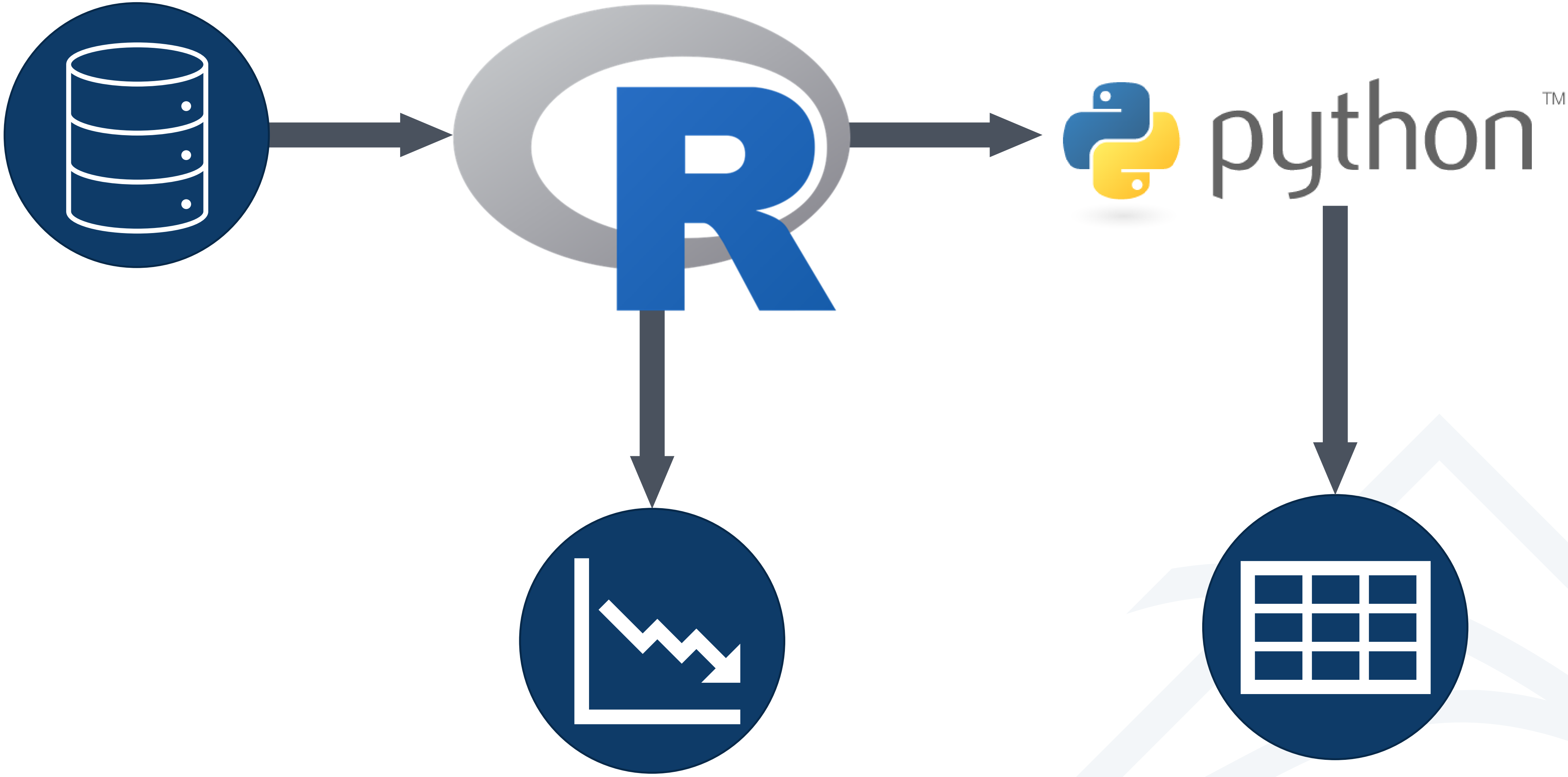
Initial Mann Kendall Automation Script

Error-prone, tedious spreadsheets



Automated approach

Strong Statistical Reputation


python

Initial Mann Kendall Automation Approach Using R

TABLE X-X
SUMMARY OF MANN-KENDALL TREND ANALYSIS RESULTS
Project Name, Project City, Project State

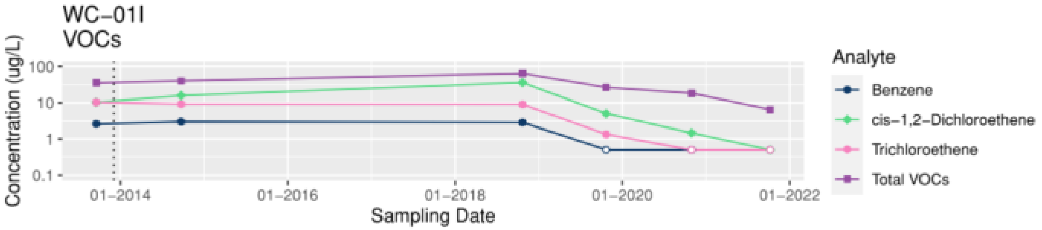
Well	Depth Interval	1,1,1-TCA	Benzene	cis-1,2-DCE	Naphthalene	PCE	TCE	Vinyl chloride	Total VOCs	1,4-Dioxane	Dissolved Arsenic	Total Arsenic	PFHxS	PFNA	PFOS	PFOA
On-Property																
MW-1	Shallow	BRL	BRL	---	Decreasing	BRL	BRL	BRL	Decreasing	---	---	Decreasing#	No Trend	BRL	No Trend#	No Trend#
MW-2	Shallow	BRL	BRL	BRL	BRL	Decreasing	BRL	BRL	Decreasing	BRL	---	---	Stable#	BRL	Stable#	Stable#
MW-3	Intermediate	---	---	---	---	---	---	---	---	No Trend	---	---	No Trend	BRL	Stable	Stable
MW-4	Shallow	BRL	Decreasing	No Trend	No Trend	---	---	BRL	No Trend	No Trend#	---	No Trend#	---	---	---	---
MW-5	Intermediate	BRL	Stable	Prob Decreasing	BRL	BRL	Decreasing	BRL	Prob Decreasing	No Trend#	---	No Trend#	---	---	---	---
MW-6	Intermediate	Decreasing	Stable#	Decreasing	BRL	Decreasing	Decreasing	Prob Increasing#	Decreasing	Decreasing#	---	Decreasing	Decreasing#	BRL	Increasing#	Stable#
MW-7	Shallow	BRL	BRL	BRL	BRL	BRL	BRL	BRL	BRL	BRL	---	---	---	---	---	---
MW-8	Shallow	BRL	No Trend	No Trend	BRL	BRL	BRL	BRL	Prob Decreasing	Decreasing	---	Decreasing#	---	---	---	---
Off-Property Monitoring Wells																
MW-9	Deep	BRL	BRL	No Trend	BRL	BRL	BRL	BRL	No Trend	Prob Decreasing#	---	BRL	BRL	BRL	Stable	No Trend
MW-10	Bedrock	---	---	---	---	---	---	---	---	---	---	Decreasing	---	---	---	---
MW-11	Shallow	---	---	---	---	---	---	---	---	---	---	Stable#	---	Stable	Stable#	Stable#
MW-12	Intermediate	---	---	---	---	---	---	---	---	Prob Decreasing	---	---	---	---	---	---
MW-13	Deep	---	---	---	---	---	---	---	---	Stable#	---	Stable#	BRL	BRL	BRL	BRL
MW-14	Intermediate	BRL	---	Decreasing	BRL	---	BRL	BRL	Decreasing	Decreasing#	---	No Trend	Stable#	BRL	No Trend#	No Trend#
MW-15	Deep	BRL	Decreasing	Decreasing	BRL	BRL	Decreasing	Increasing#	Decreasing	Decreasing#	Increasing#	Increasing#	Decreasing	BRL	Decreasing	Decreasing#
MW-16	Intermediate	BRL	BRL	Decreasing	BRL	BRL	Decreasing	Prob Decreasing	Decreasing	Decreasing	---	BRL	Stable	BRL	Stable#	Stable#
MW-17	Shallow	---	---	---	---	---	---	---	---	Decreasing	---	Decreasing	---	---	---	---
Off-Property Former Drinking Water Wells																
MW-18	Bedrock	---	Stable#	Stable	---	---	Prob Decreasing	BRL	No Trend	Stable#	---	---	---	---	---	---
MW-19	Bedrock	BRL	---	Decreasing	---	BRL	---	BRL	Decreasing	Stable#	---	---	---	---	---	---
MW-20	Bedrock	---	---	---	---	---	---	---	---	Stable	---	---	---	---	---	---
MW-21	Bedrock	---	---	---	---	---	---	---	---	No Trend#	---	---	---	---	---	---
MW-22	Bedrock	---	---	---	---	---	---	---	---	BRL	---	---	---	---	---	---
MW-23	Bedrock	---	---	---	---	---	---	---	---	No Trend#	---	---	---	---	---	---
MW-24	Bedrock	---	---	---	---	---	---	---	---	No Trend#	---	---	---	---	---	---
MW-25	Bedrock	BRL	---	No Trend#	BRL	BRL	No Trend	---	Stable	Stable#	No Trend#	No Trend#	---	---	---	---
MW-26	Bedrock	BRL	BRL	No Trend	BRL	BRL	---	BRL	No Trend	Stable#	---	---	---	---	---	---
MW-27	Bedrock	---	---	---	---	---	---	---	---	No Trend	---	---	---	---	---	---

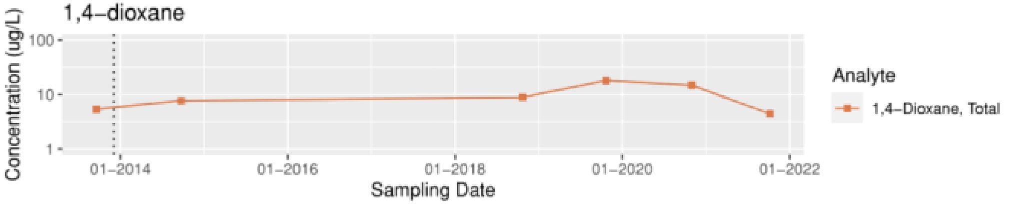
Notes:
cis-1,2-DCE = cis-1,2-dichloroethene; VOCs = Volatile Organic Compounds;
PFHxS = Perfluorohexane sulfonic acid; PFOS = Perfluorooctane sulfonic acid (PFOS); PFOA = Perfluorooctanoic acid (PFOA); PFAS = Perfluorononanoic acid
# = 2021 exceedance of the applicable Regulatory Standard
The MK calculation assumes half the reporting limit if a sample is non-detect.
BRL = Below Reporting Limit, most of the historical data is below laboratory reporting limit

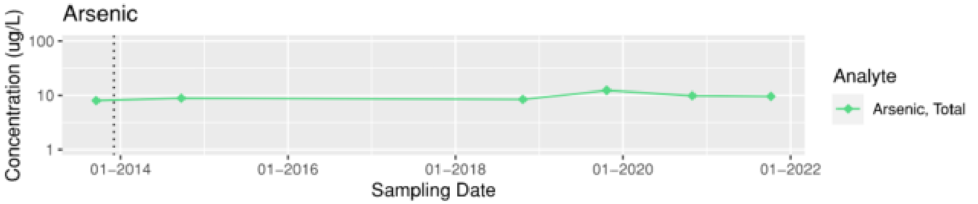
---	Mann Kendall analysis not performed.
Decreasing	Green shading indicates a decreasing or probably decreasing trend, or a stable/no trend with a current concentration below the Regulatory Standard, or results BRL.
Stable#	Yellow shading indicates a stable/no trend with a current concentration above the Regulatory Standard.
Increasing#	Orange shading indicates an increasing trend.

Woodard & Curran

Initial Mann Kendall Automation Approach Using R





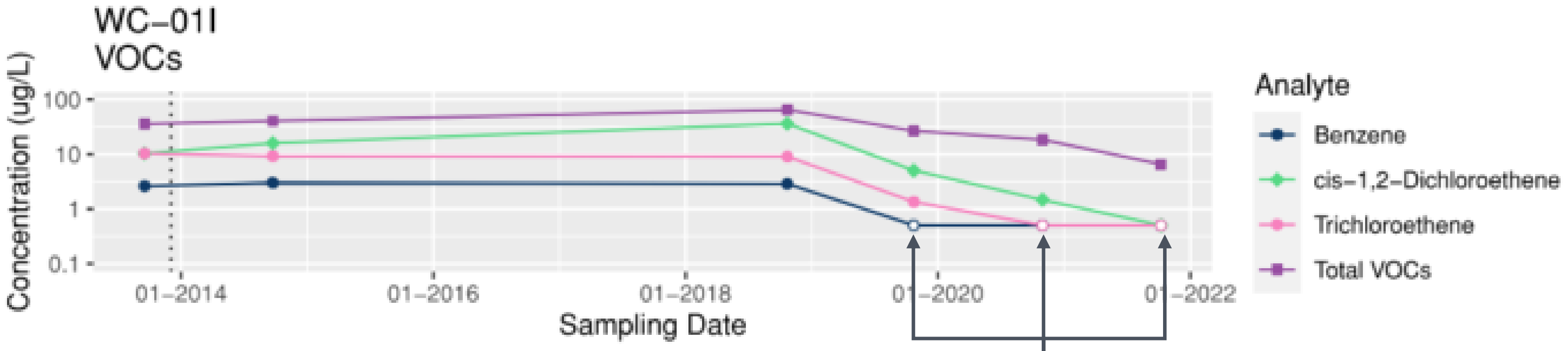


Analyte	Trend	S	Confidence Factor	COV	NHDES AGQS
Benzene	Stable	−8	89.8%	0.77	5
Cis−1,2−dichloroethene	Prob Decreasing	−9	93.2%	1.16	70
Trichloroethene	Decreasing	−14	99.5%	0.94	5
Total VOCs	Prob Decreasing	−9	93.2%	0.62	NA
1,4−dioxane, Total	No Trend#	3	64.0%	0.55	0.32
Arsenic, Total	No Trend#	7	86.4%	0.16	5

1. Non−detect results are displayed with a hollow fill symbol. Non−detect Total VOCs are displayed as one half the minimum sum of detected VOCs.

Woodard & Curran

Initial Mann Kendall Automation Approach Using R



1. Non-detect results are displayed with a hollow fill symbol. Non-detect VOCs are displayed as one half the minimum sum of detected VOCs.

Scaling of R-Approach

- Deployed across multiple projects
- Generalized Script
- Posted to W&C Github

Transition to a Dynamic Display in Power BI

Woodard & Curran

Automating Mann-Kendall with Power BI

- allowed the project team to:
  - Review updated trends in real time
  - Evaluate the impacts of
    - Outliers
    - Different time frames

Measures allowed dynamic recalculations

Chemical Name		MW-11R	MW-12	MW-14	MW-15	MW-19	MW-21	MW-22	MW-23	MW-24	MW-25R	MW-28S	MW-29D
1,1,1,2-Tetrachloroethane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1,1-Trichloroethane		N/A	N/A	N/A	N/A	N/A	No Trend	N/A	N/A	N/A	N/A	N/A	N/A
1,1,2,2-Tetrachloroethane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1,2-Trichloro-1,2,2-trifluoroethane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1,2-Trichloroethane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1-Dichloroethane		N/A	N/A	N/A	N/A	N/A	No Trend	N/A	N/A	N/A	N/A	N/A	No Trend
1,1-Dichloroethene		N/A	N/A	N/A	N/A	Stable	No Trend	N/A	N/A	N/A	Decreasing	N/A	No Trend
1,1-Dichloropropene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2,3-Trichlorobenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2,3-Trichloropropane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2,4,5-Tetramethylbenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2,4-Trichlorobenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dibromo-3-Chloropropane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichlorobenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichloroethane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No Trend
1,2-Dichloroethene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichloropropane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,3-Butadiene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,3-Dichlorobenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,3-Dichloropropane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,3-Dichloropropene (total)		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,4-Dichlorobenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,4-Dioxane	g	No Trend	N/A	N/A	N/A	Decreasing	N/A	N/A	N/A	Decreasing	Potentially Increasing	N/A	N/A
Carbon Tetrachloride		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chlorobenzene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chloroethane		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chloroform		N/A	N/A	N/A	N/A	N/A	N/A	Stable	N/A	N/A	N/A	N/A	N/A
cis-1,2-Dichloroethene	y Increasing	Decreasing	N/A	N/A	N/A	Decreasing	No Trend	N/A	N/A	No Trend	Decreasing	N/A	No Trend
Methylene Chloride		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
trans-1,2-Dichloroethylene		Stable	N/A	N/A	N/A	Decreasing	No Trend	N/A	N/A	No Trend	Decreasing	N/A	No Trend
trans-1,3-Dichloropropene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
trans-1,4-Dichloro-2-butene		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Trichloroethene		Potentially Decreasing	N/A	N/A	N/A	Decreasing	No Trend	No Trend	N/A	Potentially Decreasing	Potentially Decreasing	N/A	Potentiall
Vinyl acetate		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vinyl Chloride		No Trend	N/A	N/A	N/A	No Trend	No Trend	N/A	N/A	Increasing	Increasing	N/A	No Trend

Location Type
- Monitoring Well

Abandoned
False

Well
Multiple selections

Chem. Classification
- VOC

Chemical Name
- [ ] .alpha.-Pinene
- [x] 1,1,1,2-Tetrachloroethane
- [x] 1,1,1-Trichloroethane
- [x] 1,1,2,2-Tetrachloroethane
- [x] 1,1,2-Trichloro-1,2,2-trifluor...
- [x] 1,1,2-Trichloroethane
- [x] 1,1-Dichloroethane
- [x] 1,1-Dichloroethene
- [x] 1,1-Dichloropropene
- [x] 1,2,3-Trichlorobenzene
- [x] 1,2,3-Trichloropropane
- [x] 1,2,4,5-Tetramethylbenzene
- [x] 1,2,4-Trichlorobenzene
- [x] 1,2-Dibromo-3-Chloroprop...
- [ ] 1,2-Dibromoethan

1/1/2002 12/31/2021

Mann Kendall Summary

Well	Trend
DB-01	Potentially Decreasing
DB-30RX1	N/A

Expand Table

Collapse Table

Abandoned: False

Well Type: Monitoring Well

Chemical Cate...: VOC

Chemical Name: cis-1,2-Dichloroethene

cis-1,2-Dichloroethene

1/1/2010 12/31/2021


Mann Kendall Summary
Well
Trend
DB-01
Potentially Decreasing
DB-30RX1
N/A
Expand Table
Collapse Table
Abandoned
False
Well Type
Monitoring Well
Chemical Cate...
VOC
Chemical Name
cis-1,2-Dichloroethene
cis-1,2-Dichloroethene
Satellite
cis-1,2-Dichloroethene in Well MW-35S (Decreasing)
10,000
1,000
100
10
1
Concentration
2020
2021
Date
©2022 TomTom ©2022 Vexcel
Microsoft
1/1/2010
12/31/2021

Chem. Classification

VOC

Chemical Name

Multiple selections

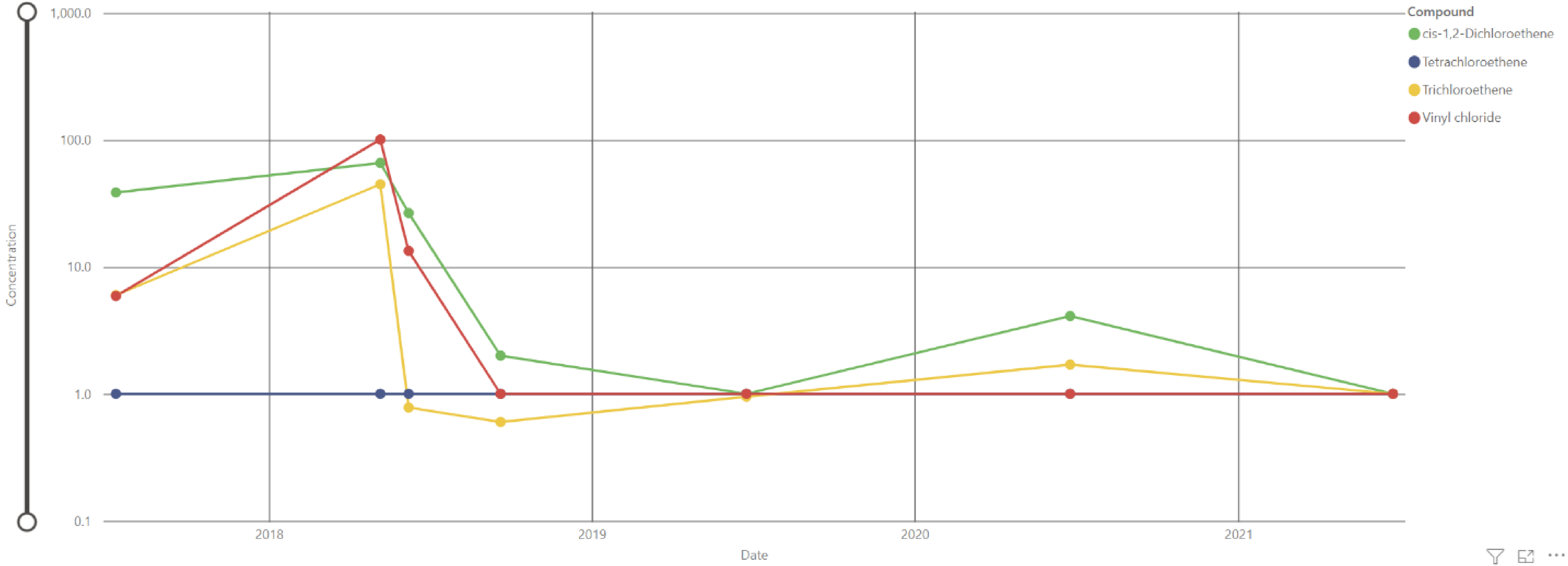
MW-33S

Chemical	MK Result	S	COV	# of Detections	P	Stan. Dev.
cis-1,2-Dichloroethene	Decreasing	-14	1.28	5	0.025	6.66
Tetrachloroethene	N/A		0.00		0.25	6.66
Vinyl Chloride	N/A	-11	2.13	3	0.068	6.66
Trichloroethene	No Trend	-3	2.05	7	0.386	6.66

Well

MW-33S

Concentration and First lab_qualifiers by Sample Date and Compound



1/1/2002 12/31/2021

Next Steps

- Scale Power BI dashboard to multi-project Azure SQL Database
- Build tools for data collection/validation/import.
- Add other analytical tools
  - Contaminants of concern summaries,
  - sampling optimization
  - Seasonal Mann-Kendall, etc.

Questions??

September 21, 2022

Woodard & Curran

References

- United States Environmental Protection Agency (USEPA), 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March.
- Maidment, David R. 1993. Handbook of Hydrology.

Woodard & Curran