A Preliminary Evaluation of Road Deicing Chemical Concentrations in North Idaho Streams Adjacent to Interstate 90 and Draining Fourth of July Pass

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Coeur d’Alene Lake Tributary WAG
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Discussion Topics

- Problem
- Background
- Study Area
- Project Findings
- Aquatic Life
- Conclusions
Deicing chemical application is increasing in north Idaho and instream concentrations are unknown.
Roadside Vegetation

April 25, 2008

February, 2011
Improving Winter Driving

- 51% of world’s salt produced is used for road deicing – annual US 15-20 million tons
- ITD began using NaCl in 2003 and has since expanded use to entire 5 county area
- Current the application rate of NaCl in north Idaho is 150-300 pounds per lane mile
  - Four lane per mile = 600-1,200 lbs/mile
- 30 salting events during a typical winter
- 80 salting events during winter 07/08
Improving Winter Driving

- Historically traction sand or sand/salt mix was used to improve traction
- Salt is more effective, longer lasting, and less expensive
Study Area
Project Scope

1. Determine if road deicing agents are transported to adjacent water bodies,

2. And if so what are the instream concentrations?

3. **Determine aquatic life tolerances…**
Monitoring Equipment

Cedar Creek 2008

Cedar Creek 2010-2011
Common Deicing Chemicals

- Sodium Chloride*
- Magnesium Chloride*
- Calcium Chloride*
- Calcium Magnesium Acetate*
- Ammonium Sulfate
- Potassium Acetate
- Potassium Chloride
- Urea

• Approved by Pacific Northwest Snowfighters Association

http://www.wsdot.wa.gov/partners/pns/default.htm
Deicing Chemical

Composition of Road Deicer Concentrate

- Sodium: 39%
- Chloride: 61%
- Potassium: 0%
- Magnesium: 0%
- Calcium: 0%
- Sulfate: 0%
- Iron: 0%

One gram of NaCl contains 0.3933 grams of sodium and 0.6067 grams of chloride or one gram of NaCl is 39% sodium and 61% chloride.
Monitoring and Lab Results

- Streams sampled 11 different occasions
  - February 14 through June 3, 2008

- Streams sampled monthly
  - October 2009 and continuing

- Samples analyzed for Sodium, Chloride, Magnesium and Calcium
Regression Analysis (2008)

Cedar, Fourth of July, and Fern Creek
Specific Conductance - Sodium (mg/L) and Chloride (mg/L)

\[ y = 0.1249x - 1.4396 \]
\[ R^2 = 0.9474 \]

\[ y = 0.2554x - 6.5326 \]
\[ R^2 = 0.977 \]
Fern Creek (Control Stream)
Regression Analysis

Specific Conductance - Sodium (mg/L) and Chloride (mg/L)

\[ y = 0.0388x + 1.0862 \]
\[ R^2 = 0.6414 \]

\[ y = 0.0427x - 0.3879 \]
\[ R^2 = 0.5789 \]
Dominant Ion Shift

- Sodium (mg/L)
- Chloride (mg/L)
- Streams impacted by highway runoff
- Stream not impacted by highway runoff

Graph showing the relationship between specific conductance (uS/cm) and sodium or chloride concentrations in streams impacted by highway runoff and those not impacted by highway runoff.
Specific Conductivity 2010-2011

Maximum 1,820
Minimum <1
Sodium Chloride Concentrations – Fourth of July Creek

2008

Maximum
471 µS/cm
58 mg/L – Na
112 mg/L - Cl
Sodium Chloride Concentrations – Fourth of July Creek

2010-2011

2010
Maximum
1,820 µS/cm
186 mg/L – Na
386 mg/L - Cl

2011
Maximum
827 µS/cm
85 mg/L – Na
175 mg/L - Cl
Sodium Chloride Concentrations – Fern Creek (Control)

2010-2011

2010
Maximum
26.8 µS/cm
2.85 mg/L – Na
0.64 mg/L - Cl
Instream Sodium Chloride Loads

Steps
1. Develop regression equations
2. Apply regression equations to continuously monitored specific conductivity
3. Estimate stream flow
4. Calculate load
Instream Sodium Chloride Loads

- Estimated stream flow
  - Measured stream discharge during 5 visits
  - Applied drainage area ratio to USGS gauging station 12415350
  - Nine years of discharge data 1986-1995
Drainage-Area Ration Equation used to estimate ungauged streams:

\[ Y = (A1/A2)X \]

- \( Y \) = Estimated stream flow from ungauged stream
- \( A1 \) = Drainage area in square miles from site of interest
- \( A2 \) = Drainage area in square miles from gauged stream
- \( X \) = Recorded stream flow in cubic feet per second recorded at gauging station

**Estimating Stream Flows**
Stream Level/Stage

Stream Level

Level/Stage

Month

Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

Fourth of July
Cedar
Fern
Level/Stage vs Discharge (cfs)

Fern Creek Level vs Discharge

\[ y = 0.0222e^{0.0446x} \]

\[ R^2 = 0.4507 \]

Fourth of July Level vs Discharge

\[ y = 0.0111e^{0.0608x} \]

\[ R^2 = 0.45 \]

Cedar Creek Level vs Discharge

\[ y = 0.0004e^{0.0882x} \]

\[ R^2 = 0.5256 \]
Instream Loads (2008)

Pounds per day = (stream flow (cfs)) (concentration (mg/L))(5.396)
Minus background load = Pounds per day attributable to road salt

<table>
<thead>
<tr>
<th>Stream</th>
<th>Total Load (tons)</th>
<th>Background Load (tons)</th>
<th>Road Salt Load (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar Creek</td>
<td>363</td>
<td>108</td>
<td>255</td>
</tr>
<tr>
<td>Fourth of July Creek</td>
<td>402</td>
<td>97</td>
<td>305</td>
</tr>
</tbody>
</table>
Application Rate

Application rate = 150-300 pounds per lane mile
4 lanes per mile
80 application events in winter 07/08
4.3 miles of I-90 draining Cedar Creek
4.7 miles of I-90 draining Fourth of July Creek

Cedar Creek = 103-206 tons
Fourth of July Creek = 113-225 tons
Aquatic Life

<table>
<thead>
<tr>
<th>Species</th>
<th>NaCl (mg/L)</th>
<th>Cl (mg/L)</th>
<th>Response Type</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue gill</td>
<td>14.100</td>
<td>8.553</td>
<td>1 day LC50</td>
<td>Acute survival</td>
</tr>
<tr>
<td></td>
<td>9.627 – 12.964</td>
<td>5.840 – 7.864</td>
<td>4 days LC50</td>
<td>Acute survival</td>
</tr>
<tr>
<td></td>
<td>20,000</td>
<td>12,132</td>
<td>6 hours LC45</td>
<td>Acute survival</td>
</tr>
<tr>
<td>Brook trout</td>
<td>50,000</td>
<td>30,330</td>
<td>15 minutes LC50</td>
<td>Acute survival</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>11,112</td>
<td>6,743</td>
<td>4 day LC50</td>
<td>Acute survival</td>
</tr>
<tr>
<td></td>
<td>20,000</td>
<td>12,312</td>
<td>6 hour LC40</td>
<td>Acute survival</td>
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<tr>
<td>Rainbow trout</td>
<td>2,400</td>
<td>1,456</td>
<td>7 to 10 day LC50</td>
<td>Sub-chronic Survival</td>
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<tr>
<td>egg embryo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>2,630</td>
<td>1,595</td>
<td>7 to 10 day LC50</td>
<td>Sub-chronic Survival</td>
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<tr>
<td>embryo/Alvin</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Caddisfly</td>
<td>5,526 – 7,014</td>
<td>4,039 – 4,255</td>
<td>4 days LC30</td>
<td>Acute survival</td>
</tr>
<tr>
<td>Chironomid</td>
<td>9,995</td>
<td>6,063</td>
<td>12 hours LC50</td>
<td>Acute survival</td>
</tr>
<tr>
<td></td>
<td>5,192 – 6,637</td>
<td>3,795 – 4,026</td>
<td>4 days LC50</td>
<td>Acute survival</td>
</tr>
<tr>
<td>Diatom</td>
<td>2,430</td>
<td>1,474</td>
<td>7 to 10 day EC50</td>
<td>Sub-chronic Survival</td>
</tr>
</tbody>
</table>

Highest estimated Chloride concentration = 386 mg/L

MN Cl standard
Acute = 860 mg/L
Chronic = 230 mg/L

(EC, 2001; USEPA, 1988; Nagpal et al., 2003; Hart et al., 1991)

EC50 – the concentration that caused an effect in 50% of the test population indicated the level of acute toxicity.
LC50 – the concentration which caused death in 50% of the tested population.
Other Impacts

- Interaction with other compounds altering natural stream chemistry
- Decreased soil permeability
- Ground water contamination
- Altered lake stratification and turnover
- Riparian vegetation degradation
Conclusion

- Road salt is transported to adjacent waters
- Specific conductivity and NaCl concentrations recede after the winter driving season
- Measured and estimated instream concentrations do not exceed researched aquatic life toxicity thresholds
- Cumulative impacts from continued use is to be determined
Questions

Final 2008 Deicer Report
http://www.deq.idaho.gov/about/regions/panhandle_bag/deicer_report.pdf

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