INTEGRATING EQUIS AND R TO STREAMLINE ML/ARD MANAGEMENT PROGRAMS

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Outline

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- Introduction to ML/ARD programs and testing

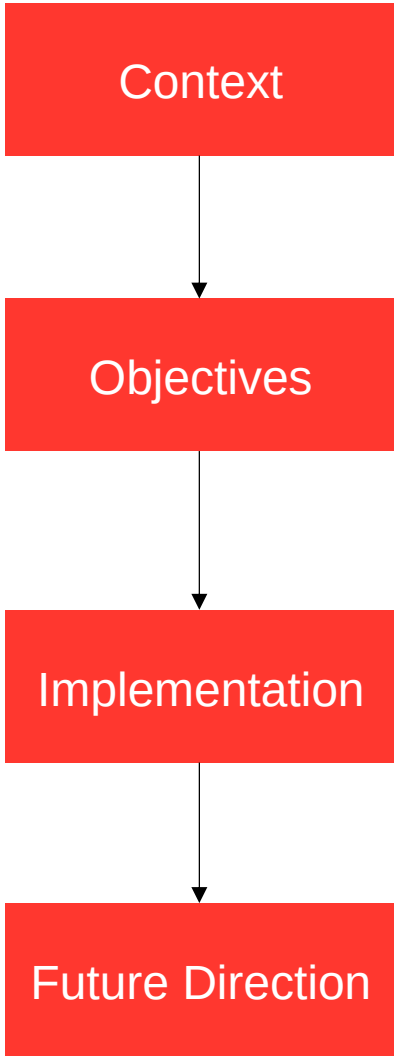
Project Objectives

- **Objective 1:** Meet QC standards
- **Objective 2:** Manage ML/ARD data

Project Implementation

- EQuIS
- R (programming language)

Future Direction



PROJECT CONTEXT

What is ML/ARD?

Metal Leaching Acid Rock Drainage (ML/ARD)

Definitions:

- **ML:** Metal leaching
- **ARD:** Acid rock drainage
- Sulphide containing minerals exposed to weathering which generates acidity (GARD Guide)
- Acidity leads to leaching of dissolved metals
- Accelerated by excavation of rock (mining)

Importance:

- Persistent and costly environmental impacts
- Static and kinetic testing to assess ML/ARD potential

Acid rock drainage (Mining.com)

Static Testing

Measure of a sample at a single point in time

Acid Base Accounting:

- Estimate the potential to produce acidic drainage

Elemental Analysis:

- Total amounts of elements in solid phase

Shake Flask Extraction Leachate:

- Determine immediate drainage chemistry

Mineralogy:

- Properties of mineral phases

Example of elemental analysis by portable XRF (SciAps)

Kinetic Testing

Measure of a sample taken over time

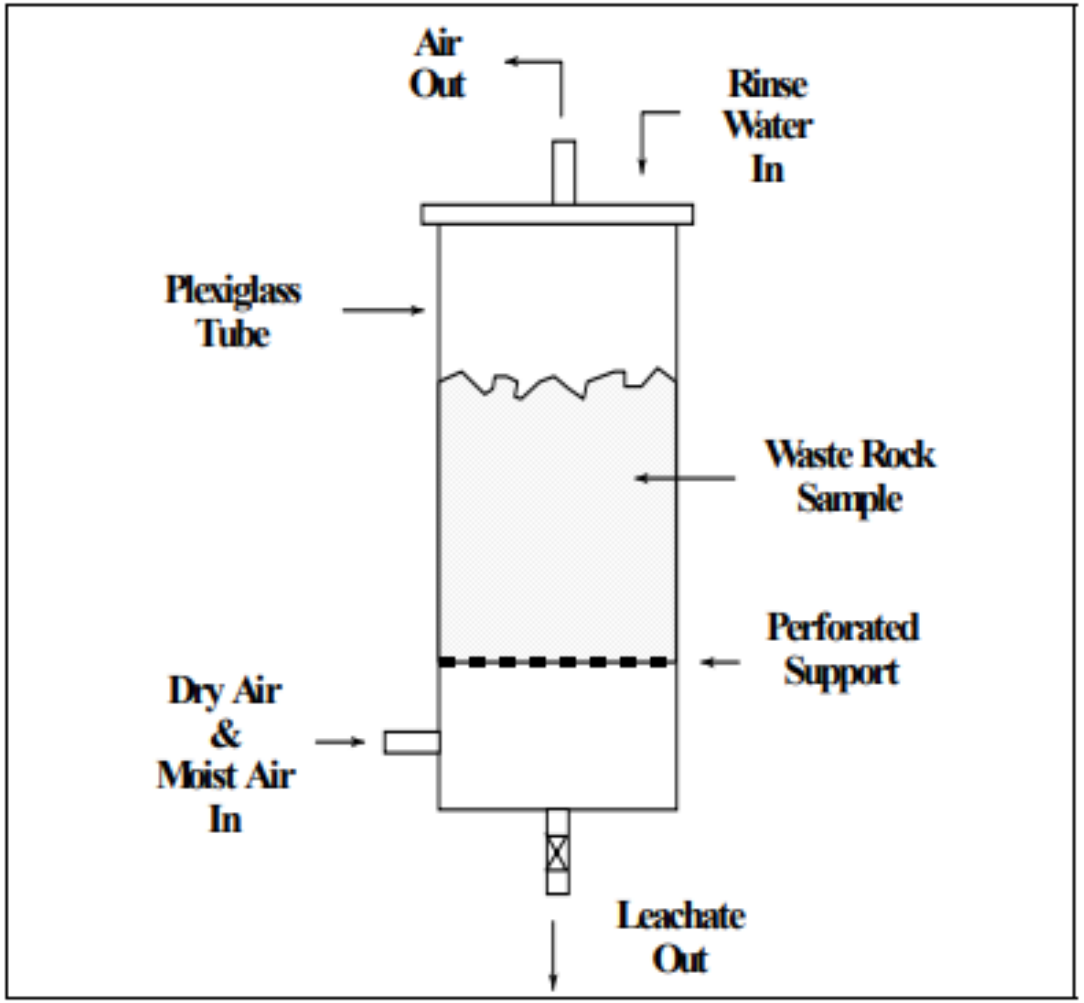
Humidity Cell Test (HCT)

Weekly:

- Dry and moist air cycles
- Addition and flush of de-ionized water
- Analysis of leachate

Project Data:

- 11 kinetic tests
- 55 weeks
- 50 parameters



HCT Design (MEND Prediction Manual)

What is the Project?

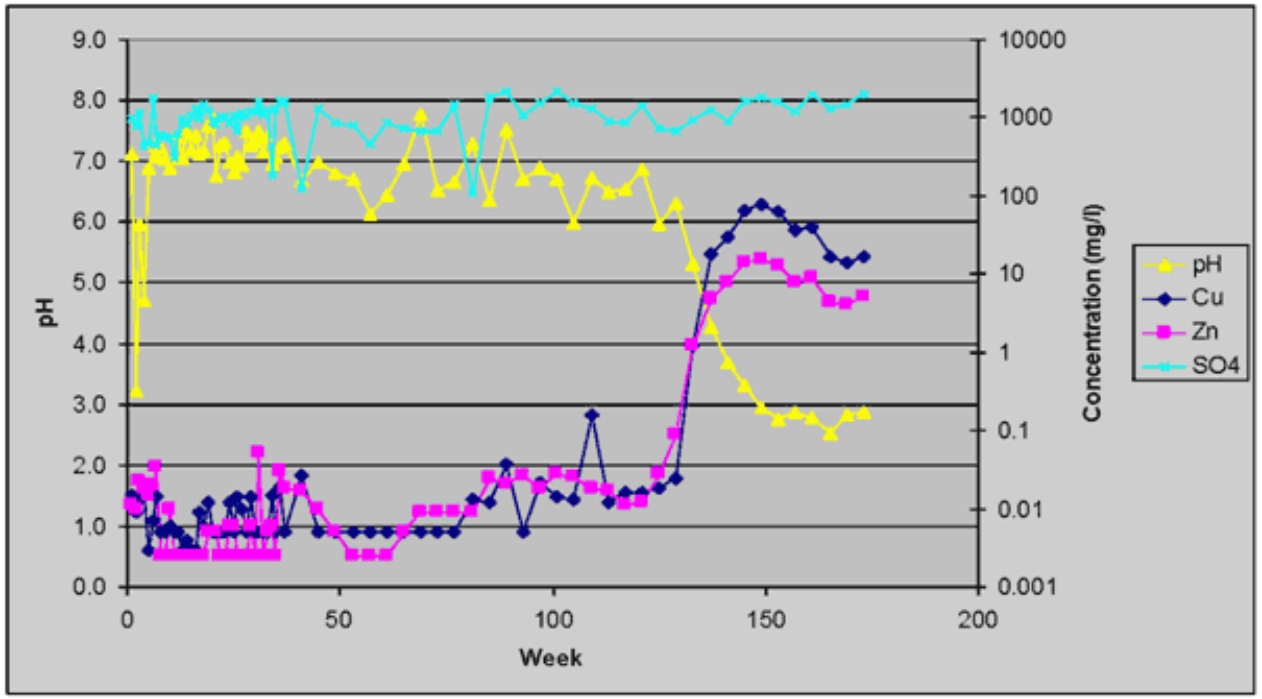
Geochemistry baseline assessment for a mine in permitting stage

Baseline assessment:

- Support the geochemical characterization of existing conditions

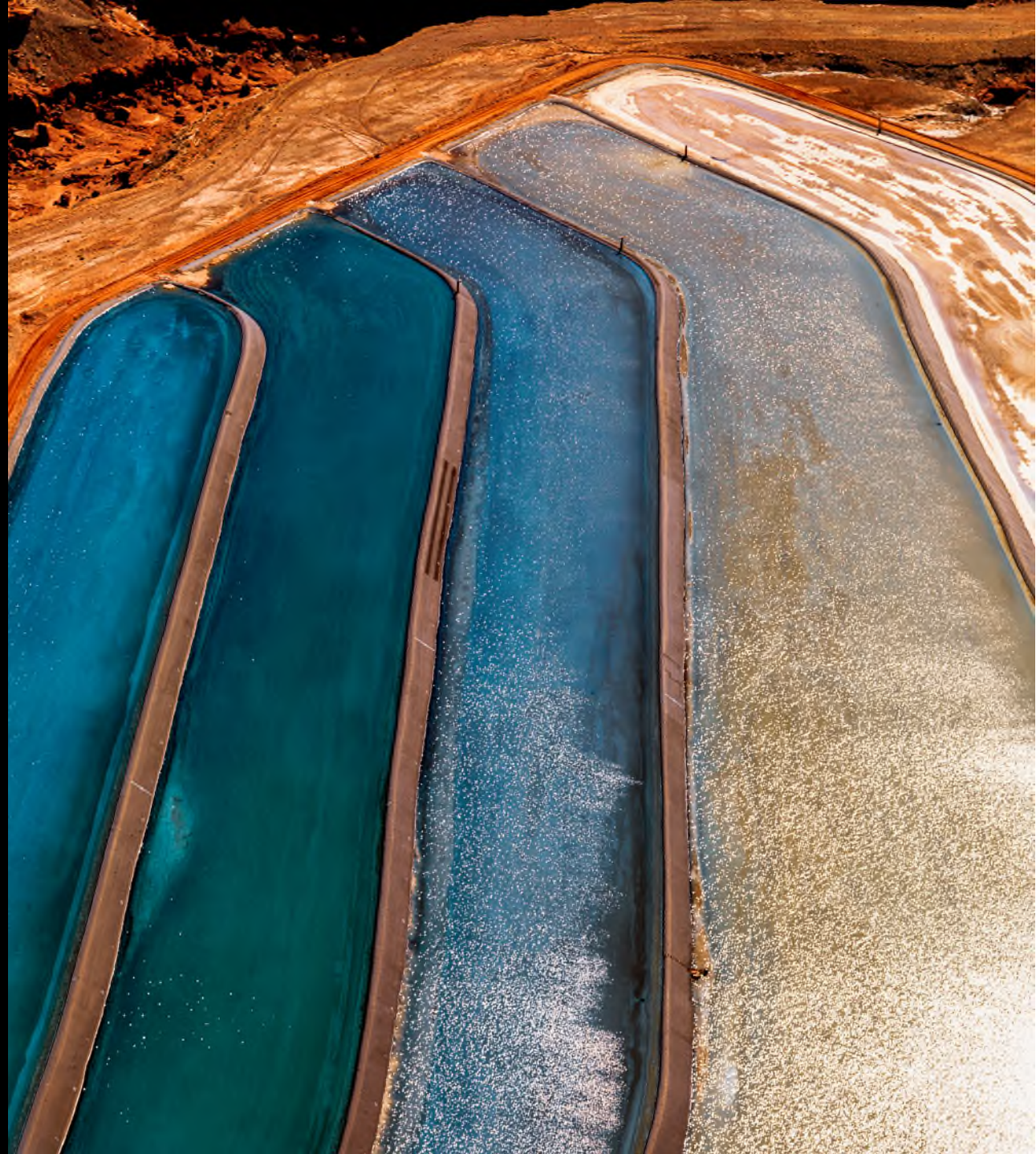
What samples and data are collected:

- 500+ static samples
- 11 kinetic tests (run for 55 weeks, potential to run for multiple years)



Example kinetic cell plot showing the cell going acidic at 120 weeks (GARD Guide)

PROJECT OBJECTIVES



Project Opportunity and Objectives

Opportunity

WSP had the opportunity to design data management protocols

Objectives

1. Meet QC Standards

- Manage with R (R Markdown)

2. Kinetic cell data

- Manage with EQuIS and R

Data Quality Objective

Desired Product

QC Information:

- Assess lab QC procedures
- Ensure high level of data quality in the kinetic cells

Quality Control Automation

Quality Control Analysis

Data available to assess:

- Matrix Blank
- Lab Control Standard (LCS)
- Duplicate
- Matrix Spike (MS)
- Hold Times

QC - Blank	QC - STD % Recovery	QC - DUP % RPD	QC - Spike Rep
---	---	---	---
NA	99.4%	1%	NA
NA	100%	1%	NA
< 2	102%	1%	NA
< 2	NA	5%	NA
< 2	NA	0%	NA
< 2	NA	ND	NA
< 2	98%	ND	NA
< 10	101%	3%	NA
< 0.10	96.9%	NA	98.5%
< 0.5	97.6%	NA	98.5%
< 0.2	94.3%	NA	94%
< 0.05	95.9%	NA	100%
< 0.05	96.9%	NA	94.7%
< 0.1	96.4%	NA	97.4%
< 0.1	100%	NA	102%

Available lab QC data including blanks, standards, spikes, and duplicates

Data Management Objective

Desired Product

Database:

- Concise database with kinetic cell data
- Comparisons to federal water quality guidelines

Figures:

- Plots for site decision making and recommendations

PROJECT IMPLEMENTATION

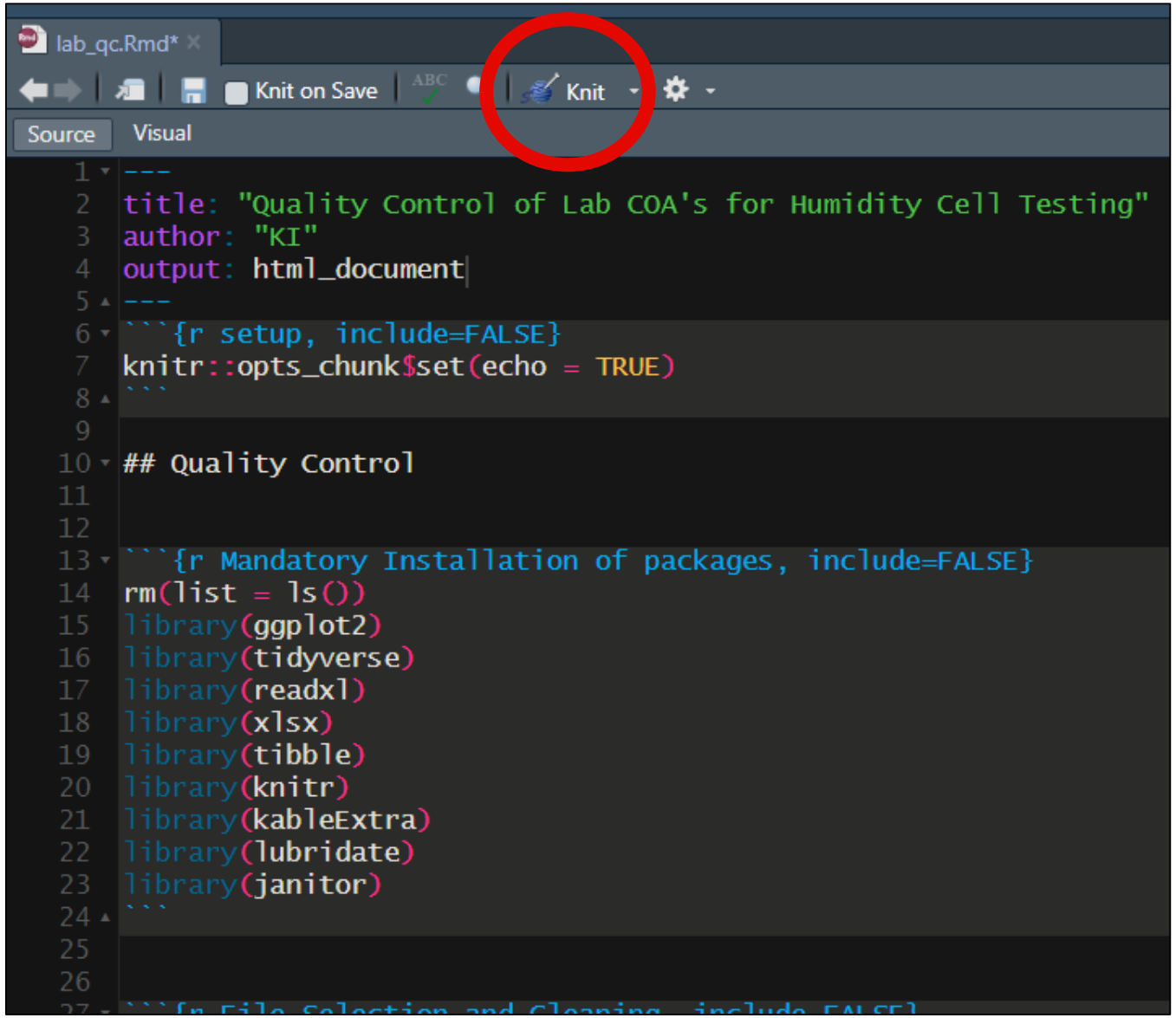
QC Standards

Automation Process

Objective 1: Automate the process of analyzing available lab QC information

- Completed using R Markdown in R

- Key input files
  - 1. Laboratory provided result file – no edits required



R Markdown example

QC Standards

Automation Process

Objective 1: Automate the process of analyzing available lab QC information

- Completed using R Markdown in R

- Key input files
  - 1. Laboratory provided result file – no edits required
  - 2. User generated data quality objective file

QC - Blank	QC - STD % Recovery	QC - DUP % RPD	QC - Spike Rep
---	---	---	---
NA	99.4%	1%	NA
NA	100%	1%	NA
< 2	102%	1%	NA
< 2	NA	5%	NA
< 2	NA	0%	NA
< 2	NA	ND	NA
< 2	98%	ND	NA
< 10	101%	3%	NA
< 0.10	96.9%	NA	98.5%
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< 0.1	96.4%	NA	97.4%
< 0.1	100%	NA	102%

Available lab QC data including blanks, standards, spikes, and duplicates

QC Standards

Automation Process Output

- Comparison of results to data quality objectives/hold times in one click
- Reports are saved as pdf
- Append to reports

Sample ID	Days	Difference	Days Past Hold Time
pH	7	22.58333	15.58333
Total Dissolved Solids	7	20.58333	13.58333

Lab Quality Controls

Lab Quality Controls such as matrix spikes, laboratory duplicates, laboratory control standards (LCS), and laboratory blanks are analyzed in the below section. A table is printed below for data that needs to be investigated further based on the lab supplied QC results. Results are presented as percentages. Values were compared to data quality objectives (DQO's) provided by SGS for shake flask extractions.

```
kable(tbl, format = "markdown") %>% kable_styling(full_width = FALSE)
```

Sample ID	QC - Spike Rep	QC - DUP % RPD	QC - STD % Recovery	QC - Blank
Chloride	2	NA	200	NA
Chromium	155	NA	NA	NA
Bismuth	NA	80	NA	NA

Sample ID	QC - Spike Rep	QC - DUP % RPD	QC - STD % Recovery	QC - Blank
Calcium	NA	40	NA	NA
Silver	NA	NA	60	NA
Aluminum	NA	NA	NA	0.002

Example report output

Kinetic Cell Data

Data Processing

Objective 2: Automate comparisons to guidelines and plotting

EQuIS:

- Store data, compare to federal water quality guidelines
- Standardized output format: GAL Report (long format: sample, results, action levels)

R:

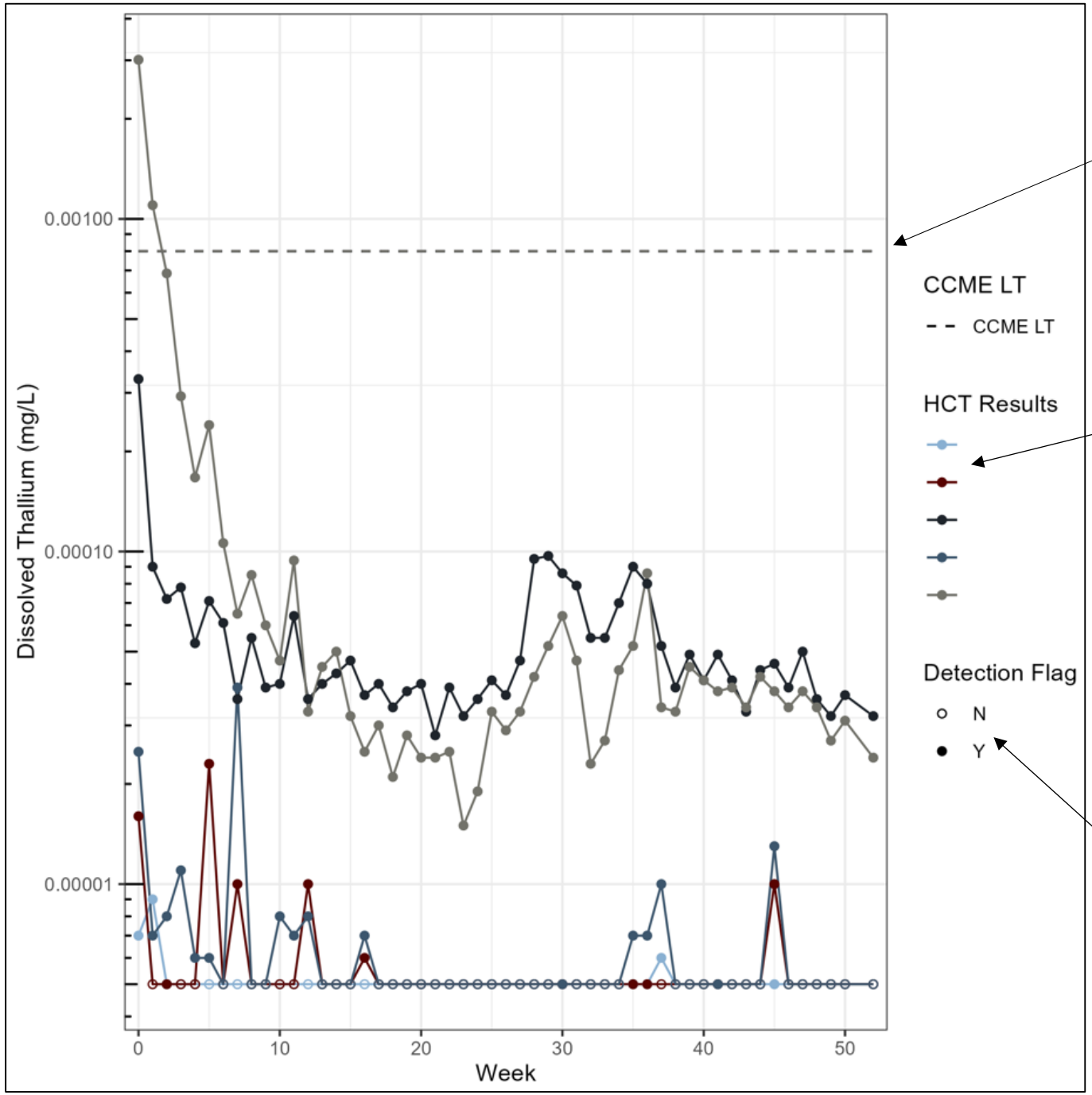
- ggplot2
- Loops through all unique parameters
- Plots all data for each cell with water quality guidelines

Kinetic Cell Data

Outcome

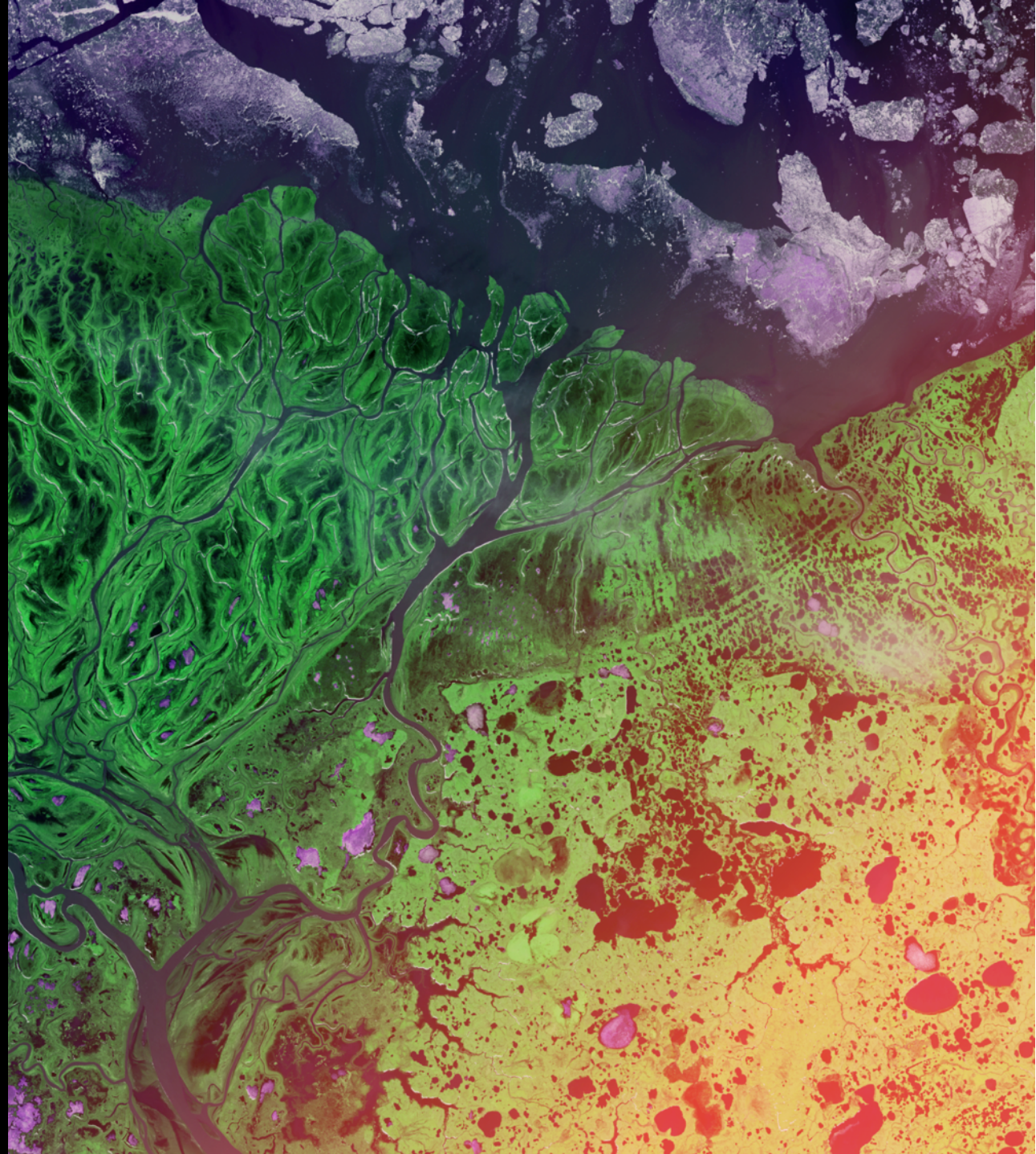
- Quickly plots all analyzed parameters

- Free up time to provide more meaningful analysis and solutions



Example plot output for thallium

SUMMARY AND NEXT STEPS



Conclusion

Integrating EQuIS and R to Streamline ML/ARD Management Programs

Project Context:

- 11 Kinetic cells running for multiple years
- Weekly QC and kinetic cell data to manage

QC Standards:

- Developed R script for lab QC analysis automation

Kinetic Cell Data:

- Rely on EQuIS for data management and outputs
- Developed R script for plots

Future Direction

Project Direction:

- Complete Environmental Assessment 2026

Objective 1 QC Standards:

- Expand to other laboratories
- Python adaptation

Objective 2 Kinetic Cell Data:

- Apply this process to additional ML/ARD programs
- PowerBI/Shiny App


Questions?