ASSESSING THE TOXICITY OF MINE WASTE PILES: CHEMICAL CRITERIA

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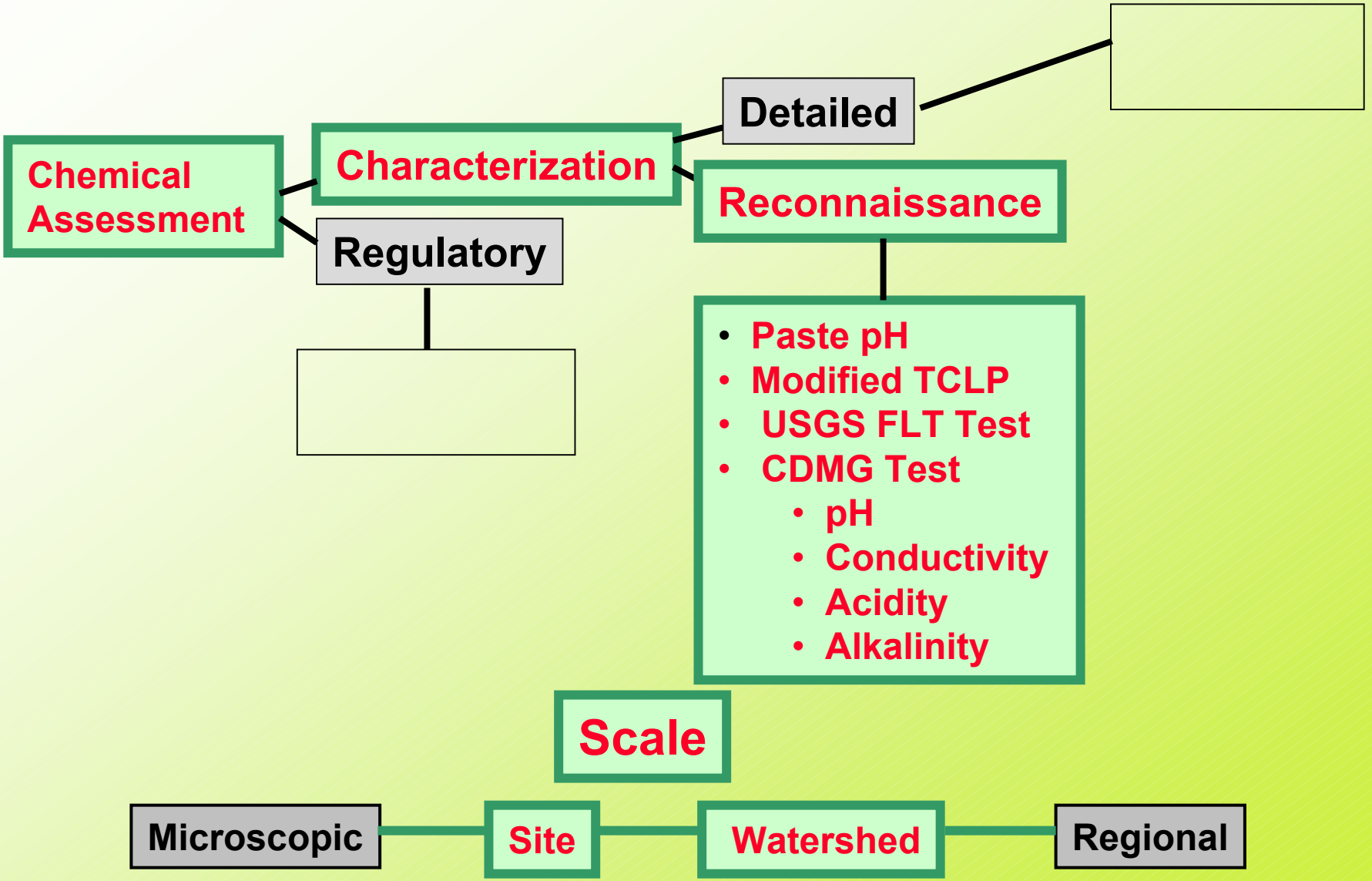
Flow Chart for Ranking and Prioritization



OUR GOAL

- **PROVIDE TOXICITY ASSESSMENT & RANKING OF MINE-WASTE PILES**
  - **–PHYSICAL & CHEMICAL ASSESSMENT**
  - **–SIMPLE ASSESSMENT TESTS**

CHEMICAL CRITERIA BUILD ON THE WORK BY THE USGS & CDMG, ESP. THE LEACHING TESTS THEY DEVELOPED

BACKGROUND

- USGS WORK
  - How To Sample A Waste-Rock Pile
  - USGS Field Leach Test
- CSM WORK (WILDEMAN & RANVILLE)
  - Search For Good Materials (Animas River)
  - Russell Gulch and North Clear Creek Studies
- CDMG WORK (JIM HERRON)
  - CDMG Leach Test (Animas River)
  - Waste-Pile Assessment (Virginia Canyon)

SUMMARY OF STUDIES

- Upper Animas River (CDMG)
  - 50 sulfidic waste piles
- Upper Animas River (CSM)
  - 28 sulfidic & carbonate waste piles
- USGS Studies
  - Approx. 300-400 samples in at least 10 studies
- Virginia Canyon (CDMG)
  - 29 stream sediments from sulfidic wastes
- Russell Gulch (CSM)
  - 27 sulfidic waste piles

MODIFIERS & ADVISEMENTS

- THE DECISION TREE HAS BEEN DEVELOPED PRIMARILY FROM INVESTIGATION OF WASTE PILES FROM SULFIDE ORE MINING, PRIMARILY IN THE WESTERN U.S.
- HOWEVER, OVER 300 WASTE PILES AND 30 SEDIMENTS HAVE BEEN ASSESSED DURING THE DEVELOPMENT.
- EVEN THOUGH THE TESTS ARE COMPARABLE TO REGULATORY TESTS, THIS IS STILL CONSIDERED A RECONNAISSANCE TOOL.
- APPLICATION IS TO MINE-WASTE PILES & NOT TO ACIDIC SOILS.

MINE WASTE DECISION TREE

CHEMICAL CRITERIA

PASTE pH, ALKALINITY

< 5

Assume Toxicity.
Check with TCLP & CDMG extraction tests.

> 5

Toxicity Uncertain

TCLP, CDMG, & USGS extraction tests are necessary.

Develop a simple bioavailability test to confirm toxicity.

Concerning the tests and observations within the criteria, only the paste pH test can be used as an either/or criterion for determining toxicity. For the other tests, ratings will have to be developed for which the aggregate score will determine the degree of hazard of a waste-rock pile.

SCIENTIFIC BACKGROUND & HIGHLIGHTS

- **VIRGINIA CANYON STUDY**
  - **SIMILARITY OF WATER CHEMISTRY DURING RUNOFF & STORM EVENTS**
  - **WHICH LEACHATE TESTS COMPARE BEST WITH THE WATER.**
  - **COMPARISON OF LEACHATE TESTS WITH WATER FROM SEDIMENTS (pH < 5)**
- **UPPER ANIMAS RIVER STUDY**
  - **THE ELEMENT CONCENTRATION PATTERN GRAPH (ECPG)**
  - **RESULTS FROM SEDIMENTS WITH pH > 5.**

UNKNOWN MINE NEAR GLORY HOLE, CENTRAL CITY

USGS SAMPLING PROTOCOL

DIVIDE DUMP INTO AT LEAST 30 CELLS OF EQUAL AREA

↓

COLLECT SURFACE SAMPLE (15 cm) OF AT LEAST 100 g FROM EACH CELL

↓

COMBINE SUB-SAMPLES INTO A COMPOSITE

↓

DRY SIEVE COMPOSITE TO < 2 mm FOR AT LEAST 1 kg OF FINAL COMPOSITE SAMPLE

NANCY DOING RANDOM SAMPLING

USGS FLT LEACHATE TEST

- Determines the potential for metal and acid release from mine waste when exposed to natural waters
- Extraction Ratio 20:1 on a mass basis (Same as EPA 1311 and EPA 1312)
- 50 g < 2 mm (< 10 mesh) sediment sample is brought to 1 L using deionized water
- Hand shaken for 5 minutes; allowed to settle for 10 minutes
- Leachate is filtered for ICP-AES analysis

CDMG LEACHATE TEST

- Determines the potential for metal release from soils when exposed to natural waters
- Volume basis with low water / sediment
- 300 ml of deionized water was added to 150 ml of whole sediment sample
- Stirred for 15 seconds; allowed to settle for 90 minutes
- Leachate prepared for ICP-AES analysis

CSM MODIFIED TCLP TEST

- **Modification of Method 1311 developed by the EPA**
- **Determines the mobility of metals in the presence of acidic waters**
  - **Extraction fluid of 5.7 ml concentrated acetic acid, 64.3 ml 1 M NaOH and ~930 ml deionized water (pH=4.93)**
  - **40 ml of the extraction fluid was added to 2.0 g < 80 mesh sediment sample**
  - **Solution agitated end over end for 18 hours**

BIG QUESTION ON TCLP

Should a pH of 5 or 3 be used???

- **pH of 5 simulates most carbonate extractions**
- **Most waste piles are already acidic**
- **Primarily looking for comparisons among the three leachate tests, and not necessarily for regulatory problems.**

OTHER MEASUREMENTS

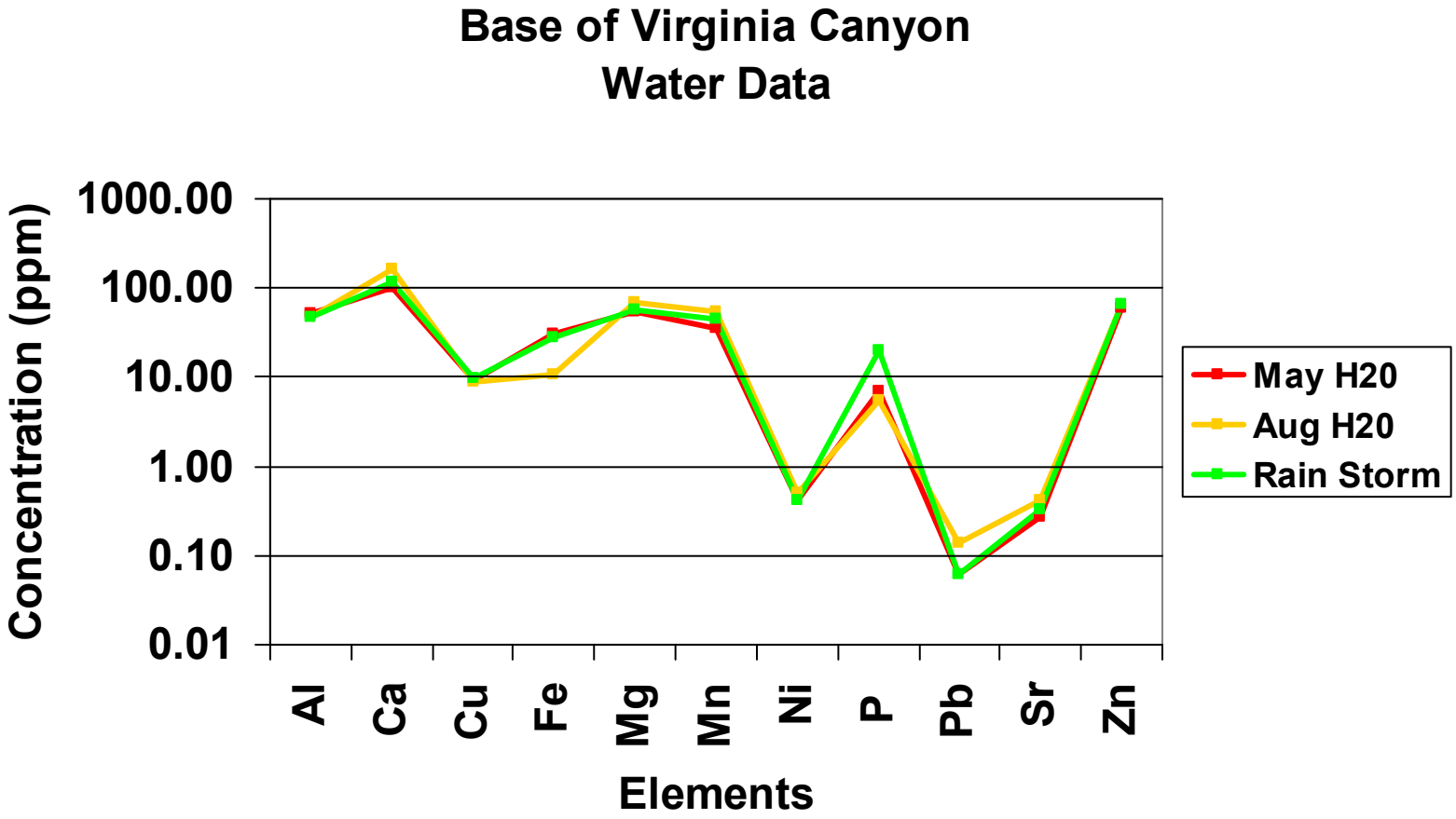
- Fizz test with 10 % HCl for presence of carbonates
- pH on the CDMG leachate
- Ionic conductivity on CDMG leachate
- Acidity/ alkalinity measurement on CDMG leachate

NOW, ON TO THE RESULTS

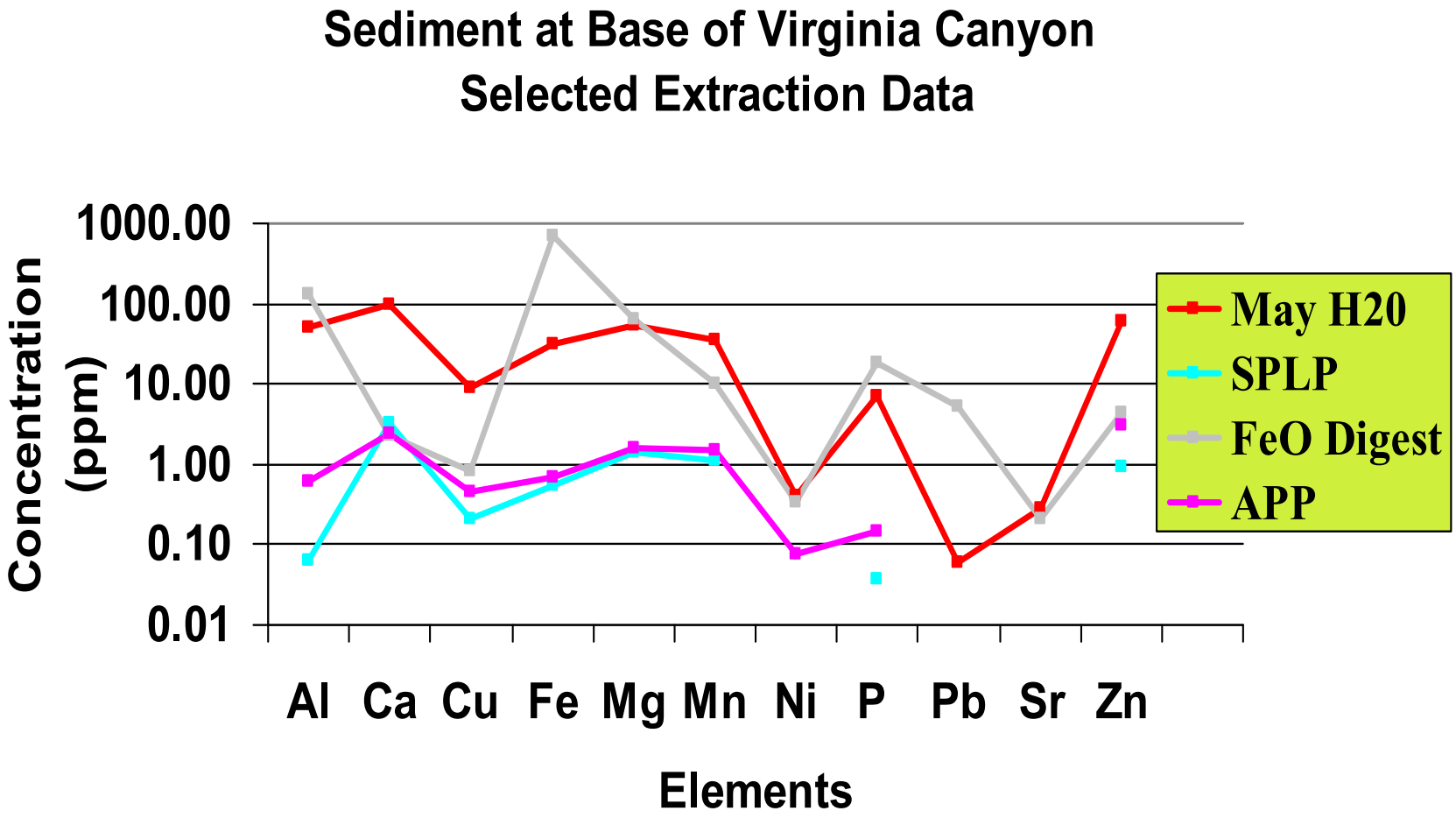
BASE OF VIRGINIA CANYON

- **pH:** **3.00**
- **Eh:** **702.1 mV**
- **Conductivity:** **1475 μS/cm**

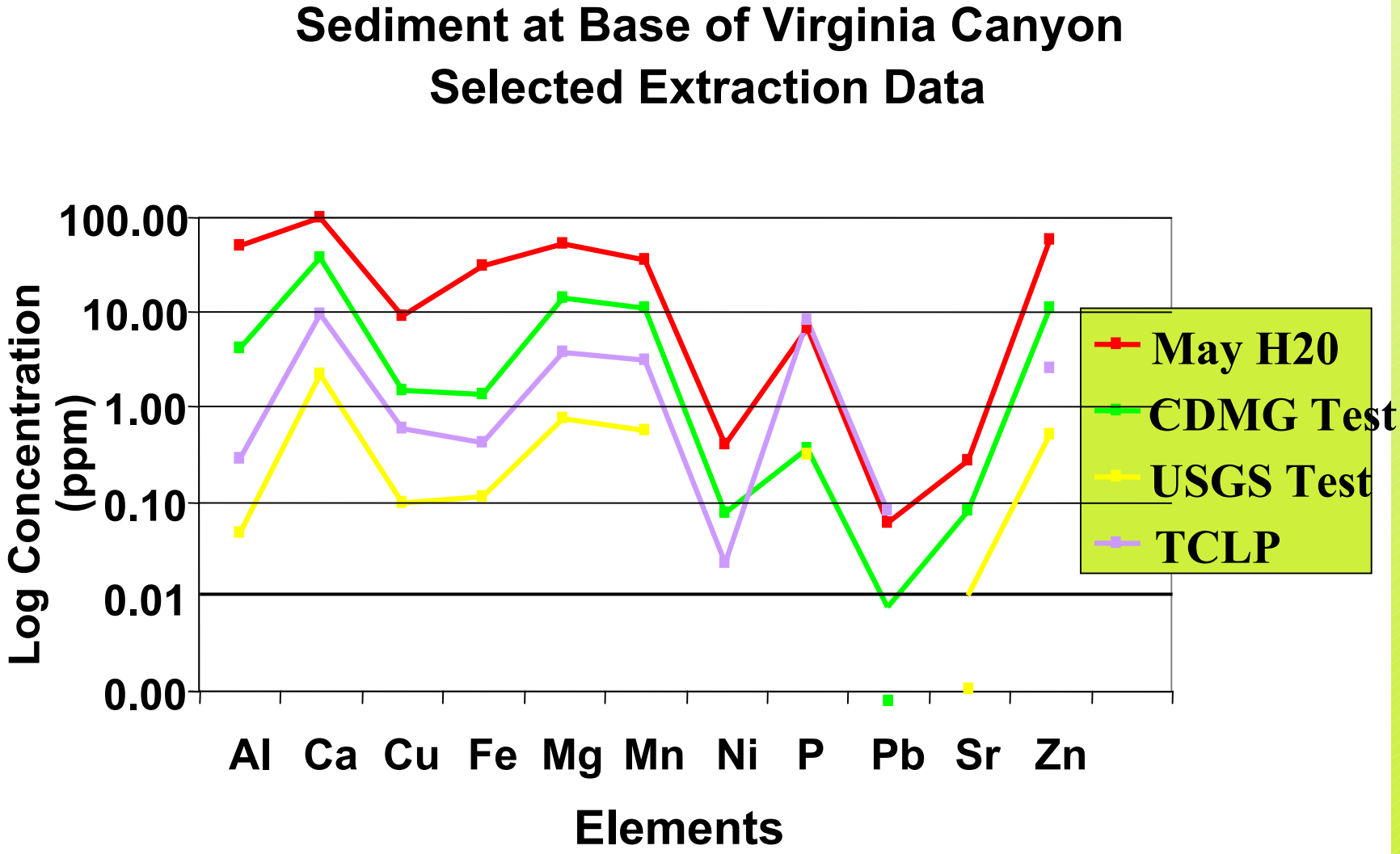
VIRGINIA CANYON WATER



OTHER POSSIBLE LEACHATE TESTS



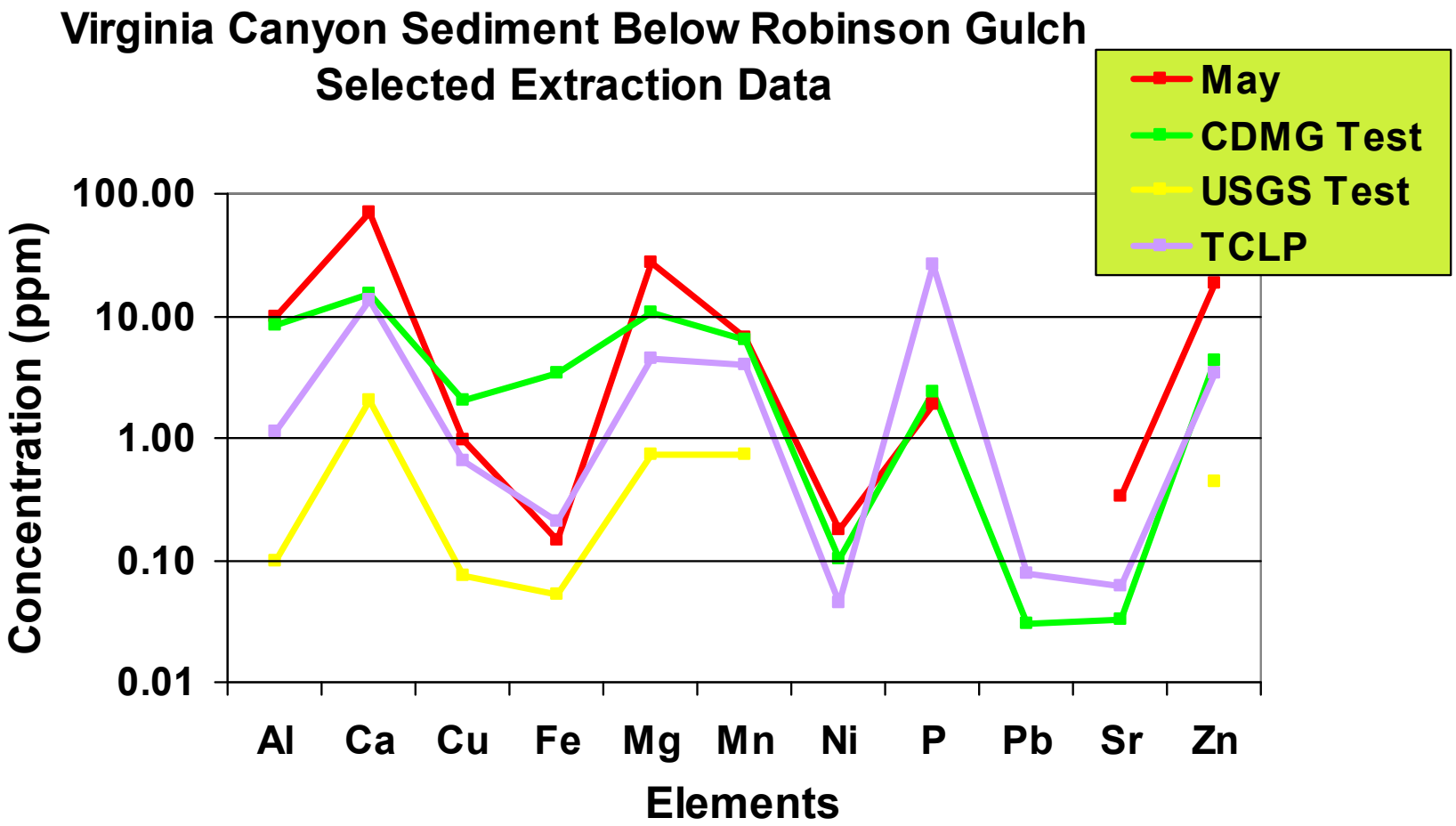
USGS, CDMG, & TCLP TESTS



VIRGINIA CANYON JUST BELOW ROBINSON GULCH

- **pH:** **4.39**
- **Eh:** **666.2 mV**
- **Conductivity:** **831 μS/cm**

USGS, CDMG, & TCLP TESTS



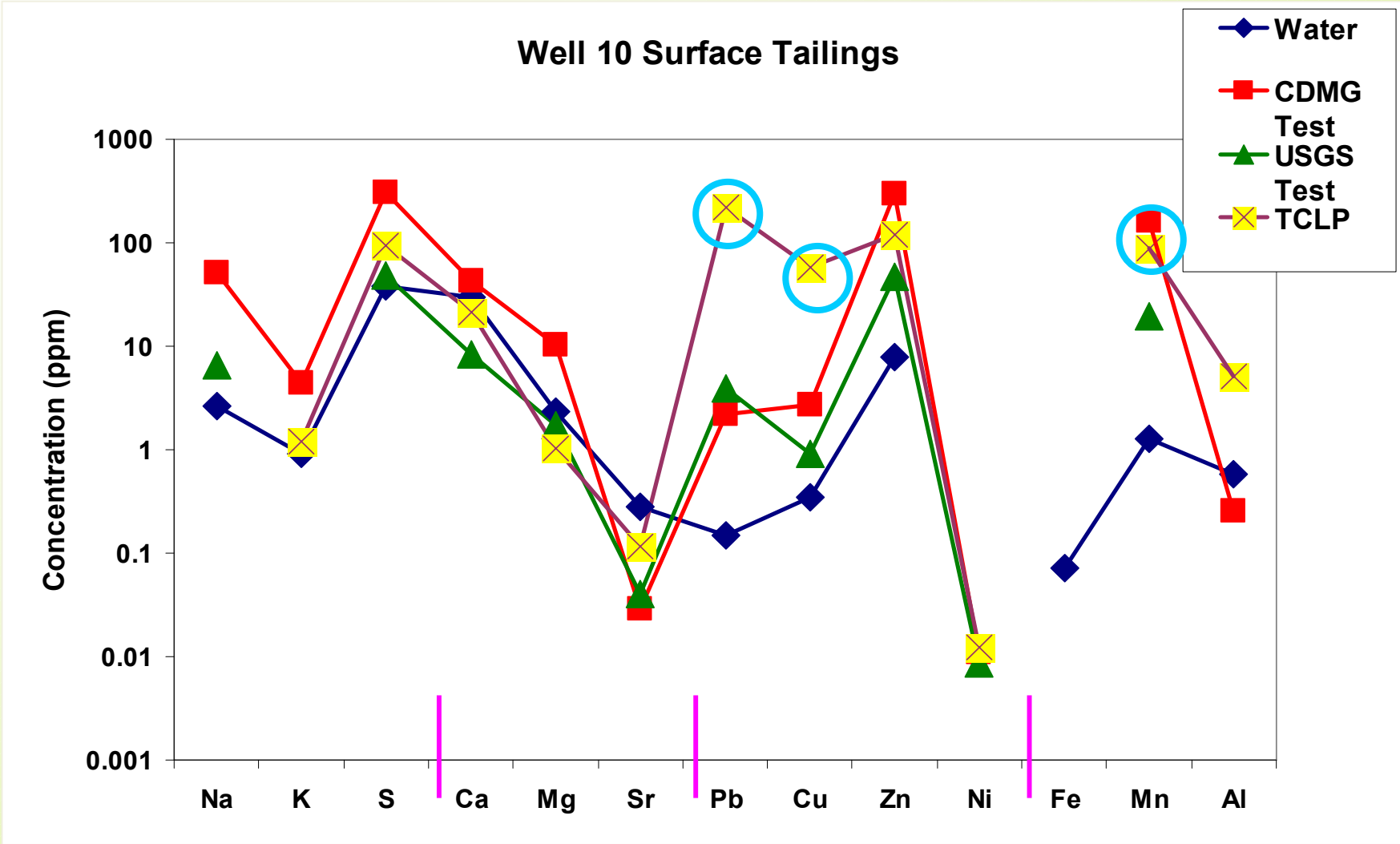
SCIENTIFIC BACKGROUND & HIGHLIGHTS

- **VIRGINIA CANYON STUDY, 29 SEDIMENTS**
  - **SIMILARITY OF WATER CHEMISTRY DURING RUNOFF & STORM EVENTS**
  - **WHICH LEACHATE TESTS COMPARE BEST WITH THE WATER.**
  - **COMPARISON OF LEACHATE TESTS WITH WATER FROM SEDIMENTS (pH < 5)**
- **UPPER ANIMAS RIVER STUDY, 11 SEDIMENTS**
  - **THE ELEMENT CONCENTRATION PATTERN GRAPH (ECPG)**
  - **RESULTS FROM SEDIMENTS WITH pH > 5**

ELEMENT PATTERN GRAPH

- USE A LOG SCALE FOR GOOD RELATIVE COMPARISONS
- GROUP ELEMENTS ACCORDING TO CHEMISTRY
  - Na, K, SO_4 readily soluble
  - Ca, Mg, Sr carbonate phases
  - Pb, Cu, Zn, Ni carbonate/sulfide phases
  - Fe, Mn, Al oxide phases

pH 5.2 TAILINGS SEDIMENT



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GRAND ASSESSMENT SCHEME

CHEMICAL CRITERIA

PASTE pH, ALKALINITY

- **< 5** → **Assume Toxicity. Check with TCLP & CDMG extraction tests.**
- **> 5** → **Toxicity Uncertain** → **TCLP, CDMG, & USGS extraction tests are necessary.** **Develop a simple bioavailability test to confirm toxicity.**

PHYSICAL CRITERIA

A. ON-SITE ASSESSMENTS

1. **Proximity to year-round or ephemeral stream or gulch.**
2. **Size of waste-rock pile.**
3. **Extensiveness of erosion features.**
4. **Presence of cementation crusts.**
5. **Presence of a kill zone.**
6. **Presence of vegetation.**

B. ON-SITE TESTS

1. **Develop a settling test.**

Concerning the tests and observations within the criteria, only the paste pH test can be used as an either/or criterion for determining toxicity. For the other tests, ratings will have to be developed for which the aggregate score will determine the degree of hazard of a waste-rock pile.

BOTH CRITERIA ARE IMPORTANT

- **CHEMICAL**
  - **Ranks availability of contaminants**
- **PHYSICAL**
  - **Ranks ability to deliver contaminants**


RIVER WATER
CONTAMINATED
BY HEAVY
METALS
DO NOT DRINK