Effective Field Techniques and Watershed Modeling for Characterizing Mercury Loading to Surface Water

Black Butte Mine Superfund Site, Lane County, Oregon

Howard Young
Scott Coffey
Steven Wolosoff

August 13, 2014
Preliminary Conceptual Site Model

Modified from Optimization Review Report (USEPA July 2012)
Technical Approach to Characterize Mercury Loading to the Watershed

• Identify streams receiving mine impacted water discharge

• Estimate mercury loading to each stream:
  • Quantify stream discharge throughout the year
  • Quantify mercury concentrations throughout the year

• Watershed model:
  • Construct watershed model using site specific data
  • Calibrate model to stream discharge and mercury concentration data
  • Utilize the model to evaluate remedial alternatives
Presentation Outline

• Field methods to determine:
  – Water level (stage)
  – Stream Discharge
  – Mercury concentration in surface water and precipitation

• Preliminary mercury loading results

• Construction and initial calibration of the watershed model
Garoutte, Furnace, and Dennis Creek Surface Water Monitoring Stations
STAGE AND STREAM DISCHARGE MEASUREMENTS
Water Level Monitoring

- **Staff Gauge** – manual water level measurements
- **Stilling Wells** – continuous monitoring with pressure transducers
Automated Water Level and Water Quality Instrumentation

**Objectives** – Track water level and water quality year round

**Stilling Wells**
- Hand-driven well points
- Johnson Vee-wire screen, SS
- Screened 12-inches above stream bed

**Instrumentation**
- Troll 9500 – Level, turb., temp., conduct., pH
- AquaTroll 200 – Level, temp., conductivity
- 15-minute data logging intervals
Stream Discharge Estimates

Technical Approach

• Collect stream discharge measurements at a range of water levels
• Establish a rating curve relating stream discharge to water level
• Use rating curve to estimate stream discharge at any given water level

Stream Discharge Measurement Methods

1. Longitudinal stream profile surveys
2. Cross-sectional stream velocity measurements
3. V-notch weir
4. Direct measurement
2 – Cross-Section Stream Velocity Surveys

- Swoffer gauge
- Depth and velocity measured along cross-section
- Stream discharge calculated from depth, velocity, and interval length
Other Discharge Measurement Methods

3 - V-notch Weir

4 - Direct Discharge Measurement
Rating Curve for GD1
Stream Discharge vs Water Level
Stream Discharge at FC1

Discharge (cfs)

No flow observed at Furnace Creek
May 6, 2013 and November 11, 2013

No flow Continuously
Starting May 11, 2014

Daily Rainfall Total (inches)
SURFACE WATER SAMPLING
Surface Water Quality Sampling

Objective

• Determine mercury concentrations over wide range of discharge rates

Surface Water Sampling Events

• Samples collected at GU1, GD1, FC1, and DC1
• One sampling event during low-discharge in dry season
• Three storm events of different intensity and antecedent conditions
Surface Water Sampling Events

- Storm Event #1
- Storm Event #2
- Storm Event #3
- Baseline Event
- Station GU1
- Sensor Damaged
Storm Event Surface Water Sampling

Sampling Approach

- Collect 6 samples throughout the storm event for a total of 10 parameters (10 sample bottles) at each of the 4 stations (240 bottles per storm event)
- Monitor and sample precipitation throughout the storm event
- Clean-Hands protocol and low-level mercury analysis

Logistical Challenges

- Storm event tracking and predictions
- Mobilize a trained field crew of 5
- Transport of samples and equipment to remote stations
Storm Event #1 Sample Collection at Furnace Creek – FC1

---

The diagram shows a graph with water level on the y-axis and time on the x-axis. The data points are marked with the following Hg Concentration (ng/L): 595, 7340, 4820, 1350, 1200, and 776. The graph also includes rainfall data with daily and hourly totals.
Black Butte Mine Weather Station and Precipitation Sampler
PRELIMINARY RESULTS
Estimated Annual Mercury Loads and Percent of Total Load in Downstream Garoutte Creek

- **Downstream Garoutte**
  - 0.304 kg/yr (100%)
- **Dennis Creek**
  - 0.034 kg/yr (11%)
- **Furnace Creek**
  - 0.072 kg/yr (24%)
- **Upstream Garoutte**
  - 0.177 kg/yr (58%)
- **Other Tributaries**
  - 0.021 kg/yr (7%)

*Sum of the total mercury loads from the mine area*
Maximum Mercury Concentration Observed During Storm Events

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Storm Event #1</th>
<th>Storm Event #2</th>
<th>Storm Event #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Mercury (ng/L)</td>
<td>6.5</td>
<td>7,340</td>
<td>99</td>
<td>93,800</td>
</tr>
<tr>
<td>GU1</td>
<td></td>
<td>7.1</td>
<td>27</td>
<td>192</td>
</tr>
<tr>
<td>GD1</td>
<td></td>
<td>7.5</td>
<td>21</td>
<td>192</td>
</tr>
<tr>
<td>FC1</td>
<td>* peak</td>
<td>rising limb</td>
<td>rising limb</td>
<td>862</td>
</tr>
<tr>
<td>DC1</td>
<td></td>
<td>rising limb</td>
<td>rising limb</td>
<td>rising limb</td>
</tr>
</tbody>
</table>

* Bank seepage sample, not representative of surface water
WATERSHED MODEL
Black Butte Mine Watershed Model

Objectives:

• Develop a model to evaluate mercury loading downstream of Black Butte Mine
• Use the model to evaluate remedial alternatives

Modeling Approach:

• Develop the model using site specific data
• Calibrate the model based on measured stream discharge and concentration data
• Update the model as new data is collected
Watershed Model Information

Model Type:

- Watershed Analysis Risk Management Framework Stream Water Quality Model (WARMF model)

Model Inputs:

- Site digital elevation model (DEM)
- Subcatchment areas and stream locations
- Land use distribution
- Subcatchment soil types
- Time series of available meteorological, hydrologic, and water quality data
Preliminary Model Mercury Concentration Calibration
Upper Garoutte Creek
Findings

• Mercury in surface water is present primarily as suspended mercury

• Mercury flux in downstream Garoutte Creek is greater than at upstream Garoutte Creek

• Estimated annual mercury loads indicate that Furnace Creek contributes only 24% of the total mercury load to Garoutte Creek

• High flow storm events have potential to generate very high suspended mercury concentrations and a much higher flux of mercury from Furnace and Dennis Creek to Garoutte Creek.

• The watershed model is capable of predicting mercury concentrations in downstream watershed
Next Steps

• Update annual mercury loading calculations using Storm Event #2 and Storm Event #3 mercury data and available discharge data

• Calibrate the watershed model using Storm Event #2 and Storm Event #3 mercury data and all available discharge data

• Storm event surface water and sediment sampling at multiple stations to identify particulate mercury source areas

• Use the watershed model to simulate source control alternatives
QUESTIONS?