# Design of Geochemical Monitoring Programs for Construction – Considerations and a Case Study

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Segregation

## Outline

1) Monitoring Program Design Considerations
2) Case Study – TSF Buttress Construction with Filter and Drains
3) Learnings

Present a framework, components and considerations for design and implementation of a geochemical construction monitoring program

Move quickly through 1 as the intent is that you can go back to this slide deck as a reference

## Design Considerations

## Why Conduct Construction Monitoring?

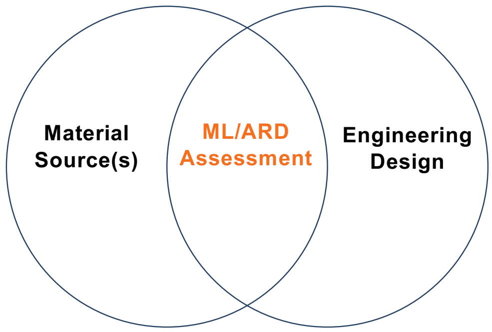
- Confirm construction material has low potential of ML/ARD
- Geochemical inventory of construction materials
  - Global Industry Standard on Tailings Management (GISTM)
- Legal requirement – Fisheries Act, regulatory requirements
- Environmental stewardship

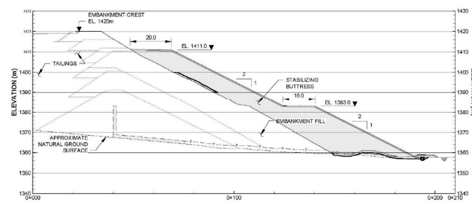
## Framework

1. **ML/ARD assessment** of construction material sources
2. **Scoping** of the construction monitoring program
3. **Design** of the construction monitoring program

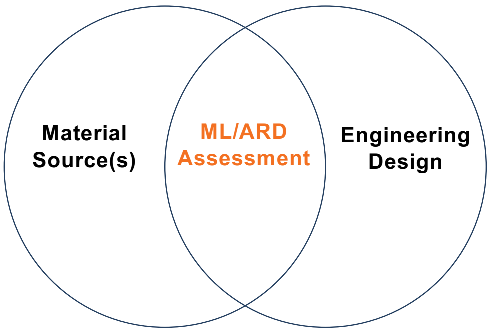
Not an exhaustive list

# ML/ARD Assessment of Sources



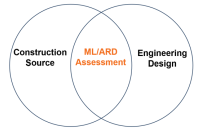
# ML/ARD Assessment of Sources




- Material inventory
- Volumes
- Material specs / Grain size
- Drawings and cross sections
- Filter/drain rock
- Design report

- Geology
- Mineralogy

# Outcomes of Initial ML/ARD Assessment

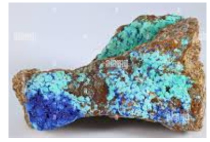



- Identify construction materials
  - Non-PAG, non-acidic, low metal leaching potential
- ML/ARD characterization program
  - Define NP, AP, ML parameters
  - Test work methods
- ML/ARD construction classification criteria
  - Permit conditions
  - Site specific criteria
  - MEND 2009
  - Visual classification criteria supported by ML/ARD data

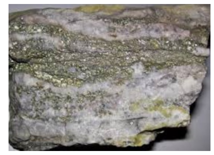
Visual classification criteria supported by ML/ARD data

## Visual Segregation Criteria

- Requires geological description of sample prior to geochemical analysis and integration with data interpretation
- Quick method of classifying and segregating rock
- Due diligence to save $$
- Conservatism (rejecting rock unnecessarily) costs $$
- Examples:
  - High fizz test as extra QC step before sending rock to the crusher and screener → Due diligence that feed will be non-PAG rock
  - Sulphide content to identify buried stockpiles of PAG low grade ore → avoid unnecessary haul to construction front
  - Geological model of sulphide mineralization coupled with quarry wall inspection to identify low sulphur rock PAG rock



Secondary Minerals

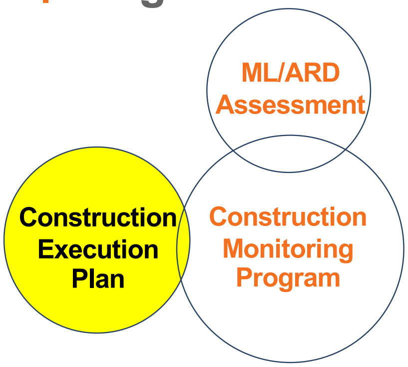


Pyrite content

Fizz resulting from HCl on calcite

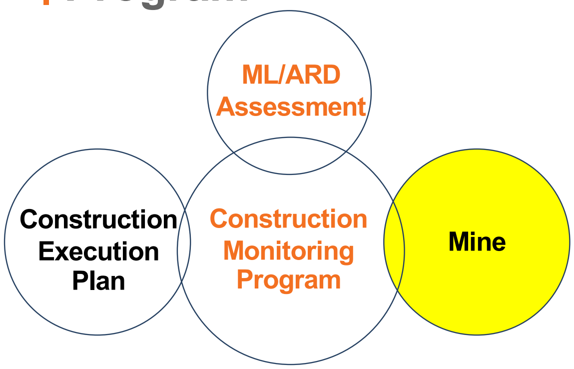
Visual classification criteria supported by ML/ARD data

## Scoping the Construction Monitoring Program



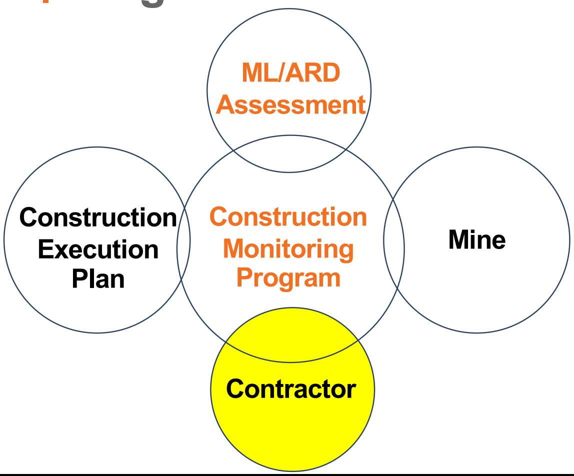

- Field fit the program
- Blasting, screening and/or crushing
  - Fractionation of AP and NP
  - Test the representative size fraction
- Material hauling rate, equipment, construction process
  - Define scale of segregation
  - Sampling method
  - Sample frequency
- Required TAT geochemical classifications
- Implementation of corrective action
- PAG management

# Scoping the Construction Monitoring Program




- Permit Conditions
- Water management
- Receiving environment
- Water bodies and receptors

# Scoping the Construction Monitoring Program




- Safe access when sampling
- Don’t introduce delays ($)
- Contract considerations ($)

## Construction Program Design

- ML/ARD monitoring at source or construction front
- Onsite or offsite lab
- Field monitor skills
- Data interpretation and ML/ARD classification onsite
  - Owner’s representative
  - Independent of the contractor and construction manager
- Data QC program
- Verification monitoring

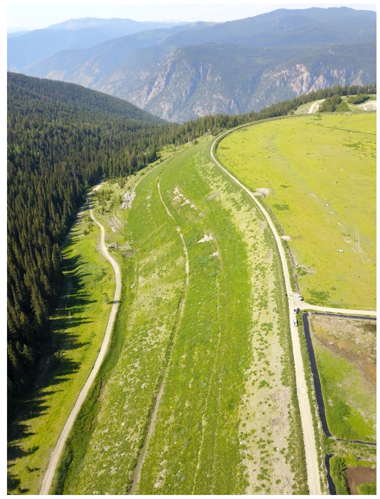
**Construction Monitoring Program**

(rock type, sulphide content, quartz veining, iron staining)

## Case Study

## Project Description

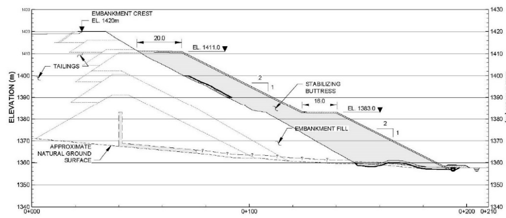
- Site and client are confidential
- Construction of a dam buttress for tailings storage facility (TSF) at a closed mine to meet Global Industry Standard on Tailings Management (GISTM)



TSF and dam face prior to buttress construction

# Design Input: Engineering & Construction

- Buttress fill was most volumetrically significant material
- Material source was ROM waste rock dump
- Filter and drains to convey seepage
- Construction method: end dump, dozer, compact in 0.5 m lifts
- Average lift ~5,800 $m^3$ = ~48 truck loads
- 24/7 construction schedule
- 17 to 24 hours between placement and burial by overlying lift

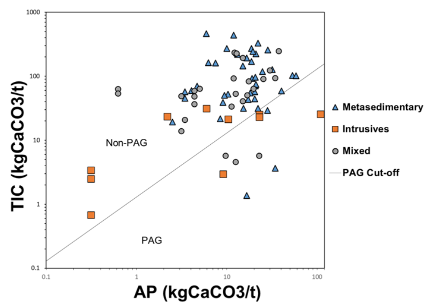



Built on DS face of TSF
2-3 km

# Design Input: Geology & Geochemistry

- Two main rock types were metasedimentary and intrusives
- Previous investigations showed:

1) ARD potential controlled by rock type
   - Intrusives more likely to be PAG due to lower carbonate content
   - Volume of intrusives relatively minor
2) Waste rock dump is well-mixed: non-PAG on mass balance basis but pockets of PAG/acidic rock present




Historical WR dump test pit results

## Design Input: Permit Conditions

- Permit conditions:
  - “must not use PAG materials for construction”
    - Acidic: paste pH <6 or rinse pH <5
    - PAG: NP/AP <2 (NP by TIC and AP by total S)
  - Definition of ML potential for waste rock:
    - SFE test concentrations > receiving water objectives
- Other considerations – water management:
    - Seepage captured and pumped to existing water treatment plant on site
    - Source terms and water and load balance model to demonstrate any seepage bypass of water management system present a low risk to WQ in the receiving environment
    - ➢ML criteria not required for buttress construction rock

As a factor of safety, we assumed there will be seepage bypass so we assessed the potential impact to downstream WQ

## Waste Rock Monitoring Criteria

- Monitoring criteria :
  - “must not use PAG materials for construction”
    - Acidic: Paste pH <6 or rinse pH <5
    - PAG: TIC/AP <2
  - Definition of ML potential:
    - SFE test concentrations > receiving water objectives
- Other considerations:
  - Seepage capture pumped to existing water treatment plant on site
  - Source terms and water and load balance model to demonstrate any seepage bypass of water management system present a low risk to WQ in the receiving environment
  - No ML criteria for buttress construction rock

NP is based on TIC
AP is based on total S

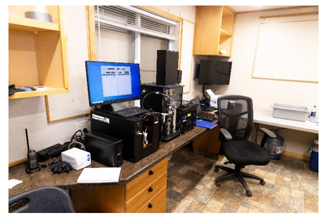
## Buttress Fill Program Design

***The "must haves" from the contractor***

- Sample at construction front rather than source
- ARD classification within 12-hour after material placement

***The solution***

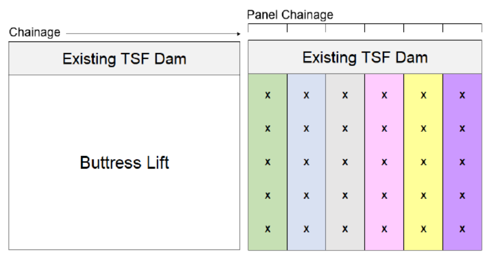
- Visual geological inspection before excavation to identify and reject probable PAG materials
  - Sulfides > 2%; fizz test; intrusives at the haul truck scale
- On-site lab: sample prep (sieving, crushing and pulverizing), rinse pH, TIC by coulometry, Total S by pXRF (Leco not available)



Sample at source due to construction schedule – no time to wait around for characterization
Supply chain issue due to Covid

## Buttress Fill Program Design

- Sample collection method considered material placement, capturing material heterogeneity and material removal if classified as PAG
- Each lift divided into panels of ~500 $m^3$
- 12 to 17 panels per lift
- Classification within 12-hour period
- Excavation of panel, if classified as PAG

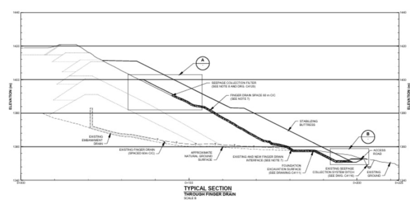



Key take away here is capturing of geological and geochemical heterogeneity according to truck dumping and dozer pushing of ROM rock sample size fraction and rationale, e.g. orientation of transect and fize points: shape of panel is excavatable unit by Contractor in event of corrective action (PAG classification after placement)

Also panel length varied with lift elevation so Contractor set panel chainage (width) according to panel volumes set out in the plan.

## Filter & Drain Rock Program Design

- Visual inspection at source: target high fizz
- ROM waste rock crushed then screened
- Sample collection from final stockpiles
- 1 sample per 500 $m^3$ of rock
- Same parameters as buttress fill
- Equilibrium modeling seepage and filter rock to assess geochemical processes of geotechnical significance
  - Secondary mineral formation
  - Dissolution of carbonates




Purpose is to convey seepage

# Verification Monitoring

***Data QA/QC of construction monitoring program:***

- Field duplicate samples analyzed at site lab (10%)
- Lab duplicate samples analyzed at site lab (10%)
- Certified reference materials

***Verification Program:***

- 10% of all samples analyzed at site lab were analyzed at an offsite commercial lab (rinse pH, ABA, trace metals, SFE)
- Purpose:
  - QC of onsite lab
  - Geochemical Inventory (GISTM)

## Program Execution

Sampling program executed by site personnel. Program went as planned except…

- Downtime before start of construction due to scheduling delays
- Panel sampling program pivoted to test pit sampling for material classification at the waste rock dump

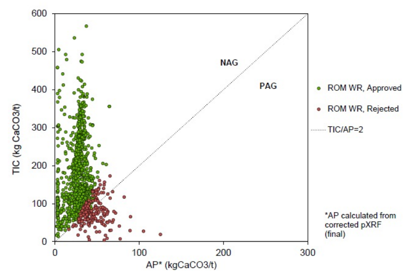
***New program (buttress fill):***

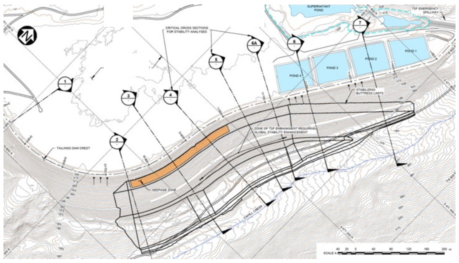
- Waste rock dump delineated into dig blocks (500m$^3$)
- One test pit per dig block – depth equivalent to the height of excavation front (operational scale)
- Geological inspection of excavated rock (visible sulfides; fizz test)
- One composite sample per dig block (test pit)
- Rejected materials left in-situ

# Verification Monitoring Program

***Material classification:***

- >1,000 dig blocks classified
- Consistent classification between on-site and external labs:
  - All approved dig blocks were classified as non-PAG by external lab
- SFE results compared to source terms inputs – within base and upper case





Design drawing

Completed buttress

## Learnings

## Shared Learnings from SRK

- Flag requirement of ML/ARD characterization of construction sources ***early in the design phase*** *(Issue for Review)*
- Embed **operational flexibility** in the monitoring program
- ML/ARD **classifications by site personnel**
- Success of program execution hinges on ***interdisciplinary collaboration and communication*** between company, construction manager, contractor and design engineer
- ***Geology and mineralogy*** to define visual segregation criteria
  - **"All eyes on deck"** - heavy equipment operators
  - Consider night shift!
- Monitoring of **blasting residual on quarry rock surfaces**
  - QC of ANFO handling, before rip rap placement in fish bearing stream
- Higher standard of care for ***permanent structures*** such as dams with additional emphasis on filters and drains
- Visual geological inspection and monitoring **after construction**

Start early
Design changes in the project

Thank you!!