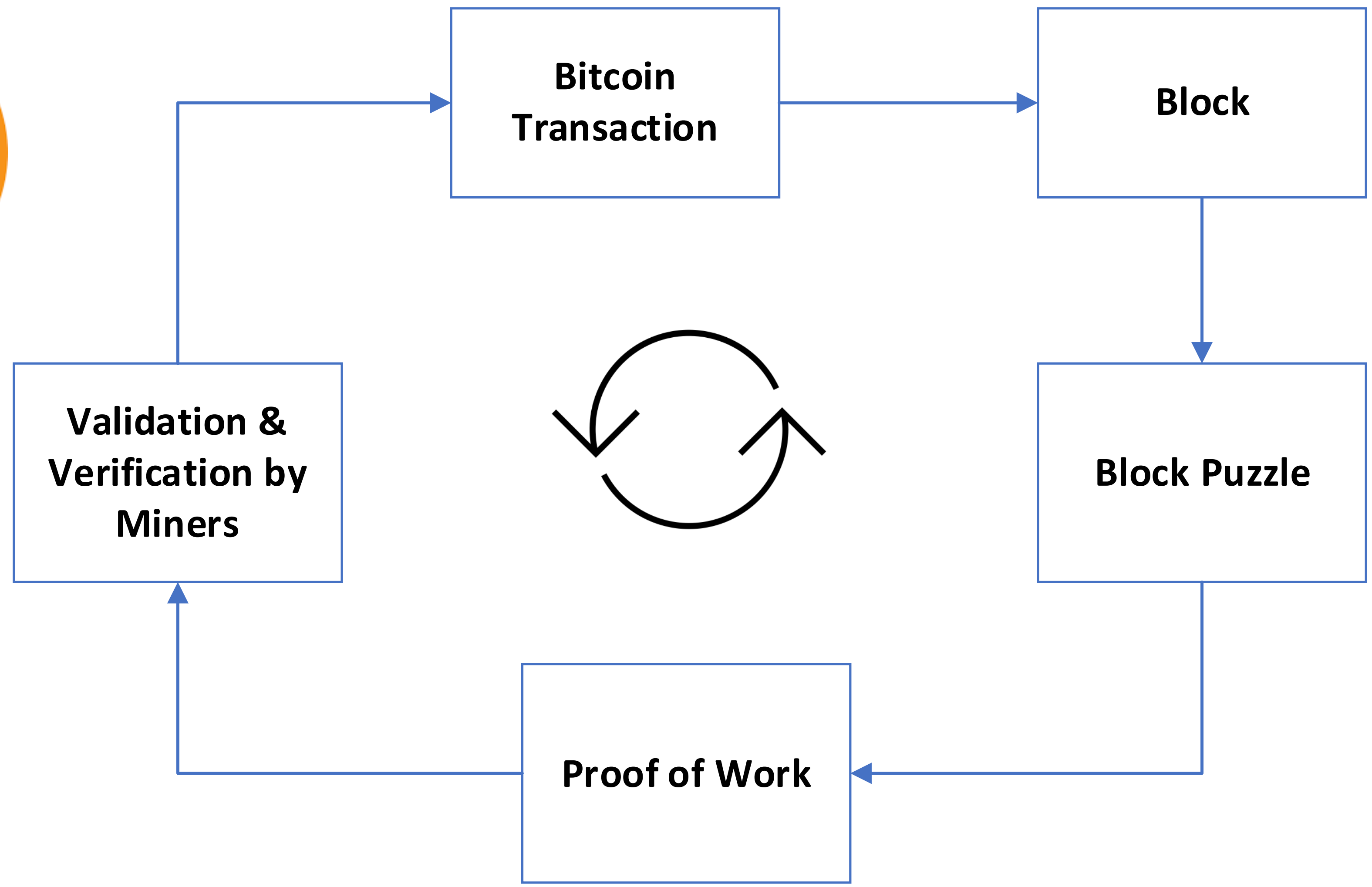
Mining Bitcoin from Your Groundwater Database

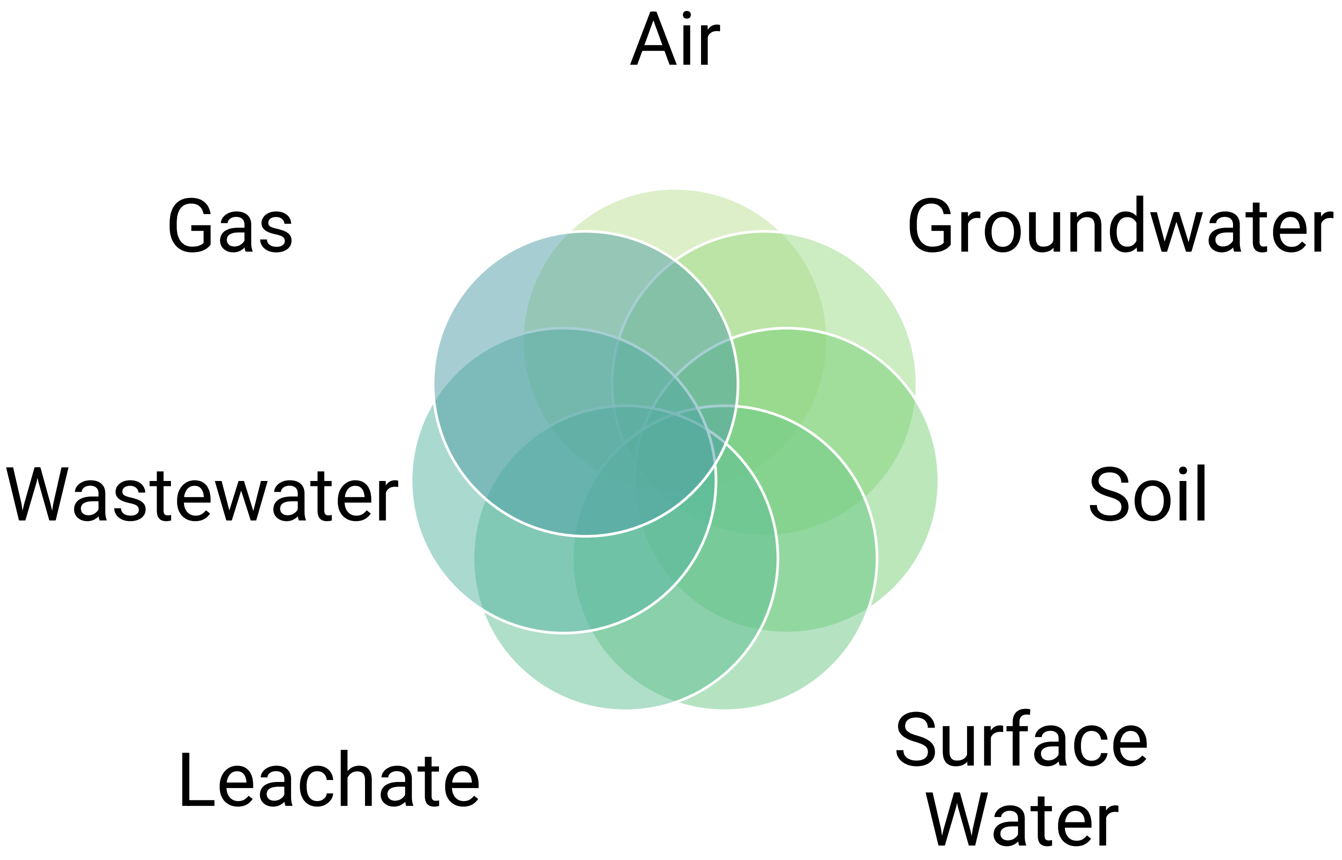
A presentation to:
Missouri Waste Control Coalition
2023 Environmental Conference

July 10, 2023 | Jill Dekart

What is Bitcoin Mining?

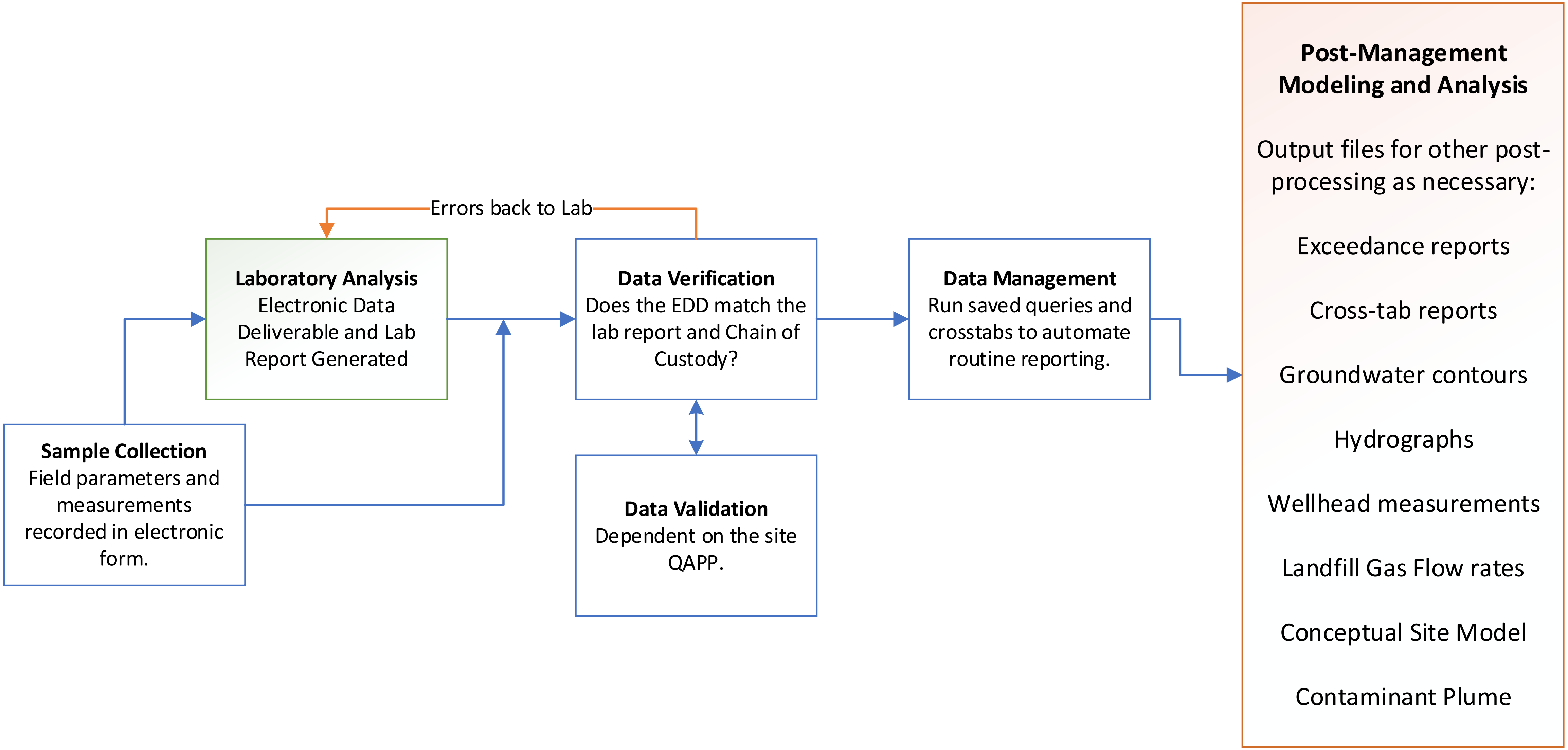


Environmental Domains are connected



Our database must be able to evaluate the interface of the domains.

Overview of a Typical Data Management Workflow



Data Management, like Bitcoin Mining, is a Circular Process

Post-Management Modeling and Analysis

Output files for other post-processing as necessary:

Exceedance reports

Cross-tab reports

Groundwater contours

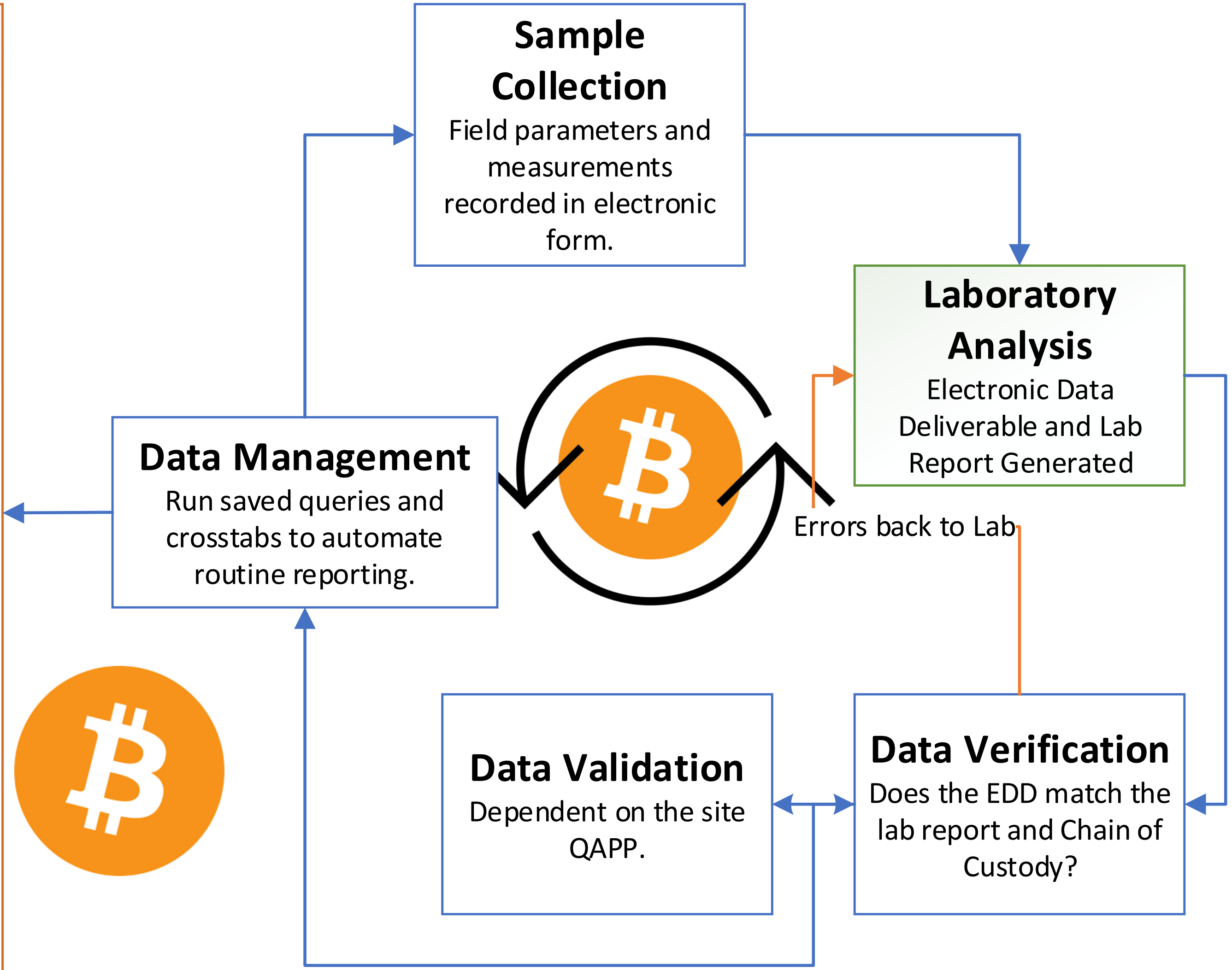
Hydrographs

Wellhead measurements

Landfill Gas Flow rates

Conceptual Site Model

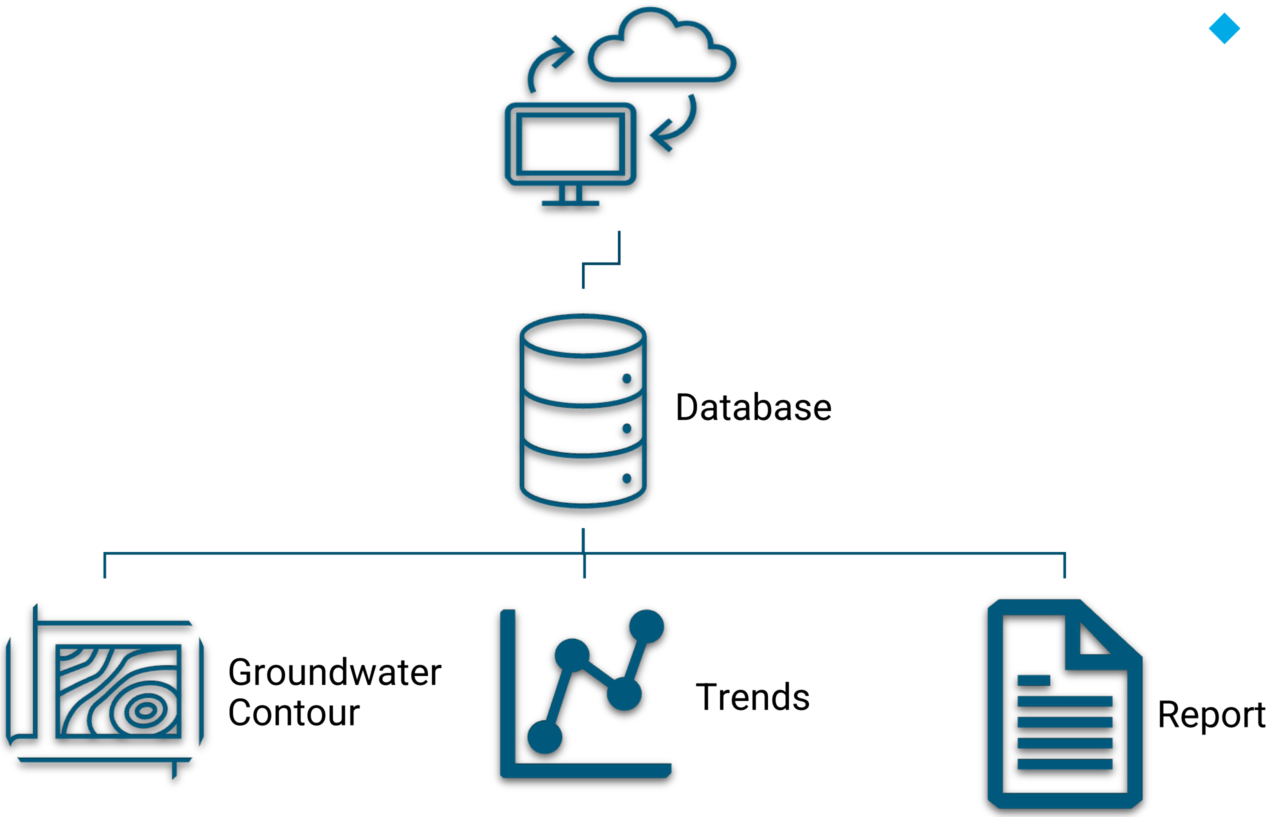
Contaminant Plume



Foth

Case Studies

Automating Data Reporting



- Creating saved query and cross tab structures you can easily run reports with a click of a button.
  - Run Water Level Elevations
  - Run a table with only field parameters
  - Create an exceedance report against the intervention limit or other action level.

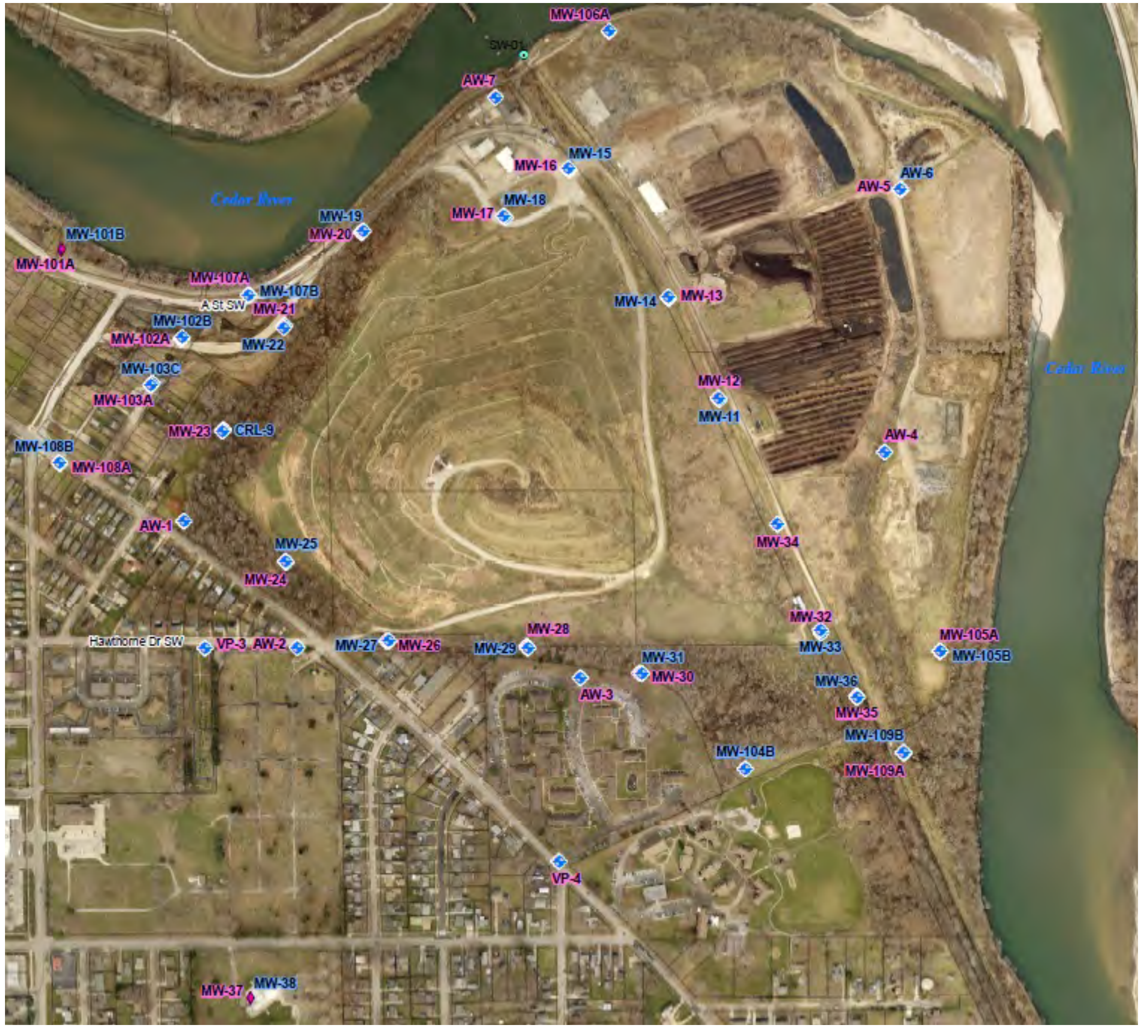
Foth

GW Monitoring Network Optimization: Sufficiency vs Redundancy

- Sufficiency and Redundancy evaluations can include:
  - Statistical evaluation (e.g., detect count),
  - Temporal evaluation (e.g., detections with time), and
  - Spatial evaluation (e.g., detections in space).

Case Study - Redundancy

GW Monitoring Network Review - Redundancy



1. Statistics Screening
2. Temporal
3. Spatial

Foth

Initial Statistics Screening

- Any low hanging fruit?
- e.g., no exceedances and <10% detection?

Analyte	MW-3-89		MW-4A-89		MW-5-89		MW-6-89		MW-103A-12	
	Frequency	% Detects	Frequency	% Detects	Frequency	% Detects	Frequency	% Detects	Frequency	% Detects
Appendix I Metals										
Arsenic	Annual	56%	Annual	100%	Annual	100%	Annual	56%	Annual	89%
Barium	Annual	100%	Annual	100%	Annual	100%	Annual	100%	Annual	100%
Beryllium	Annual	19%	Annual	15%	Annual	7%	Annual	7%	Annual	11%
Chromium	Biennial	19%	Biennial	19%	Biennial	4%	Biennial	7%	Annual	17%
Cobalt	Annual	67%	Annual	70%	Annual	67%	Annual	70%	Biennial	100%
Copper	Biennial	41%	Biennial	26%	Biennial	19%	Biennial	26%	Annual	50%
Lead	Biennial	26%	Annual	26%	Biennial	33%	Biennial	7%	Annual	33%
Nickel	Annual	74%	Annual	67%	Annual	67%	Biennial	67%	Biennial	100%
Selenium	Biennial	7%	Biennial	26%	Biennial	7%	Annual	11%	Biennial	11%
Vanadium	Annual	46%	Biennial	44%	Biennial	11%	Annual	56%	Annual	56%
Zinc	Biennial	41%	Biennial	22%	Biennial	22%	Biennial	26%	Annual	28%
Appendix I VOCs										
1,1-Dichloroethane	Annual	22%	Biennial	15%	No Detects	0%	Annual	37%	No Detects	0%
1,2-Dichloropropane	Annual	4%	No Detects	0%	No Detects	0%	Biennial	30%	No Detects	0%
1,4-Dichlorobenzene	Annual	7%	Biennial	22%	No Detects	0%	Annual	11%	No Detects	0%
2-Butanone	Annual	4%	Biennial	7%	Annual	7%	No Detects	0%	Annual	11%
Acetone	Biennial	4%	Annual	19%	Biennial	4%	Biennial	11%	Annual	11%
Benzene	Biennial	7%	Annual	30%	No Detects	0%	Annual	26%	Annual	44%
Chlorobenzene	Annual	15%	Annual	19%	No Detects	0%	Annual	33%	No Detects	0%
Chloroethane	Biennial	7%	Annual	15%	Annual	4%	Annual	15%	No Detects	0%
cis-1,2-Dichloroethene	Biennial	33%	Biennial	7%	No Detects	0%	Annual	37%	Annual	39%

Temporal Evaluation

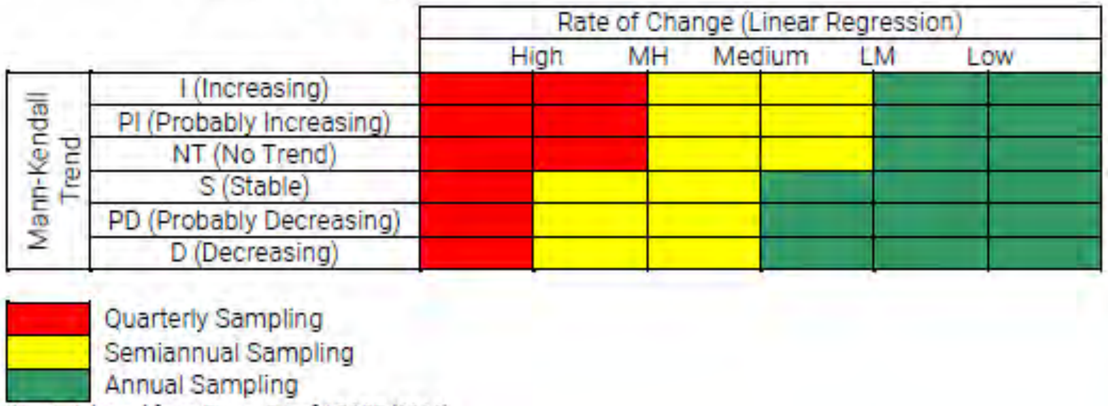
- Is a change in sample frequency supported by the Rate of Change of detections (i.e., the slope of fitted linear regression line)?

Table 2
Modified CES Mann-Kendall Decision Criteria

Mann-Kendall Statistic	p-Level (probability of no trend)	Coefficient of Variation	Trend Conclusion
S > 0	< 0.05	Not Restricted	I (Increasing)
S > 0	0.05 – 0.10	Not Restricted	PI (Probably Increasing)
S > 0	> 0.10	Not Restricted	NT (No Trend)
S ≤ 0	> 0.10	≥ 1	NT (No Trend)
S ≤ 0	> 0.10	< 1	S (Stable)
S < 0	0.05 – 0.10	Not Restricted	PD (Probably Decreasing)
S < 0	< 0.05	Not Restricted	D (Decreasing)

Note: Adapted from Table 2.1 of AFCEE (2012).

Table 3
Summary of Optimal Sampling Frequency Flowchart



Note: Adapted from Figure 5.1 of AFCEE (2012)

Foth

GW Monitoring Network Review: Sufficiency vs Redundancy

- The following equation can be used for spatial evaluation of sufficiency and redundancy.

$$RPD = \frac{\left| Observed\ Concentration_i - Interpolated\ Concentration_i \right|}{Maximum\left[\left(Observed\ Concentration_i + Interpolated\ Concentration_i\right)/2,\ MCL\right]} \times 100\%$$

- **Insufficient** locations give a high Relative Percent Difference (RPD).
- **Redundant** locations give a low Relative Percent Difference (RPD).

Spatial Evaluation

- What is the potential change in interpretation resulting from removing a well?
- Percent change between the known vs. interpolated concentration
- Percent change in area of the plume exceeding the GWPS
- Percent change in volume of the plume exceeding the GWPS
- If percent change less than 15%, then it is acceptable to remove well.

Wells Considered for Spatial Optimization and Optimization Results

Aquifer	Well	Arsenic	Cobalt	Thallium
Upper Bedrock	MW-102A	X	X	X
Upper Bedrock	MW-103A	X	X	X
Upper Bedrock	MW-105A	X		X
Upper Bedrock	MW-106A			X
Upper Bedrock	MW-107A	X		
Upper Bedrock	MW-108A	X	X	X
Upper Bedrock	MW-109A			
Deeper Bedrock	MW-102B	X	X	
Deeper Bedrock	MW-103C	X	X	X
Deeper Bedrock	MW-104B			
Deeper Bedrock	MW-105B			
Deeper Bedrock	MW-107B			
Deeper Bedrock	MW-108B			X
Deeper Bedrock	MW-109B			
Deeper Bedrock	MW-11			
Deeper Bedrock	MW-15		X	X
Deeper Bedrock	MW-18			X
Deeper Bedrock	MW-19	X	X	
Deeper Bedrock	MW-25		X	X
Deeper Bedrock	MW-27	X	X	X
Deeper Bedrock	MW-29	X	X	X
Deeper Bedrock	MW-31		X	X

X = Well contributes only a lesser amount of information in delineating groundwater concentrations.

Summary Output

- Summarize existing monitoring vs proposed monitoring for;
- number of parameters per well (stats)
- frequency of monitoring per well (temporal)
- omit or abandon monitoring per well (spatial)

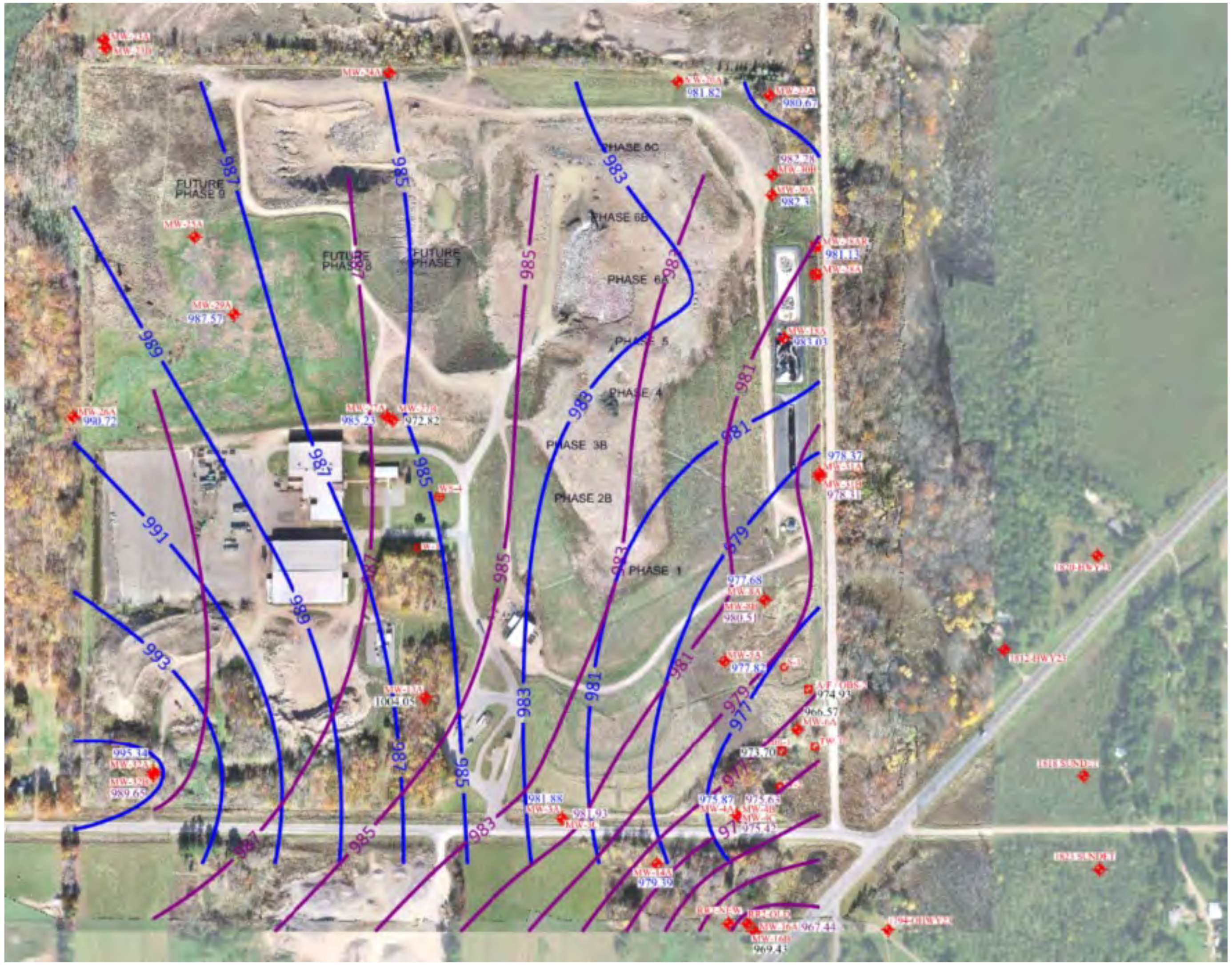
Table 4
Groundwater Monitoring Program Recommendations

Monitoring Well	Current Monitoring Program	Current Schedule [1]	Recommended Optimized Schedule [1]
MW-1-89	Assessment	Semiannual Appendix II	Annual Appendix II
MW-3-89	Detection	Semiannual Appendix I	Annual Appendix I
MW-4A-89	Detection	Semiannual Appendix I	Annual Appendix I
MW-4B-89	Assessment	Semiannual Appendix II	Annual Appendix II
MW-5-89	Detection	Semiannual Appendix I	Annual Appendix I
MW-6-89	Detection	Semiannual Appendix I	Annual Appendix I
MW-11	Delineation	Semiannual Appendix I VOCs, Arsenic, Cobalt	Annual Appendix I VOCs, Arsenic, Cobalt
MW-101B	Delineation	Semiannual Appendix I VOCs	Annual Appendix I VOCs
MW-102A-12	Assessment	Semiannual Appendix II	Annual Appendix II [2]
MW-103A-12	Detection	Semiannual Appendix I	Annual Appendix I
MW-104A-12	Assessment	Semiannual Appendix II	Annual Appendix II
MW-107A	Delineation	Semiannual Appendix I VOCs, Arsenic, Cobalt	Annual Appendix I VOCs, Arsenic, Cobalt
MW-108A	Delineation	Semiannual Appendix I VOCs, Arsenic, Cobalt	Annual Appendix I VOCs, Arsenic, Cobalt

[1] Appendix II wells are monitored for the Appendix I and detected Appendix II analytes. In accordance with Permit Special Provision X.5.h, Appendix II wells are resampled for the full Appendix II list every five years.
[2] Professional judgment was utilized to recommend an annual optimized frequency for MW-102A-12. If future sampling events indicate elevated bis(2-ethylhexyl)phthalate concentrations, semiannual monitoring will be resumed at MW-102A-12

Case Study –
Initial Statistics Screening

Groundwater Monitoring Network in Minnesota



- Any low hanging fruit? e.g., no exceedances and <10% detection?

Foth

Legend for the Next Slides

LEGEND
66% - 100%
11% - 65%
0% - 10%

Looking at the detection frequency at our entire database

Parameter	Analytical Method	Analyte Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
			% Detected	% Detected	% Detected	% Detected	% Detected	% Detected	% Detected	% Detected	% Detected	% Detected	% Detected
Barium	EPA 200.7/6010/6010B/6010D	Metal		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Calcium	EPA 200.7/6010/6010B/6010D	Metal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Magnesium	EPA 200.7/6010/6010B/6010D	Metal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Potassium	EPA 200.7/6010/6010B/6010D	Metal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sodium	EPA 200.7/6010/6010B/6010D	Metal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sulfate	EPA 300/ASTM D516-90,02	Metal	100%	97%	94%	94%	100%	90%	100%	97%	94%	94%	94%
Nickel	EPA 200.7/200.8/6010/6020/6020B	Metal				0%	83%	50%	67%	75%	71%	86%	86%
Manganese	EPA 200.7/6010/6010B/6010D	Metal	84%	83%	74%	81%	75%	68%	67%	82%	83%	86%	77%
Iron	EPA 200.7/6010/6010B/6010D	Metal	56%	10%	26%	22%	81%	74%	80%	91%	81%	83%	74%
Copper	EPA 200.7/200.8/6010/6020/6020B	Metal	28%	80%	26%	6%	59%	39%	60%	32%	50%	46%	49%
Phosphorus	EPA 365.1	Metal				33%	83%	33%	50%	38%	29%	29%	43%
Arsenic	EPA 200.8/6010/6020/2340B	Metal	31%	23%	26%	22%	53%	68%	57%	47%	61%	49%	34%
Mercury	EPA 245.1/245.7/7470	Metal	0%	0%	0%	0%	17%	5%	0%	32%	4%	8%	8%
Zinc	EPA 200.7/200.8/6010/6020/6020B	Metal	22%	20%	38%	20%	93%	14%	4%	9%	3%	3%	3%
Boron	EPA 200.7/6010/6010B/6010D	Metal	6%	3%	0%	0%	0%	0%	0%	0%	7%	0%	0%
Cadmium	EPA 200.8/6010/6020/6020B	Metal	13%	3%	0%	0%	9%	5%	0%	0%	8%	0%	0%
Chromium	EPA 200.7/6010/6010B/6010D	Metal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cobalt	EPA 200.7/6010/6010B/6010D	Metal	6%	7%	33%	0%	0%	0%	0%	0%	0%	0%	0%
Lead	EPA 200.8/6020/6020B	Metal	3%	0%	4%	4%	9%	0%	0%	0%	0%	0%	0%
Selenium	EPA 200.8/6010/6020/6020B	Metal				0%	17%	0%	0%	0%	0%	0%	0%
Silver	EPA 200.8/6010/6010B/6010D	Metal				0%	0%	0%	0%	0%	0%	0%	0%
Hexachlorobutadiene	EPA 8260/8260B	SVOC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Naphthalene	EPA 8260/8260B	SVOC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ethyl Ether	EPA 8260/8260B	VOC	4%	2%	2%	0%	17%	28%	37%	23%	26%	24%	17%
Vinyl Chloride	EPA 8260/8260B	VOC	0%	0%	0%	0%	2%	18%	15%	11%	8%	9%	6%
Toluene	EPA 8260/8260B	VOC	0%	0%	2%	0%	14%	7%	0%	19%	8%	2%	5%
4-Methyl-2-pentanone	EPA 8260/8260B	VOC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%
cis-1,2-Dichloroethene	EPA 8260/8260B	VOC	11%	2%	4%	0%	2%	4%	4%	2%	2%	0%	2%
Trichloroethene	EPA 8260/8260B	VOC	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	2%
1,1,1,2-Tetrachloroethane	EPA 8260/8260B	VOC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1,1,1-Trichloroethane	EPA 8260/8260B	VOC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Exceedance Report: Frequency Count

	22Q2		22Q3		22Q4	
	IL	HRL	IL	HRL	IL	HRL
Arsenic					5	5
Manganese	2	2	2	2	20	20
Nitrogen, NO3 + NO2	1	1	1	1	4	4
Perfluorobutanesulfonic acid					2	2
Perfluorohexanoic acid (PFHxA)					2	2
Trichloroethene					1	1
Vinyl Chloride	1	1	1	1	2	2

IL is the Invervention limit and HRL is the Health Risk Limit.

Evaluating VOCs by Method

Year	Detection Frequency
2012	0.2635%
2013	0.0845%
2014	0.1126%
2015	0.0000%
2016	0.5578%
2017	1.3311%
2018	0.8442%
2019	1.4706%
2020	0.8197%
2021	0.6239%
2022	0.4751%

- VOCs analyzed by EPA 8260
- Evaluating the entire dataset in our database there is no year with detection frequencies greater than 10%.

Evaluating Metals by Method

	Detection Frequency			
	ASTM D516	EPA 245.7	EPA 6010/6010D	EPA 6020B
2018	100%	0%	66%	34%
2019	97%	32%	70%	26%
2020	94%	4%	68%	35%
2021	94%	8%	68%	30%
2022	94%	8%	66%	27%

- Method 245.7 is for Mercury

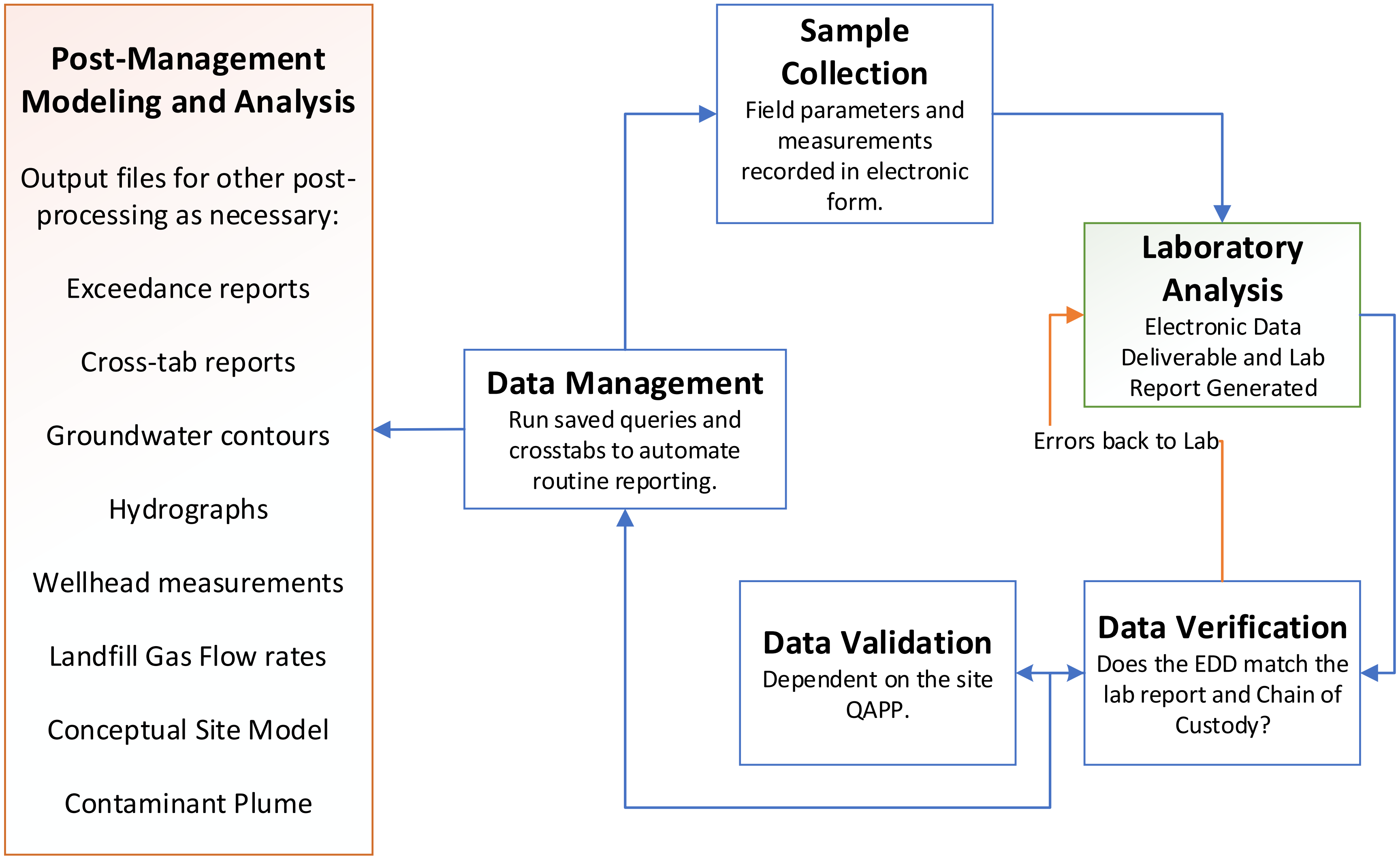
Foth

Retained for further Spatial and Temporal

Analyte or Group	Current Frequency	Location (s)
VOC (run for VC and TCE)	annual Q4	MW-13A, MW-14A, MW-16A, MW-16B, MW-18A
VOC (run for VC and TCE)	annual Q2	MW-25A
VOC (run for VC and TCE)	semi-annual	MW-20A, MW-22A, MW-28AR, MW-3A, MW-3C, MW-8A, MW-8B
VOC (run for VC and TCE)	quarterly	MW-27A, MW-29A, MW-30A, MW-30B, MW-31A, MW-31B, MW-32A, MW-32B, MW-4C, MW-5A
Metals: Mercury Method 245.7	annual	MW-13A, MW-14A, MW-16A, MW-16B, MW-18A, MW-20A, MW-22A, MW-28AR, MW-30A, MW-30B, MW-31A, MW-31B, MW-32A, MW-32B, MW-3A, MW-3C, MW-4A, MW-4B, MW-4C, MW-5A, MW-6A, MW-8B, OBS-1, OBS-2
Metals	Annual	MW-25A

Now what?

Data management is a circular process.



Mining our database can save costs.

Post-Management Modeling and Analysis

Output files for other post-processing as necessary:

Exceedance reports

Cross-tab reports

Groundwater contours

Hydrographs

Wellhead measurements

Landfill Gas Flow rates

Conceptual Site Model

Contaminant Plume

- Communicating the data and site clearly to all regulatory staff and owners is essential for monitoring the impacts to environmental and human health.
  - Evaluate the redundancy and sufficiency of the groundwater monitoring network on your site
  - Describe the site Conceptual Site Model
  - Perform Plume Stability Calculations
  - Create Macros or code to format your database outputs specific to how you want it.

Questions & Answers

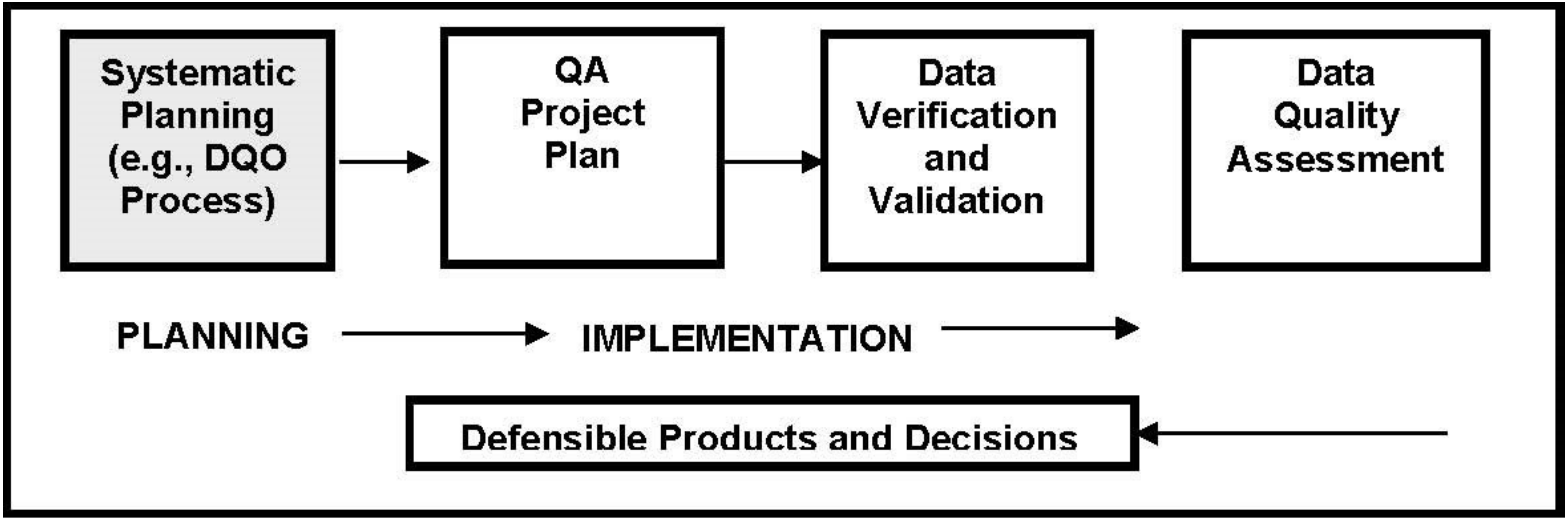
Q&A

foth.com

References

- United States Environmental Protection Agency (USEPA), 2005. *Road Map to Long Term Monitoring Optimization*. EPA 542-R-05-003, EPA/National Service Center for Environmental Publications, Cincinnati, OH. https://clu-in.org/download/char/542-r-05-003.pdf
- USEPA, 2012. *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. OSWER Directive 9200.3-75. Office of Solid Waste and Emergency Response and Office of Superfund Remediation and Technology Innovation, Washington, D.C. https://clu-in.org/download/REMED/hyopt/Final-National-Strategy.pdf
- USEPA clu-in website: https://clu-in.org/Optimization/index.cfm
- Interstate Technology & Regulatory Council (ITRC), 2016. "Geospatial Analysis for Optimization at Environmental Sites." Interstate Technology & Regulatory Council. https://gro-1.itrcweb.org/.

Data Verification & Validation


Systematic Planning (e.g., DQO Process)
QA Project Plan
Data Verification and Validation
Data Quality Assessment
PLANNING
IMPLEMENTATION
Defensible Products and Decisions

Data Verification

Completeness check to confirm that the specified analytical requirements have been met.

Foth Infrastructure & Environment, LLC

Data Verification Checklist

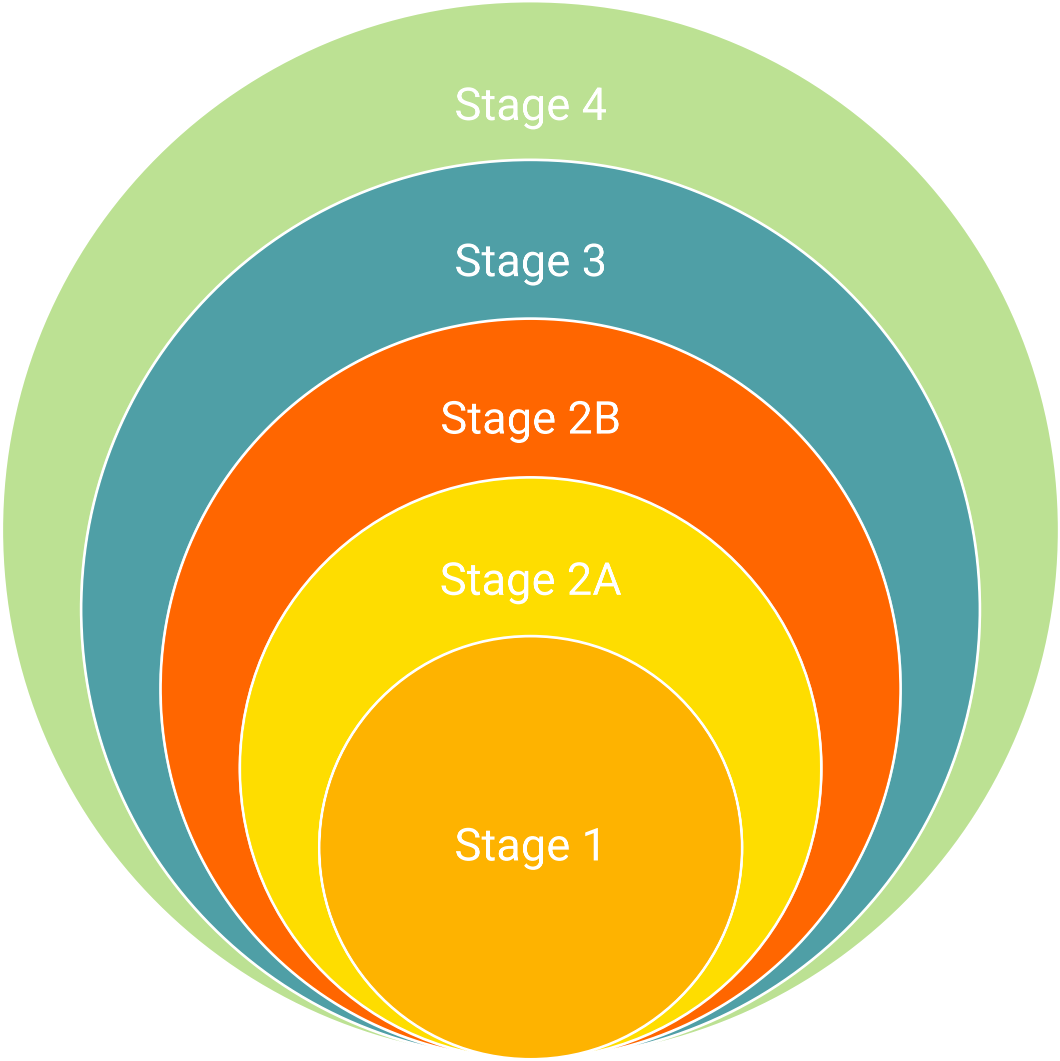
Data Verification Criteria	Yes	No	Not Applicable
CHAIN OF CUSTODY (COC)			
1. Are relinquish and receipt signatures present on the COC?	☐	☐	☐
2. Do the analyte and analytical methods requested on the COC agree with the project requirements (e.g., QAPP, SAP)?	☐	☐	☐
SAMPLE PRESERVATION & HOLDING TIMES			
3. Samples received by the project laboratory, intact, with correct preservation, and at the correct temperature (less than or equal to [≤] 6 degrees Celsius [°C] but not frozen)? Comments:	☐	☐	☐
4. Samples extracted and analyzed within the holding time limits set by the respective analytical method(s)? Comments:	☐	☐	☐
ANALYTICAL METHOD REQUIREMENTS			
5. Method blanks analyzed at the required frequencies?	☐	☐	☐
6. Target compounds detected in the method blanks? Compounds detected:	☐	☐	☐
7. Method duplicate samples performed at the required frequency? Comments:	☐	☐	☐
8. Were LCS/LCSD analyses performed at the required frequency? Comments:	☐	☐	☐
9. Are the percent recoveries and RPDs for the LCS/LCSD within acceptance limits? Comments:	☐	☐	☐
10. Were MS/MSD analyses performed at the required frequency?	☐	☐	☐
11. Are percent recoveries and RPDs for the MS/MSD within acceptable limits? Comments:	☐	☐	☐
QUALITY ASSURANCE REQUIREMENTS			
12. Were the appropriate number of trip blanks collected? Comments:	☐	☐	☐
13. Were the appropriate number of field blanks collected? Comments:	☐	☐	☐
14. Were the appropriate number of duplicates collected? Comments:	☐	☐	☐
15. Were the appropriate number of equipment blanks collected? Comments:	☐	☐	☐
16. Were the appropriate number of mercury field blanks collected? Comments:	☐	☐	☐
QUALITY CONTROL REQUIREMENTS			
17. Is the charge balance error less than 10% or 1 milliequivalents per liter (meq/L), whichever is greater? Comments:	☐	☐	☐

Foth

Data Validation

Confirmation that the particular requirements for a specific intended use are fulfilled.

Data validation consists of analyte and sample specific process for evaluating compliance of the laboratory data received with methods, procedures, or contract requirements.



Eliminated through this Screening

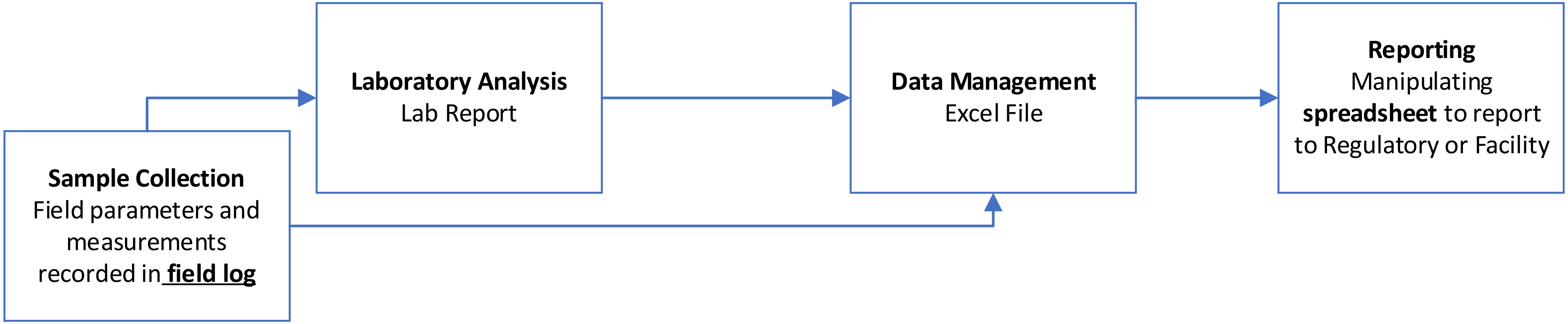
Location	Parameter	Sampling Frequency	Reason for retaining at current schedule
MW-8A	Mercury	Annual	Detected Annually
MW-26A	VOC	quaterly	Detected 22Q3
MW-27B	VOC	annual Q4	Detected 22Q4
MW-29A	VOC	quaterly	Detected 22Q3
MW-4B	VOC	quaterly	Detected 21Q4, 21Q3, 21Q2, … and more
MW-4C	VOC	quaterly	Detected 22Q4, 22Q3, 22Q2, … and more
MW-6A	VOC	quaterly	Detected 22Q4
OBS-2	VOC	quarterly	Detected 22Q4, 22Q3, 22Q2, … and more
OBS-1	VOC	annual, Q4	Detected 22Q4, 21Q4
All	Barium		Detected 100% in 2022
All	Calcium		Detected 100% in 2022
All	Magnesium		Detected 100% in 2022
All	Potassium		Detected 100% in 2022
All	Sodium		Detected 100% in 2022
All	Sulfate		Detected 94% in 2022
All	Nickel		Detected 85% in 2022
All	Manganese		Detected 77% in 2022
All	Iron		Detected 74% in 2022
All	Copper		Detected 48% in 2022
All	Phosphorus		Detected 42% in 2022
All	Arsenic		Detected 34% in 2022
Spray Field WMS (MW-26A, MW-27A, MW-29A, MW-25A)	PFAS	annual, Q4	Retained at current frequency due to Spray Field requirements
Spray Field WMS (MW-26A, MW-27A, MW-29A)	Metals	quarterly	Retained at current frequency due to Spray Field requirements

Support Slides

Compliance Hiccups with Historic Method

- Delay in reporting to agencies
- Lack of ease to transform data and model
- Issues with verification or validation of data
- Calculations
- Modeling long term data

Historic Method of Monitoring and Reporting



Efficient and clear reporting is essential to communicate to Regulatory Officials and Facility.

Foth

It Begins in the Field

Field Data Collection

Planning

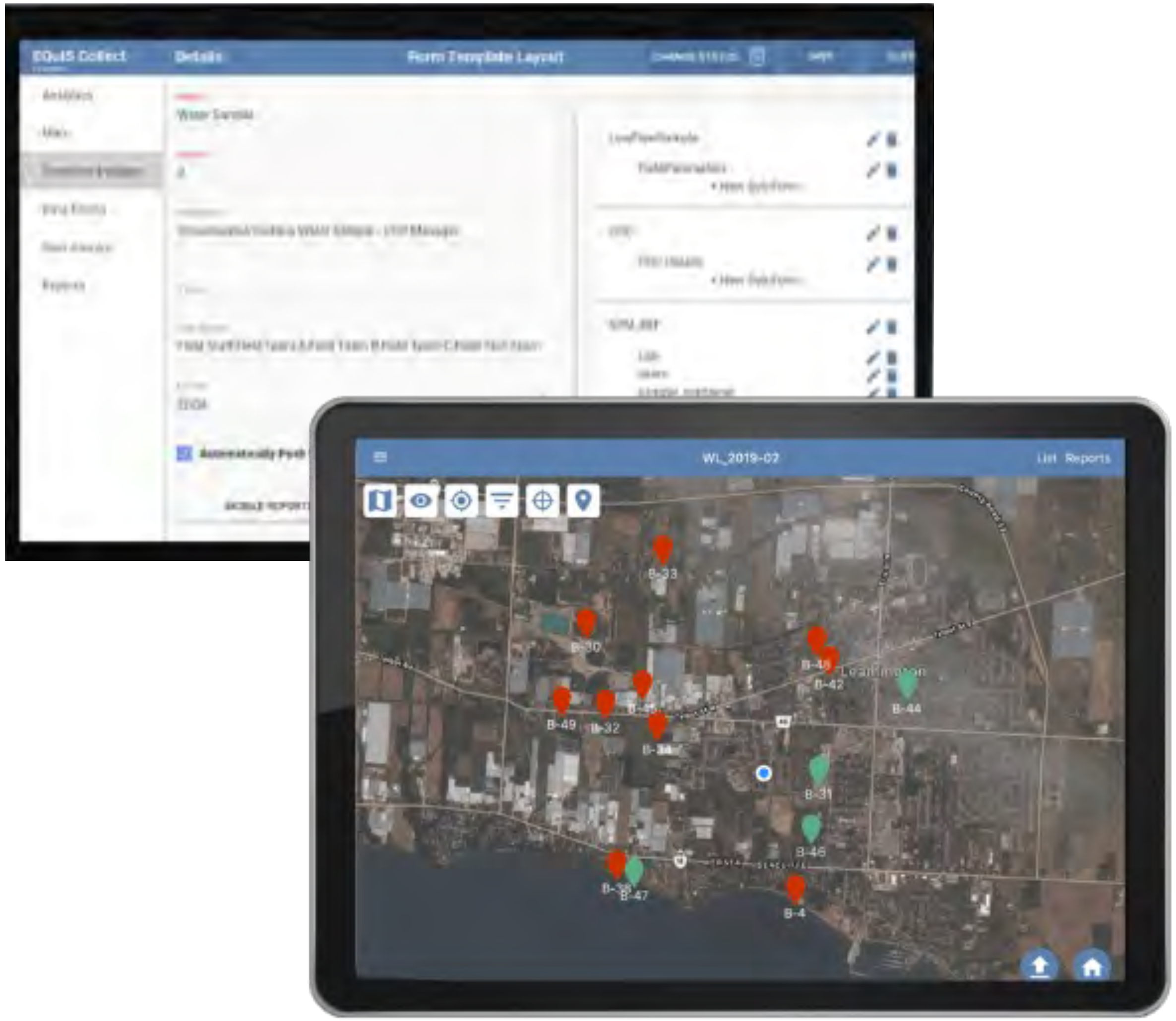
- Generate forms for mobile devices
- Match forms to COC and permit or operational requirements

Deployment

- Use tools to track which locations have monitoring completed
- Enter information into forms

Database Merge

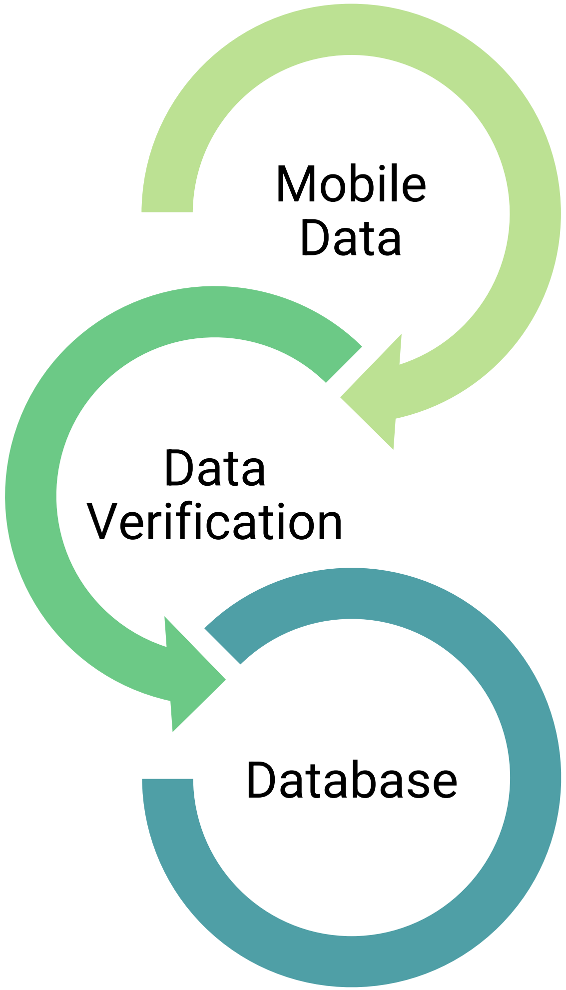
- Seamlessly upload EDD into database.



Source: https://earthsoft.com/products-equis-data-acquisition-equis-collect/

Foth

Benefits of using a Collect System



- Team can track progress virtually.
- Seamless upload into database provides team ease of communication between the Project Manager and Field Team.
- Forms can be changed for site specific needs:
  - Soil Sampling
  - Landfill Monitoring (gas and groundwater systems)
- Reduces time to upload information
- Improves accuracy

Gas Compliance Monitoring

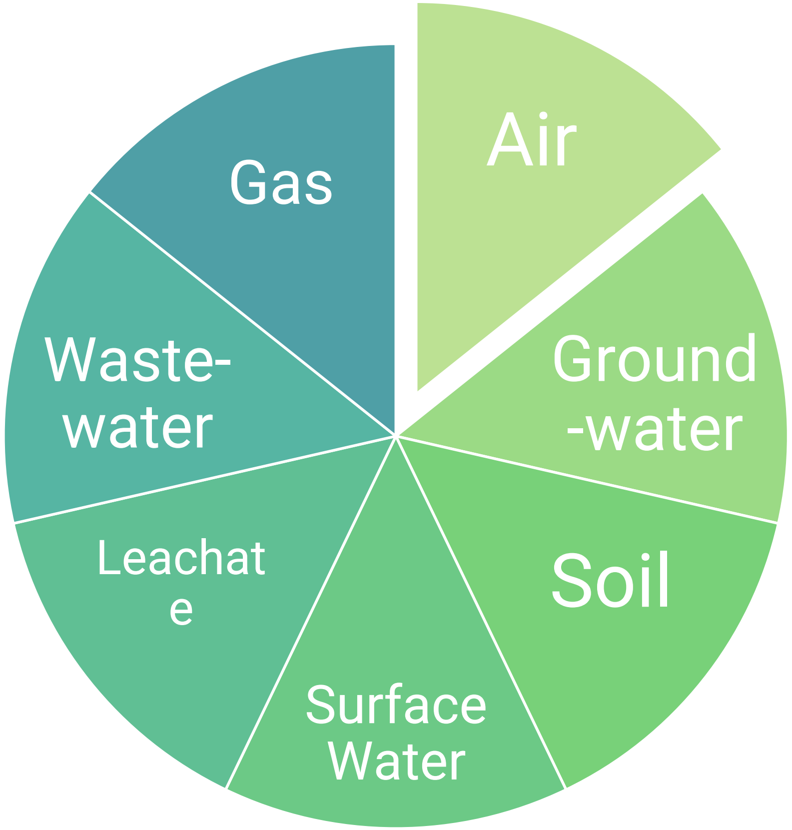
Well ID	Sample Date	Methane, % of Dissolved (percent)	Oxygen, % of Dissolved (percent)	Temperature (deg f)	Well Pressure (inches H2O)	Well Pressure (Header) (inches H2O)
Landfill Gas Data and Exceedance Report - Last 3 Months						
Title V Exceedance Parameters (RED): O_2>=5%, Temp>=131F, Static Press.>=0"H_2O						
PSW-21						
PSW-21	1/19/2018	60.9	0.4	32	-1.3	-14.49
PSW-21	2/26/2018	61.3	0.8	**134**	-1.2	-12.22
PSW-21	3/22/2018	62.1	0.6	36	-1.3	-13.94
PSW-11						
PSW-11	1/19/2018	26.3	2.9	18	-0.9	-13.98
PSW-11	2/26/2018	25.3	3.2	52	**1**	-12.15
PSW-11	3/22/2018	26.3	3.5	12	-0.5	-13.48
PSW-5						
PSW-5	1/19/2018	64.7	0.6	58	-13.9	-14.21
PSW-5	2/26/2018	65.3	0.8	68	-12.7	-12.61
PSW-5	3/22/2018	65.8	0.5	56	-13.4	-14.07
PSW-4						
PSW-4	1/19/2018	58.4	0.4	44	-13.9	-14.12
PSW-4	2/26/2018	59.4	0.6	56	-12.1	-12.02
PSW-4	3/22/2018	60.2	0.3	44	-13.4	-13.62

Report Rules: O2>=5%, Temp>=131F, Static Press.>=0"H2O

Start with your Sampling and Analysis Plan

Use the Sampling Plan as a framework for your database.

What monitoring domains are within your permit?



Foth

Other Uses

"Evaluate the effect the facility is having on ground water and surface water quality"

Sample Location	Date Sampled	Parameter:	1,2-Dichloropropane	1,4-Dichlorobenzene	Arsenic	Benzene	Cadmium *	cis-1,2-Dichloroethene	Manganese*	Nitrogen, NO3 + NO2	Trichloroethene	Vinyl Chloride
		Units:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
		MDH Standard (HRL):	5	10	0.5	2	0.1	6	100	10000	0.4	0.2
		MPCA Standard (IL):	1.25	2.5	2.5	0.5	0.125	1.5	25	2500	0.1	0.05
		MPCA Standard (SWIL):	NA	NS		4487	NA	NA	4600	10000	6988	NA
PSW-14	4/1/2019	GWM	-	-	-	-	-	-	-	-	3.68	-
PSW-16	4/1/2019	GWM	2.10	-	-	1.93	-	30.39	-	-	1.60	0.98
PSW-20	4/1/2019	GWM	-	-	-	-	-	2.26	-	-	0.95	-
PSW-22	4/1/2019	GWM	-	8.53	-	-	-	6.47	-	-	0.84	0.26
PSW-23	4/1/2019	GWM	1.88	-	-	2.00	-	38.56	-	-	7.81	1.15
PSW-24	4/1/2019	SWM	-	-	-	-	0.19	-	287.0	-	-	-
PSW-25	4/1/2019	SWM	-	-	4.59	-	-	-	-	4620.0	-	-
PSW-5	4/1/2019	GWM	-	-	-	-	-	-	-	-	0.71	0.10
PSW-7	4/1/2019	SWM	-	-	-	-	-	-	-	-	-	0.16

“Tabulate the analytical results **to date** and **highlight** those that exceeded the ground water performance standards of Minn. R. 7035.2815 subpart 4 or surface water quality standards”

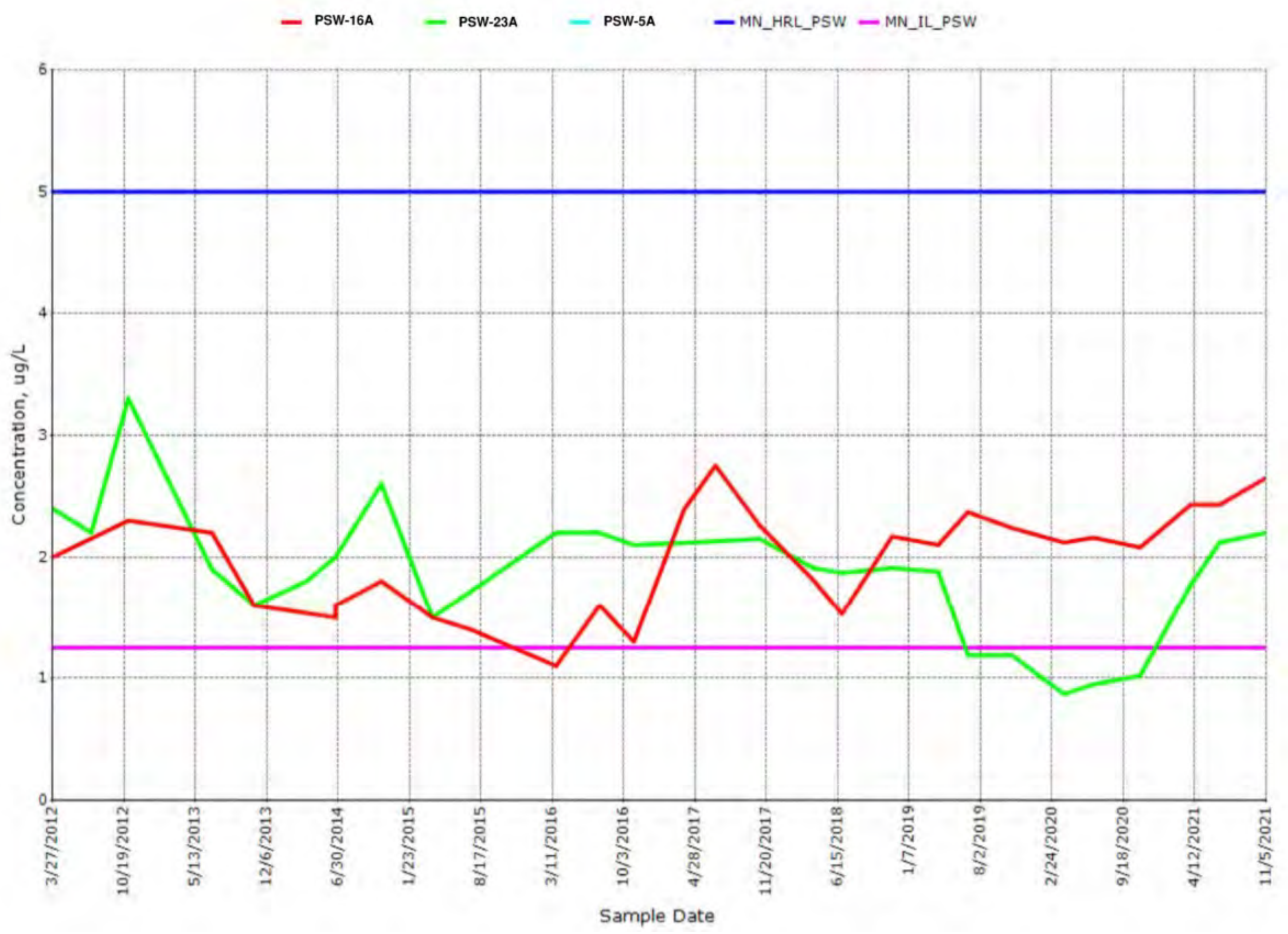
	A	B	C	D	E	F	G	H	I	J	K	L
2					SYS_LOC_CODE	PSW-1A	PSW-1A	PSW-1A	PSW-1A	PSW-1A	PSW-1A	PSW-1A
3					SAMPLEDATE	27 Mar 2017	26 Jun 2017	01 Nov 2017	05 Apr 2018	27 Jun 2018	19 Nov 2018	01 Apr 2019
4	METHOD_ANALYTE_GROUP	CHEMICAL_NAME	REPORT_RESULT_UNIT	MN_HRL	MN_IL	""	""	""	""	""	""	""
5	MN_PSW_Inorganics	Alkalinity as CaCO3	mg/L				519			463		
6	MN_PSW_Inorganics	Anion Summation	me/L				12.10			10.70		
7	MN_PSW_Inorganics	Cation Summation	me/L				12.95			11.49		
8	MN_PSW_Inorganics	Cation-Anion Balanc	percent				3.4			3.6		
9	MN_PSW_Inorganics	Chloride	mg/L				< 3.0			4.5		
10	MN_PSW_Inorganics	Nitrogen, Ammonia	mg/L				< 0.050			< 0.050		
11	MN_PSW_Inorganics	Nitrogen, NO3 + NO	ug/L	10000	2500		< 50.0			70.0		
12	MN_PSW_Inorganics	Sulfate	mg/L				78.6			63.0		
13	MN_PSW_Inorganics	Total Dissolved Solid	mg/L				642			553		
14	MN_PSW_Inorganics	Total Suspended Sol	mg/L				< 2.0			2		
15	MN_PSW_Metals	Arsenic	ug/L	10	2.5		0.59			< 0.50		
16	MN_PSW_Metals	Cadmium	ug/L	0.5	0.125		< 0.10			< 0.10		
17	MN_PSW_Metals	Calcium	mg/L				156.0			134.0		
18	MN_PSW_Metals	Chromium	ug/L	100	25		< 10.00			< 10.00		
19	MN_PSW_Metals	Copper	ug/L	1000	250		< 0.50			< 0.50		
20	MN_PSW_Metals	Iron	ug/L				2070			1410		
21	MN_PSW_Metals	Lead	ug/L	15	3.75		< 0.50			< 0.50		
22	MN_PSW_Metals	Magnesium	ug/L				51100			47300		
23	MN_PSW_Metals	Manganese	ug/L	100	**25**		**117.0**			**115.0**		
24	MN_PSW_Metals	Mercury	ug/L	2	0.5		< 0.0050			< 0.0050		
25	MN_PSW_Metals	Potassium	ug/L				3430			3240		
26	MN_PSW_Metals	Sodium	ug/L				17300			17200		
27	MN_PSW_Metals	Zinc	ug/L	2000	500		< 10.00			< 10.00		
28	MN_PSW_Organics	1,1-Dichloroethane	ug/L	100	25		0.59					
29	MN_PSW_Organics	Dichlorodifluoromet	ug/L	500	125	0.66	0.70					
30	MN_PSW_Organics	Dichlorofluorometha	ug/L			1.08	1.29				0.52	0.68
31	MN_PSW_Organics	Tetrachloroethene	ug/L	5	**1.25**	**3.28**	**3.90**	**1.60**	**1.73**	**2.25**	**1.68**	0.75
32	MN_PSW_Organics	Trichloroethene	ug/L	0.4	**0.1**	**2.65**	**3.46**	**0.94**	**1.04**	**1.41**	**2.20**	**3.68**
33	MN_PSW_Organics	Vinyl Chloride	ug/L	0.2	**0.05**	**0.050**						

Bolded values exceed the MPCA IL. Highlighted values exceed the MPCA IL and MDH HRL.

Foth

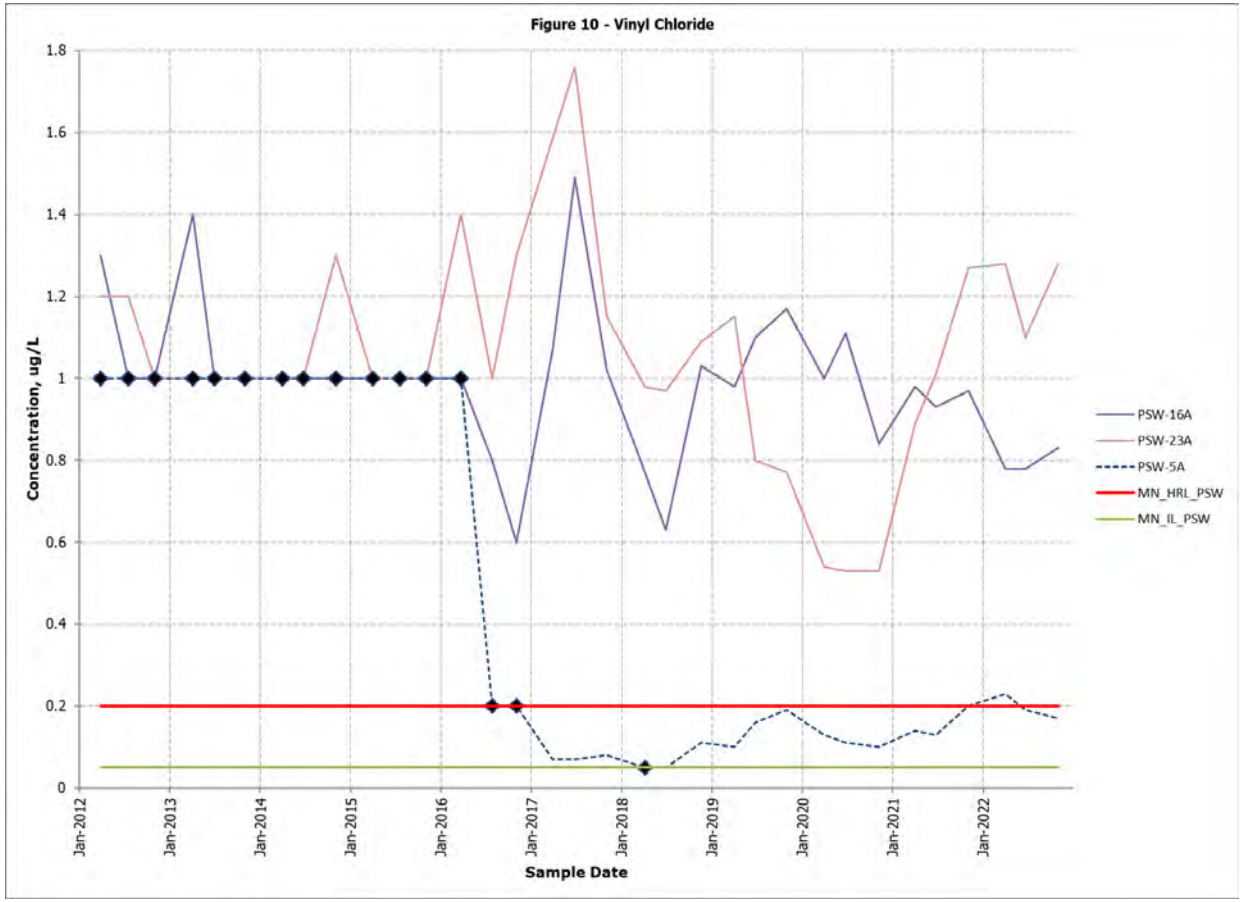
“Identify recent and long-term trends in the concentrations of monitored constituents and in water elevations”

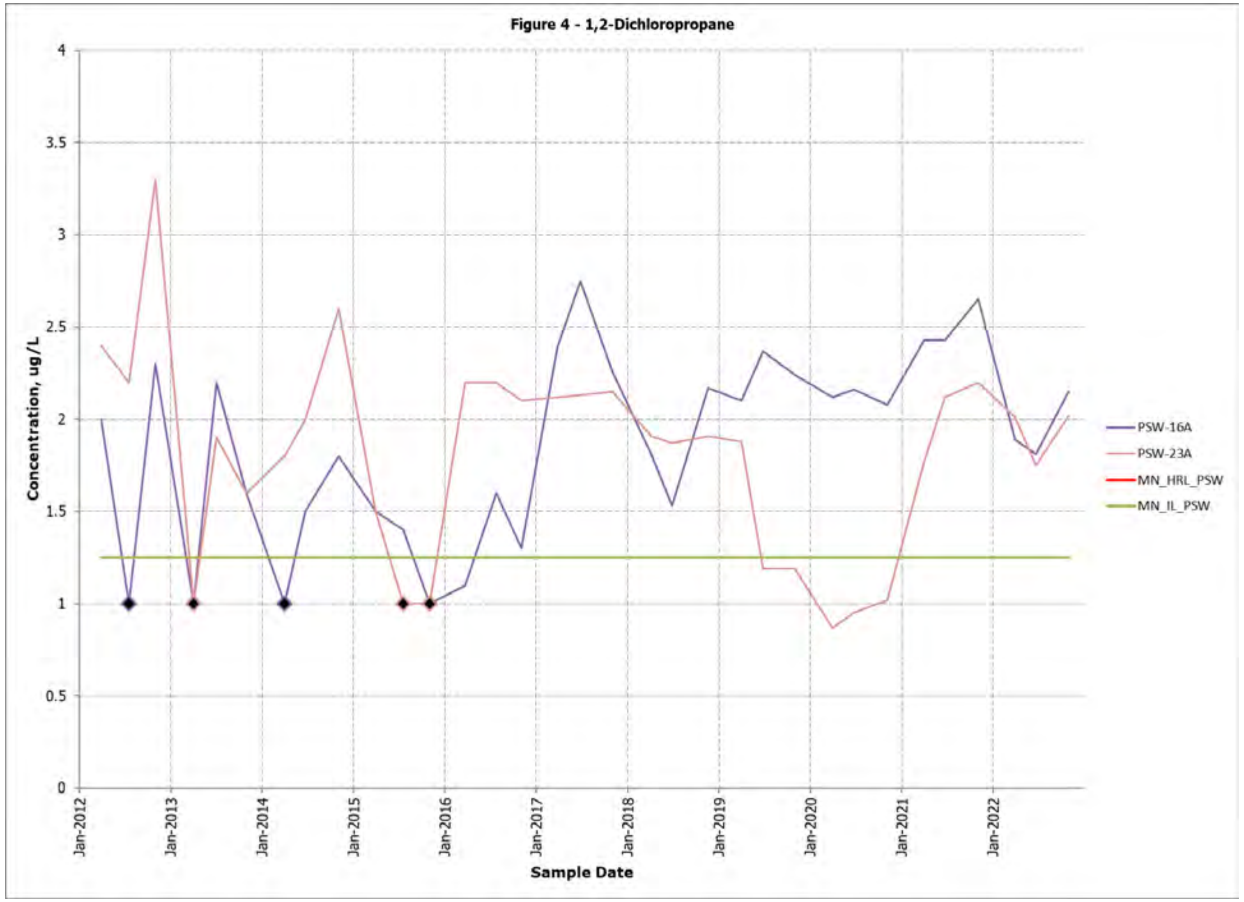
Figure 4: 1,2-Dichloropropane



Foth

Format Automation in Excel using Macro





Calculate Chemical Loading on Land Application Site

Table 9
Spray Application of Landfill Leachate
Chemical Loading Summary in 2022
May 2022 - October 2022

Year	Mean Treatment Ponds Concentration (µg/L)[1]												Applied Leachate (ft³)
	Arsenic	Boron	Cadmium	Copper	Lead	Mercury	Nickel	NH3*	PAN*	Selenium	SAR	Zinc	
2012	42.50	10078.33	0.65	19.64	2.24	0.01	93.30	32.78	113.94	12.33	12.04	50.17	212,847.6
2013	21.93	5657.17	0.34	14.90	1.85	0.01	50.91	61.65	48.32	5.08	8.55	43.00	294,264.7
2014	12.05	4830.00	0.29	22.45	0.91	0.01	53.30	30.40	37.73	3.94	6.99	35.50	157,018.7
2015	35.55	7115.00	0.68	4.48	0.50	0.01	78.40	69.25	116.23	1.40	11.68	22.00	119,358.3
2016	28.60	5360.00	0.11	7.71	1.06	0.01	59.45	82.25	122.10	1.26	8.42	36.50	60,962.6
2017	28.65	5360.00	0.12	4.68	0.50	0.01	61.50	72.50	86.05	3.97	9.65	20.50	150,160.4
2018	30.90	5005.00	0.16	3.78	0.58	0.01	50.25	115.50	88.23	2.03	9.16	22.50	59,037.4
2019	43.32	8538.33	0.10	2.06	0.50	0.01	75.58	219.50	129.79	2.35	13.10	38.67	65,454.5
2020	36.32	7430.00	0.10	2.45	0.61	0.01	73.25	143.53	111.60	0.86	11.71	33.50	48,770.1
2021	35.00	8945.00	0.10	4.05	0.84	0.01	94.82	117.55	132.44	2.09	13.30	20.67	306,075.0
2022	58.40	10256.67	0.31	11.67	2.85	0.01	109.65	91.04	217.94	3.23	14.74	62.67	263,101.6

Year	Annual Mass Loading (lb/acre)[2]											
	Arsenic	Boron	Cadmium	Copper	Lead	Mercury	Nickel	NH3	NA	Selenium	SAR	Zinc
1996-2011*	0.36	**5.14**	2.62E-03	2.43	0.13	4.06E-04	1.02	**61.01**	**99.73**	0.05	6.25	1.19
2012	0.08	**19.69**	1.3E-03	0.04	0.00	1.3E-05	0.18	**64.05**	**222.49**	0.02	**12.04**	0.10
2013	0.06	**15.28**	9.2E-04	0.04	0.00	2.7E-05	0.14	**166.55**	**130.43**	0.01	**8.55**	0.12
2014	0.02	**6.96**	4.1E-04	0.03	0.00	1.6E-05	0.08	43.82	54.35	0.01	6.99	0.05
2015	0.04	**7.80**	7.5E-04	0.00	0.00	5.5E-06	0.09	**75.88**	**127.27**	0.00	**11.68**	0.02
2016	0.02	3.00	6.2E-05	0.00	0.00	3.9E-06	0.03	46.03	**68.29**	0.00	8.42	0.02
2017	0.04	**7.39**	1.7E-04	0.01	0.00	6.9E-06	0.08	**99.95**	**118.54**	0.01	**9.65**	0.03
2018	0.02	2.71	8.4E-05	0.00	0.00	3.8E-06	0.03	**62.60**	47.79	0.00	**9.16**	0.01
2019	0.03	**5.13**	6.0E-05	0.00	0.00	3.0E-06	0.05	**131.90**	**77.94**	0.00	**13.10**	0.02
2020	0.02	3.33	4.5E-05	0.00	0.00	2.4E-06	0.03	**64.26**	49.93	0.00	**11.71**	0.01
2021	0.10	**25.13**	2.8E-04	0.01	0.00	2.8E-05	0.27	**330.31**	**308.06**	0.01	**13.30**	0.06
2022	0.14	**24.77**	7.5E-04	0.03	0.01	2.3E-05	0.26	**219.91**	**526.04**	0.01	**14.74**	0.15
Lifetime Sum	0.92	--	7.41E-03	2.60	0.15	5.39E-04	2.26	--	--	0.12	--	1.79
Lifetime Limit	37[a]	--	35[a]	1339[a]	268[a]	15[a]	375[a]	--	--	89[a]	--	2500[a]
Annual Limit	--	4[a]	--	--	--	--	--	50- 200[a]	75- 300[b]	--	8.5[a]	--

Notes:
-- = Not Applicable
µg/L = micrograms per liter
ft³ = cubic feet
lb/acre = pounds per acre
NA = Nitrogen Applied, as TKN and NO2+NO3 as N, according to MPCA guidance (August, 2012)
[1]The mean treatment pond concentrations are calculated from samples collected from the east and west ponds three times per year.
[2]The Annual Mass Loading was calculated according to the following equations and constants for metals and nutrients (MPCA, 2011).
For laboratory analytical concentrations less than the reporting limit, the reporting limit was used.
* = Nitrogen Species are reported in milligrams per liter (mg/L) and not micrograms per liter (ug/L).
[a] = The Maximum Cumulative Loading Limits were referenced from the MPCA Land Treatment of Landfill Leachate (April, 2011) publication.
[b] = The Maximum Annual Loading Limits were referenced from the MPCA Nitrogen Management at Land Application of Landfill Leachate Sites (August, 2012) publication.

NH3 = Ammonia as Nitrogen, according to MPCA guidance (April, 2011)
MPCA = Minnesota Pollution Control Agency
PAN = Potentially Available Nitrogen, TKN and NO2+NO3 as N, according to MPCA guidance (August, 2012)
SAR = Sodium Adsorption Ratio

Prepared by: ASL1
Checked by: BMS2

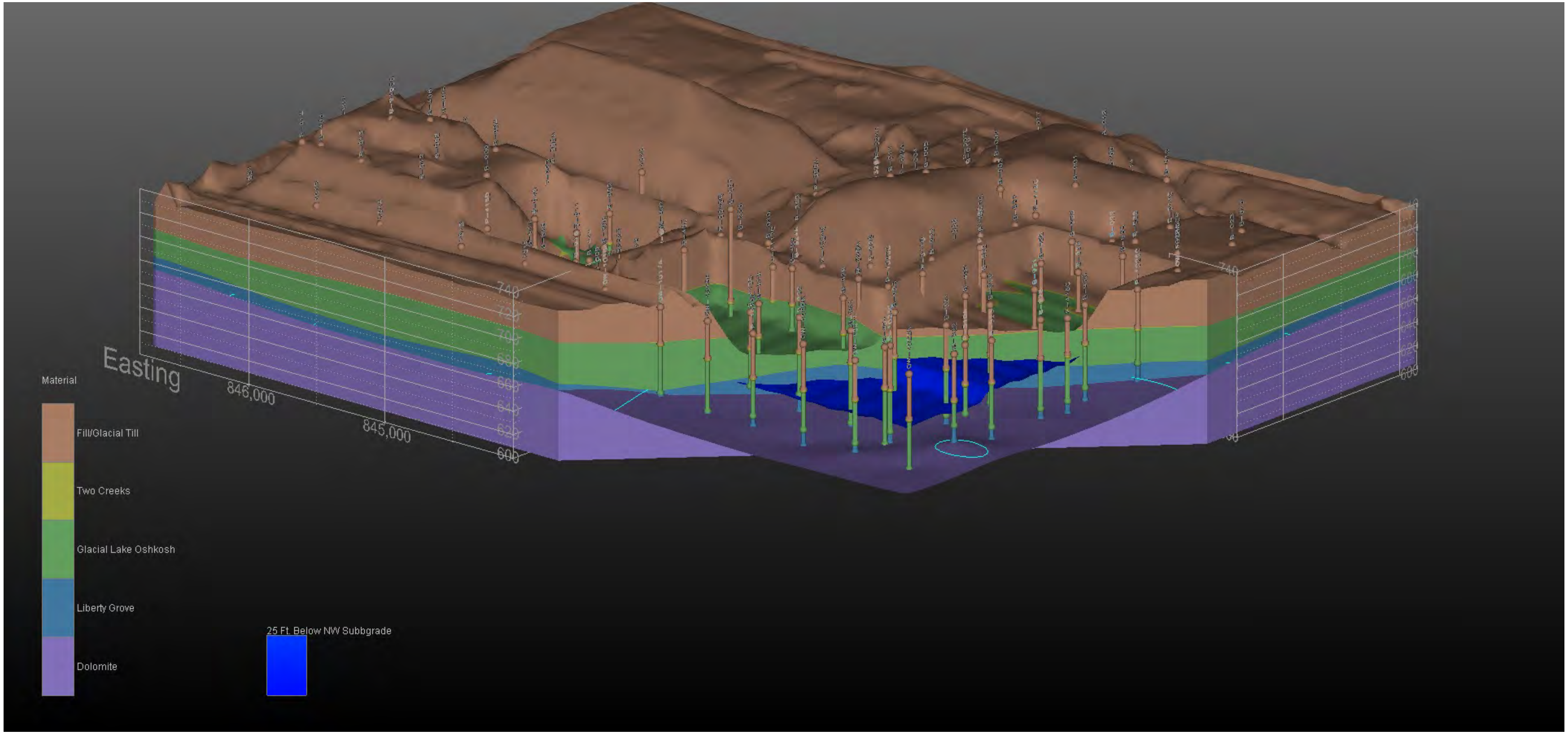
$$M\_load\ (lbs/acre) = \frac{C\_mean\ (ug/L) * V(ft^3) * (1lb/453{,}592{,}400\ ug) * (28.32\ L/1\ ft^3)}{A(acre)}$$

Applicable Conversions

1 pound =	4.5E+08	micrograms
Spray Area =	6.80	acres
1 cubic foot =	28.32	liters
One gallon of nitrogen =	8.34	pounds

Our database can easily transform the data to meet the needs of owners and operators.

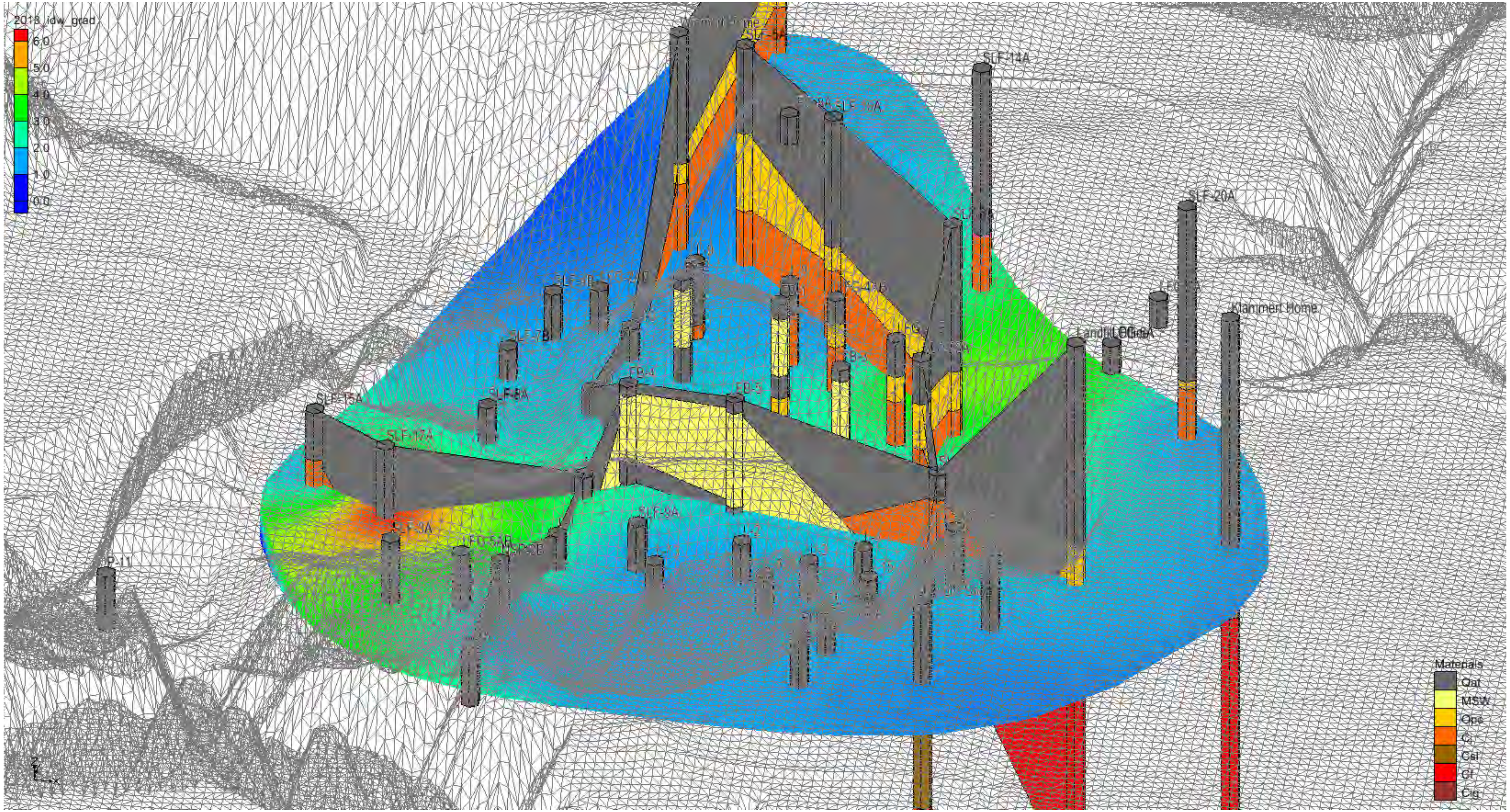
Conceptual Design Component: Liner and Groundwater Elevation



Spatial

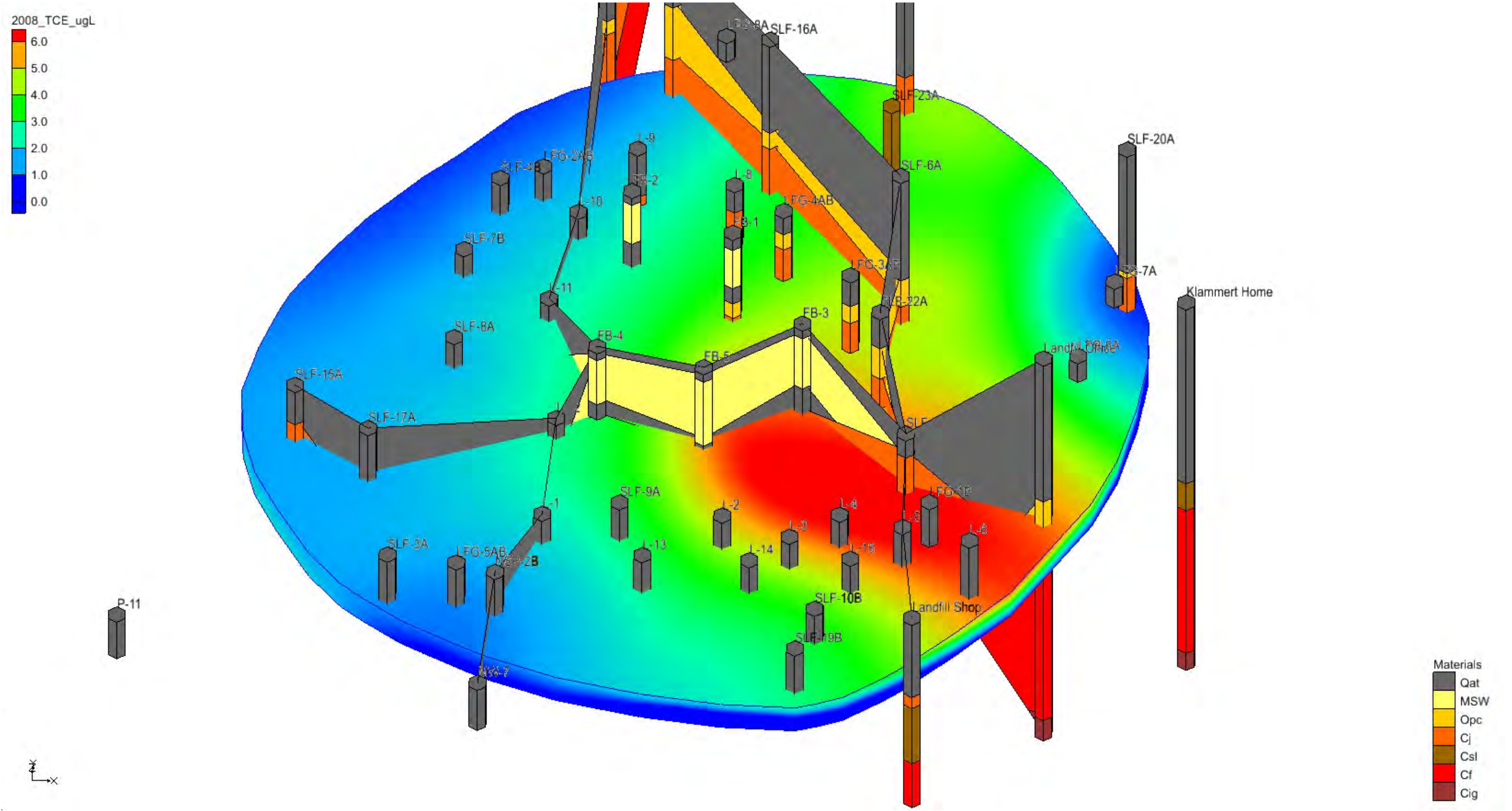
GW Monitoring Network Review- **SUFFICIENCY** (spatial)

GW Monitoring Network Review- **SUFFICIENCY** (spatial)



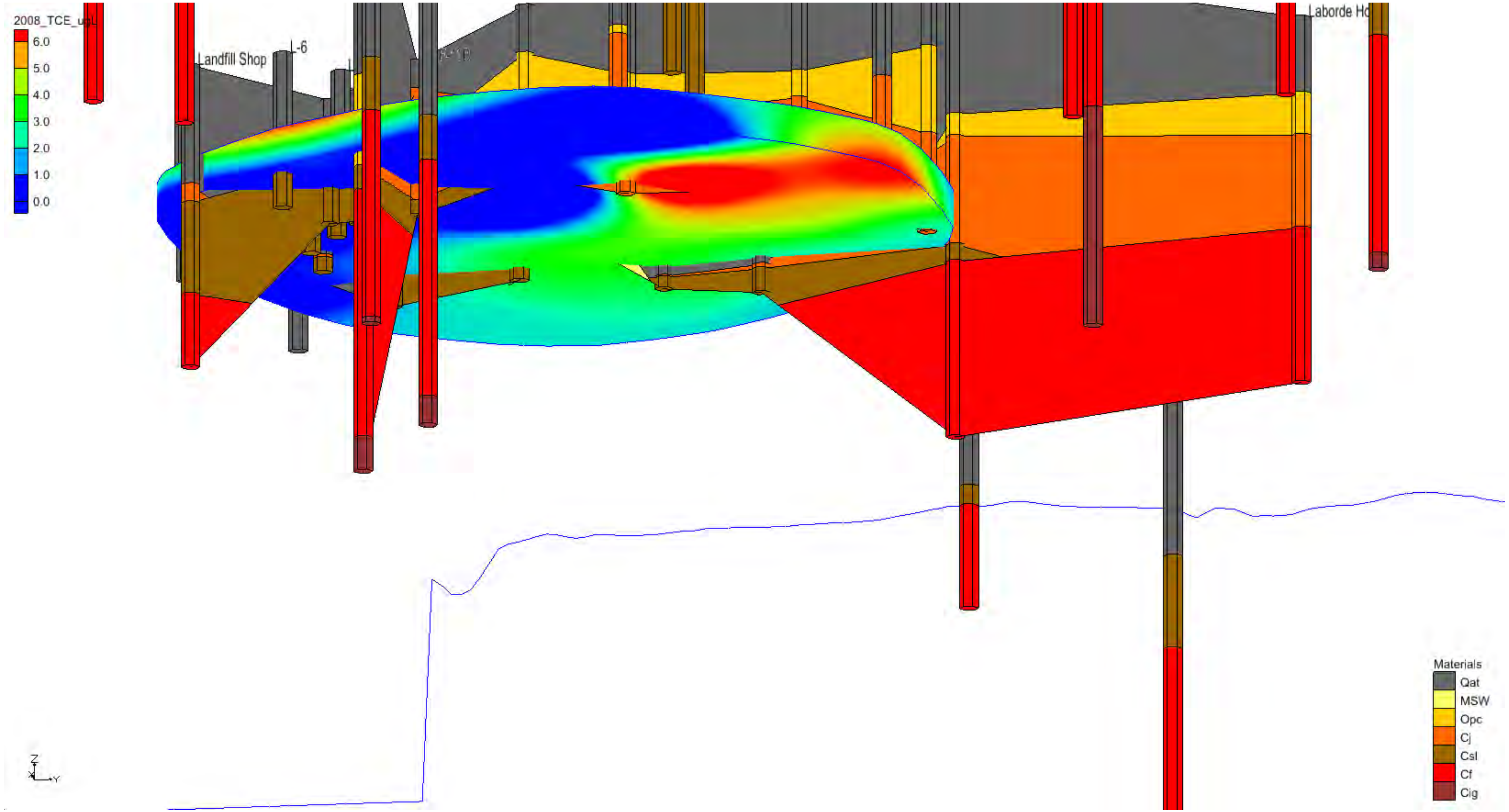
Foth

GW Monitoring Network Review- **SUFFICIENCY** (spatial)



Foth

GW Monitoring Network Review- **SUFFICIENCY** (spatial)



Foth

GW Monitoring Network Review- Sufficiency (spatial output)

Foth