Region 2 Water Board
Mines Cleanup Program

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SAN FRANCISCO BAY WATER BOARD
CA ABANDONED MINE LANDS AGENCY GROUP MEETING,
JANUARY 24, 2018
(510) 622-2363
lwhalin@waterboards.ca.gov
https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/MinesCleanupProgram.html
Talk Outline

- Region 2 mines
- Prioritization strategy & desktop analysis tool
- Tool implementation (inspection prioritization results)
- Inspection/data collection strategy
  - Data Quality Objectives, XRF Standard Operating Procedures
- Initial inspection results
- Next steps & regulatory tools
Inactive Mines in Region 2

(Water Code defines “abandoned mine” as no RP)
<table>
<thead>
<tr>
<th>Location</th>
<th>Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gambonini (Marin)</td>
<td>mercury</td>
</tr>
<tr>
<td>La Joya (Napa)</td>
<td>mercury</td>
</tr>
<tr>
<td>New Almaden (Santa Clara)</td>
<td>mercury</td>
</tr>
<tr>
<td>Mine Hill, Senator, Jaques Gulch, Hicks Flat, San Mateo, Enriquita, San Francisco Open Cut, and portions of Alamitos Creek and Deep Gulch</td>
<td>mercury</td>
</tr>
<tr>
<td>Challenge/Stulsaft (San Mateo)</td>
<td>mercury</td>
</tr>
<tr>
<td>Leona (Alameda)</td>
<td>sulfur</td>
</tr>
<tr>
<td>Black Diamond (Contra Costa)</td>
<td>coal</td>
</tr>
</tbody>
</table>
Leona Heights Sulfur Mine: Before
Leona Heights Sulfur Mine: After Cleanup

https://www.waterboards.ca.gov/sanfranciscobay/water_issues/hot_topics/Leona.shtml
Current Investigations/Remedial Efforts

- Guadalupe (Santa Clara) - mercury
- Hillsdale (Santa Clara) – mercury
- New Almaden (Santa Clara) - mercury
  - Randol, Hacienda Furnace Yard, Santa Mariana, Valesco, Harry, Central Stope, Cora Blanca
- April, Cristobal, San Francisco, Enriquita, Santa Teresa, and Bernal (Santa Clara) - mercury
- Cycle and Franciscan (Marin) - mercury
Hillsdale Mercury Mine
(GeoTracker T10000007018)
Unaddressed Mines

- 6 **mercury** mines
- 1 **sulfur** mine
- 3 **coal** mines
- 1 **chromium** mine district
- 2 **copper** mines
- 2 **silver** mines
- 13 **manganese** mine districts
- 2 **magnesium** mines
Prioritization Strategy

GOALS AND OBJECTIVES
Maximize efficient use of available resources to identify and rank mines that impact water quality

Project phases:

I. Desktop analysis to prioritize for inspection
II. High priority mine inspection, site screening data collection
   I. Interim remedy implementation
III. Prioritize for regulatory action
IV. Regulatory action
   i. Investigation
   ii. Remediation
   iii. Efficacy Verification & Maintenance
V. Medium priority mine inspection, eval unknowns (see USGS MRDS)
Prioritization Objectives

Key questions for all phases of prioritization:

- Is the site contaminated?
  - Solid mining wastes
    - Tailings/Calcines  Overburden  Low Grade Ore  Exposed Vein  Fall out...
  - Liquid mining wastes
    - ARD  Seeps  Adit Drainage  Leachate...
  - Other sources (processing chemicals, equipment chemicals...)

- Is the contamination mobile?
  - Erodible, eroding solids; liquids discharging offsite

- Is the site impacting water quality (hydrologically connected)?
Prioritization Strategy

DESKTOP ANALYSIS - DATA COLLECTION
Inspections Are Resource Intensive
Estimate Impacts from Desktop Using...
Collate and summarize available data, highlight factors relevant to potential impacts, score and rank mines for inspection.

<table>
<thead>
<tr>
<th>Category</th>
<th>Column Type</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINE</td>
<td>Data</td>
<td>Site identification data for ease of scrolling through large excel database.</td>
</tr>
<tr>
<td>STATUS</td>
<td>Results</td>
<td>Status summary information for use in documents and GIS Layer.</td>
</tr>
<tr>
<td>LOCATION</td>
<td>Data</td>
<td>Location data for virtual and literal inspections.</td>
</tr>
<tr>
<td>PRIORITIZATION SCORES</td>
<td>Results</td>
<td>Prioritization ranking scores, summarize relevant data columns.</td>
</tr>
<tr>
<td>MINE CHARACTERISTICS</td>
<td>Data</td>
<td>Summarize relevant information from data sources columns.</td>
</tr>
<tr>
<td>HYDROLOGY/GEOMORPHOLOGY/WATERSHED CHARACTERISTICS</td>
<td>Data</td>
<td>Summarize relevant information from data sources columns.</td>
</tr>
<tr>
<td>ADMIN</td>
<td>Data</td>
<td>Administrative information, including ownership and access information.</td>
</tr>
<tr>
<td>DATA SOURCES</td>
<td>Data Sources</td>
<td>Summarize information obtained from each existing and new source of data reviewed.</td>
</tr>
</tbody>
</table>
## Data Sources in MSD

<table>
<thead>
<tr>
<th>Mine Characteristics</th>
<th>Hydrologic Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS Database: USGS MRDS</td>
<td>GIS Database: USGS topo maps</td>
</tr>
<tr>
<td>GIS Database: USGS Prospects and Mine-Related Features</td>
<td>GIS Database: USGS NHD (med &amp; high resolution)</td>
</tr>
<tr>
<td>GIS Database: DOC PAMP</td>
<td>Google Earth and ArcGIS ruler and grade tools</td>
</tr>
<tr>
<td>Minedat.org, Westernmininghistory.com</td>
<td></td>
</tr>
<tr>
<td>Historical images (Google Earth and NMMR)</td>
<td></td>
</tr>
<tr>
<td>* XRF metal/metalloid concentration data of mining waste, soils, sediments</td>
<td></td>
</tr>
<tr>
<td>* Inspection findings</td>
<td>Previous inspection/er reports, notes, input</td>
</tr>
<tr>
<td>Google Earth and ArcGIS satellite images</td>
<td></td>
</tr>
<tr>
<td>Chemical Impairment Status - GIS Database: EPA MyWaters (303d, TMDLs)</td>
<td></td>
</tr>
<tr>
<td>GIS Database: OEHHA Fish Advisories</td>
<td></td>
</tr>
<tr>
<td>GeoTracker and Envirostor</td>
<td></td>
</tr>
</tbody>
</table>

* Collected during inspection, thus only used to prioritize regulatory action.


MRDS – Mines Resources Data System

DOC PAMP – California Department of Conservation Abandoned Mine Lands Unit Principle Areas of Mine Pollution

NMMR – National Mine Map Repository

NHD – National Hydrography Dataset
Prioritization Factors

- Site specific data on prioritization factors
  - How to identify potential water quality impacts?
    - Mine characteristics
    - Hydrologic/geomorphic characteristics

* There must also be sufficient data available for all mines, to avoid skewing the results.
# Mine Characteristic Factors

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineralogy (commodity and gangue)</td>
<td>Indicates potential COCs and ARD</td>
</tr>
<tr>
<td>Mine productivity</td>
<td>More productive mines may contain more contamination</td>
</tr>
<tr>
<td>Mine size</td>
<td>Larger mines may contain more contamination</td>
</tr>
<tr>
<td>Mining waste at surface (known/suspected from aerials)</td>
<td>Wastes at the surface may be more mobile</td>
</tr>
<tr>
<td>Volume of mining waste (known/suspected from aerials)</td>
<td>If mining waste is contaminated, the larger the volume the greater the threat</td>
</tr>
<tr>
<td>Mining waste mobility, e.g., evidence of erosion or drainage (known/suspected from aerials)</td>
<td>Increases probability of offsite discharge</td>
</tr>
</tbody>
</table>
| Evidence ore processed on site                      | - Processed ore (tailings) can contain more environmentally available contaminants, and   
|                                                      | - Ore processing was generally inefficient, leading to contamination of native soils.                                                       |
## Mine Characteristic Factors (cont.)

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Applicability</th>
</tr>
</thead>
</table>
| Mining Equipment remains on site (known/suspected from aerials)           | - Evidence Ore processed on site  
- Can be a continuing source of contamination (and can inform targeted sampling)                                                   |
| WB files/reports                                                          | Indicates previous inspectors determinations and recommendations regarding water quality threat                                                |
| * XRF data of mining waste, soil, sediment                                | Indicates metal/metalloid contamination                                                                                                        |
| * pH data                                                                  |                                                                                                                                               |
| * Inspection of geotechnical characteristics of mining waste and/or contaminated soils/sediments and for evidence of leaching or ARD. | Indicated offsite discharge                                                                                                                      |

* Collected during inspection, thus only used in second phase of analysis to inform regulatory action.
## Hydrologic Connectivity Factors

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite and historical images</td>
<td>Indicates current and historic drainages</td>
</tr>
<tr>
<td>National Hydrography Dataset (NHD)</td>
<td>Indicates drainages and receiving waters</td>
</tr>
<tr>
<td>USGS Topographic Maps</td>
<td>Provides rough estimate potential for off-site discharges to reach receiving waters</td>
</tr>
<tr>
<td>“Ruler” and “Grade” tools to estimate distance and grade of mine and mine features (e.g., piles of mining waste) to receiving waters or drainages</td>
<td>Provides rough estimate potential for off-site discharges to reach receiving waters</td>
</tr>
<tr>
<td>Receiving water impairment with potential mine COC (e.g., 303d)</td>
<td>- Can signal potential discharge</td>
</tr>
<tr>
<td></td>
<td>- Indicates potential sensitive habitat</td>
</tr>
<tr>
<td>Fish advisories</td>
<td>- Can signal potential discharge</td>
</tr>
<tr>
<td></td>
<td>- Indicates potential sensitive habitat</td>
</tr>
<tr>
<td>WB files/reports</td>
<td>Indicates previous inspectors determinations and recommendations regarding water quality threat</td>
</tr>
</tbody>
</table>
## Hydrologic Connectivity Factors (cont.)

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Inspection of drainages, tributaries…</td>
<td>- Confirm surface water connectivity</td>
</tr>
<tr>
<td></td>
<td>- Identify discharged waste</td>
</tr>
<tr>
<td>* Inspection for geomorphological characteristics of site and drainage</td>
<td>- Identify sensitive habitats</td>
</tr>
<tr>
<td>Potentially:</td>
<td></td>
</tr>
<tr>
<td>- Sensitive Habitat (USFWS National Wetland Inventory, Inspections)</td>
<td></td>
</tr>
<tr>
<td>- Fishing locations (CDFW <a href="https://map.DFG.ca.gov/fishing/">https://map.DFG.ca.gov/fishing/</a>)</td>
<td></td>
</tr>
<tr>
<td>- Protected species (California Natural Diversity Database)</td>
<td></td>
</tr>
<tr>
<td>- Density of mine features density of mines discharging to same receiving water</td>
<td></td>
</tr>
</tbody>
</table>

* Collected during inspection, thus only used in second phase of analysis to inform regulatory action.
Satellite Reconnaissance
Satellite Reconnaissance GIS

[Image of a satellite image with a pop-up window displaying data about Hastings Mine. The data includes fields such as FID, DEP_ID, SITE_NAME, LATITUDE, LONGITUDE, REGION, COUNTRY, STATE, COUNTY, COMMOD1, M, COMMOD3, OPER_TYPE, DEP_TYPE, PROD_SIZE, DEV_STAT, ORE, GANQUE, OTHER_MATL, OREBODY_FM, WORK_TYPE, MODEL, ALTERATION, CONC_PROC, PREV_NAME, ORE_CTRL, REPORTER, HROCK_UNIT, HROCK_TYPE, AROCK_UNIT, AROCK_TYPE, and SUBUNIT.]
Satellite Reconnaissance

GIS

Hastings Mine

PAMP_KEY: 1424
PAMP_NUM: 2023A
NAME_OF_MI: Hastings Mine
OWNER:
DMLAT: 380691
DMLONG: 1220999
DDLAT: 38.1152
DDLONG: -122.166
COUNTY: Solano
COMMODITIE: mercury
HISTORY: active in 1870s, 1904-1905, 1917-1920, 1927-1930, inactive 1930
TYPE_OF_MI: underground
POINT_OF_D: Sulphur Springs Creek (Lake Herman)
POTENTIAL: mine closed because of excessive water, potential Hg contamination of surface waters
REFERENCES: CDMG Bull 748, p 171-2 (1918), Bull. 149, p 100-1
Surface Water Flow-Lines

GIS

Potential Mining Waste Pile

Spring Flow-Path
Topographic Data to Estimate Grade

Potential Mining Waste Pile

Spring Flow-Path

© www.historicmapdyds.com
Water/Habitat Quality Databases
Water/Habitat Quality Databases GIS
Water/Habitat Quality Databases GIS
Prioritization Strategy

DESKTOP ANALYSIS - SCORING/RANKING TOOL
Factors Affecting Water Quality

- Factors are weighted and mines scored
  - Exacerbating Factors +, ++, ...
  - Mitigating Factors −, ‒, ...
  - Summed for total score
  - Higher score = higher water quality threat
- Mines ranked by score
- Relatively low tech, but sufficient for site screening/prioritization; balance between accurate and efficient.
## Prioritization Scoring/Ranking System

<table>
<thead>
<tr>
<th>Mine Characteristics</th>
<th>Scores for Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commodity COC</strong></td>
<td>++++ Hg, S (or ARD), Pb, Cr</td>
</tr>
<tr>
<td></td>
<td>+ Cu, Ag, Au, Sb, coal</td>
</tr>
<tr>
<td></td>
<td>- Remaining</td>
</tr>
<tr>
<td><strong>Other COC (e.g., associated with gangue)</strong></td>
<td>++ Hg, S (or ARD), Pb, Cr</td>
</tr>
<tr>
<td></td>
<td>+ Cu, Ag, Au, Sb, coal</td>
</tr>
<tr>
<td></td>
<td>0 Remaining</td>
</tr>
<tr>
<td><strong>Buffering Mineralogy</strong></td>
<td>- For carbonates (Only relevant if commodity or COC indicates potential for ARD. Also, to be conservative, will only apply for carbonates in addition to silica-carbonate alterations of mercury)</td>
</tr>
<tr>
<td><strong>Mine Productivity/Size</strong></td>
<td>++ thru --</td>
</tr>
<tr>
<td><strong>Ore Processed On Site</strong></td>
<td>++ Known yes</td>
</tr>
<tr>
<td></td>
<td>+ Suspected yes</td>
</tr>
<tr>
<td></td>
<td>-- Known no</td>
</tr>
<tr>
<td></td>
<td>0 Remaining</td>
</tr>
</tbody>
</table>
### Prioritization Scoring/Ranking System

<table>
<thead>
<tr>
<th>Mine Characteristics (cont.)</th>
<th>Scores for Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Piles Evident</td>
<td>++ Known, large volume</td>
</tr>
<tr>
<td></td>
<td>+ Suspected, large volume or known or suspected small volume</td>
</tr>
<tr>
<td></td>
<td>0 Remaining</td>
</tr>
<tr>
<td>Erosion or Mine Drainage Evident</td>
<td>+++ Known, large volume</td>
</tr>
<tr>
<td></td>
<td>++ Suspected, large volume, Known or suspected small volume</td>
</tr>
<tr>
<td></td>
<td>-- Known none</td>
</tr>
<tr>
<td></td>
<td>0 Remaining</td>
</tr>
</tbody>
</table>
### Prioritization Scoring/Ranking System

<table>
<thead>
<tr>
<th>Hydrology Characteristics</th>
<th>Scores for Ranking</th>
</tr>
</thead>
</table>
| Potential Connection to Receiving Water (distance and grade     | +++ Known Waste Pile  
| from mine feature to receiving water)                          | ++ Suspected Waste Pile, Known Connected Drainage  
|                                                                | + Suspected Connected Drainage, Known Closest Mine Feature  
|                                                                | -- Known none  
|                                                                | 0 Remaining |
| Potential Connection to Drainage (ephemeral or intermittent     | ++ Known connection of waste pile  
| creek, distance and grade)                                      | + Suspected connection of waste pile, known connection of other mine feature  
|                                                                | -- Known none  
|                                                                | 0 Remaining |
| Adjacent Receiving Water Impaired By Mine COC                   | ++ to +++ Yes    |
|                                                                | 0 No |
| Distant Receiving Water Impaired By Mine COC                    | + Yes    |
|                                                                | 0 No |
### Prioritization Scoring/Ranking System

<table>
<thead>
<tr>
<th>Hydrology Characteristics (cont.)</th>
<th>Scores for Ranking</th>
</tr>
</thead>
</table>
| Fish Advisory Based on Mine COC in Receiving Water | + Yes (Cumulative with impairment)
|                                                                 | 0 No |
| - Mine Upstream of Sensitive Habitat (e.g., for mercury wetland, reservoir, or riparian habitat) | TBD in cleanup prioritization |
| USFWS National Wetland Inventory, Inspections) | |
| - Fishing locations (CDFW) | |
| - Protected species (California Natural Diversity Database) | |
| - Density of mine features density of mines discharging to same receiving water | |
Prioritization Strategy

DESKTOP ANALYSIS - TOOL IMPLEMENTATION RESULTS
Desktop Analysis and Prioritization

Successful

- Inspection priorities changed
  - Example - Bella Oak moved down in priority
    - Distance, grade to surface water long & flat
    - Other mines closer to surface waters, impaired receiving waters

- Found mines of previously unknown location

- Discovered mines and features not identified in previous efforts

- Drainage pathways, receiving waters corrected

- Confirmed several mines not in R2
**Inspection Prioritization Results**

- **Mercury**
  - Highest priorities - St. John’s, Hastings, & Chileno Valley
  - Some medium, only a few low priority

- **Acid Mine Drainage**
  - Pendarin - Coal
  - Silverado, Palisades

- **Chromium**
  - Newman – Possible immediate human health concern (inhalation) – referred to DTSC

*Details available as a link on webpage*
Inspection/Data Collection Strategy
Site Specific Inspection Plans

- Site specific and comprehensive
- Designed to confirm desktop analysis/estimates
  - Potential Mine Features
    - Lat/long
    - Previous data/info
    - Satellite/photographic imagery suspicions
- Include historical photos for replication
- Double as inspection log for visual observations and data collection
Satellite Recon Identified Potential Mine Features
Potential Calcines and Adit
To prioritize regulatory action, NOT to fully characterize site
To confirm desktop analysis findings

### Visual Observations
- Mine features
  - Waste - unnatural topo, soil characteristics, color, odor
  - Openings (adit, shafts...)
  - Structures
- Contaminant mobility
  - Erosion and erodability
  - Mine drainage, ARD
- Hydrologic connection

### Measurements
- Distance/grade to water features
- Solids
  - Metals/metalloids via XRF
- Liquids (mine drainage, creeks, seeps...)
  - pH
  - EC
XRF DQOs and SOP (see QAPP link on webpage)

- Data Quality Objectives relatively low, site screening
- Targeted sampling for waste, contamination with XRF
- In situ analysis (unless sample needs to be air dried)
- 90-360s analysis time, longer for higher quality
- Blanks before, after & any time contamination possible, “B” flagged subtract mean from results or reported as qualitative
- Calibration before, after, & any time drift suspected, “J” flag for results outside of ± 20% (Cr 30%)
- Detection Limit calculated as 1.5 x standard error (CL set at 95%) reported for blank (or low CRM)
Implementation
Implementation – XRF Analysis
St. John’s Mercury Mine
(GeoTracker T10000011123)

- Confirmed contamination
  - Elevated $\text{Hg}$, $\text{As}$, Ni & Co (Tier 1 soil ESLs)
- Confirmed erosion and offsite discharge
- Confirmed hydrologic connectivity, intermittent (perennial flow miles downstream)

- Recommended next steps:
  - Consider interim remedial/mitigating actions, erosion of contamination discharging directly:
  - Consider requiring evaluation of risk to site visitors, grazing animals, and wildlife from arsenic:
  - Complete survey of highest priority mines, compare to remaining 2 sites, then:
  - Consider requiring investigation of remaining discharges.
Next Steps and Regulatory Tools
Next Steps

- 2 more high priority mines to inspect
- Prioritize sites for regulatory action
  - Additional factors might include:
    - Mine Upstream of Sensitive Habitat (e.g., for mercury wetland, reservoir, or riparian habitat)
  - Fishing locations
  - Protected species
  - Density of mine features density of mines discharging to same receiving water
  - IDEAS?? LMK
Regulatory Tools Provide Flexibility

- **Require investigations**
  - Water Code section 13267

- **Require cleanup (Cleanup and Abatement Order)**
  - Water Code section 13304

- **Waste Discharge Requirements**
  - California Code of Regulations Title 27

- **NPDES Industrial Stormwater Permit**
  - State Board general permit 2014-0057-DWQ
Acknowledgements

Thanks to:
Nicholas Piucci
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Kristina Yoshida
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Christina Toms
Glenda Marsh &
CAMLAG members

“Freddie Mercury” by Pablo Bustos