Evaluation of Service Loss: Molycorp Surface Water HEA

Hillary Browning
David Chapman
Josh Lipton

Stratus Consulting Inc.
Boulder, CO

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Presentation Overview

Service loss approaches

Invertebrate results

Fish results

Toxicity model results

Summary and implications

Overview of Approach to Service Loss

- Based on May 11, 2004 meeting with Molycorp Tech Representatives
- Developed a tiered approach to estimate service loss
  - First – Evaluate biological (resident trout, invertebrates) data
  - Second – Evaluate toxicity data to confirm biology
  - If toxicity suggest greater impacts than biology, average biology and toxicity service loss
  - No explicit agreements re “combining” trout, invertebrates

Overview of Approach to Service Loss (cont'd)

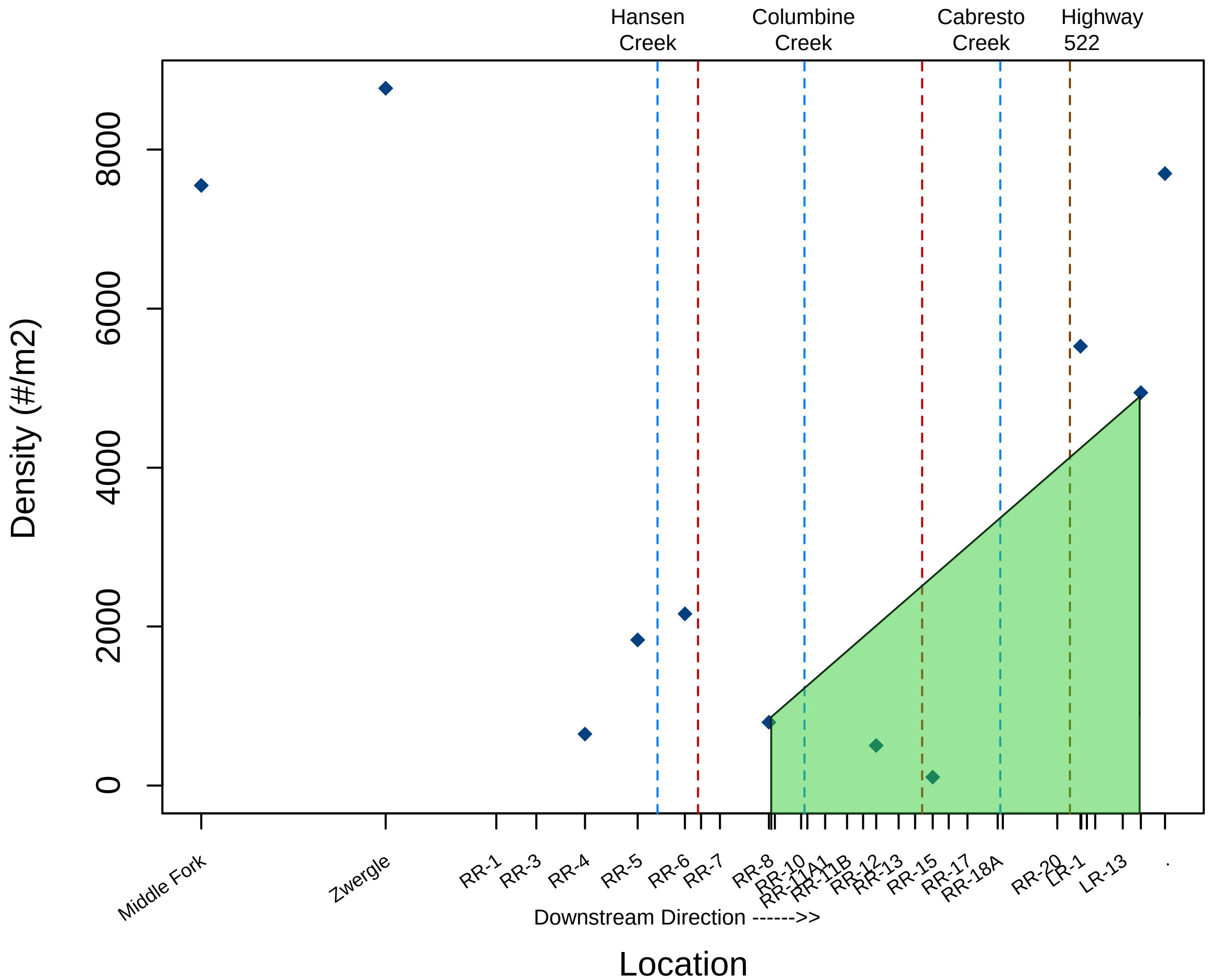
Agreed-upon conceptual model:

- Hansen Cr./scar influences degrade river
- Absent mine contributions, recovery should begin at Columbine Cr.
- Evaluate service loss as integrated difference in current conditions v. assumed recovery trajectory downstream of Hansen Cr. (AKA, the "wedge")

Technical Approach

- "Primary" service loss calculation based on biological data
  - Resident trout population density
  - Invertebrate density (all taxa); other invertebrate metrics?
- Consider water chemistry as "check" on biological approach: "joint toxicity approach"
- How to calculate service loss?
  - The "wedge"

Invertebrate Density (#/m2) in spring of 2002



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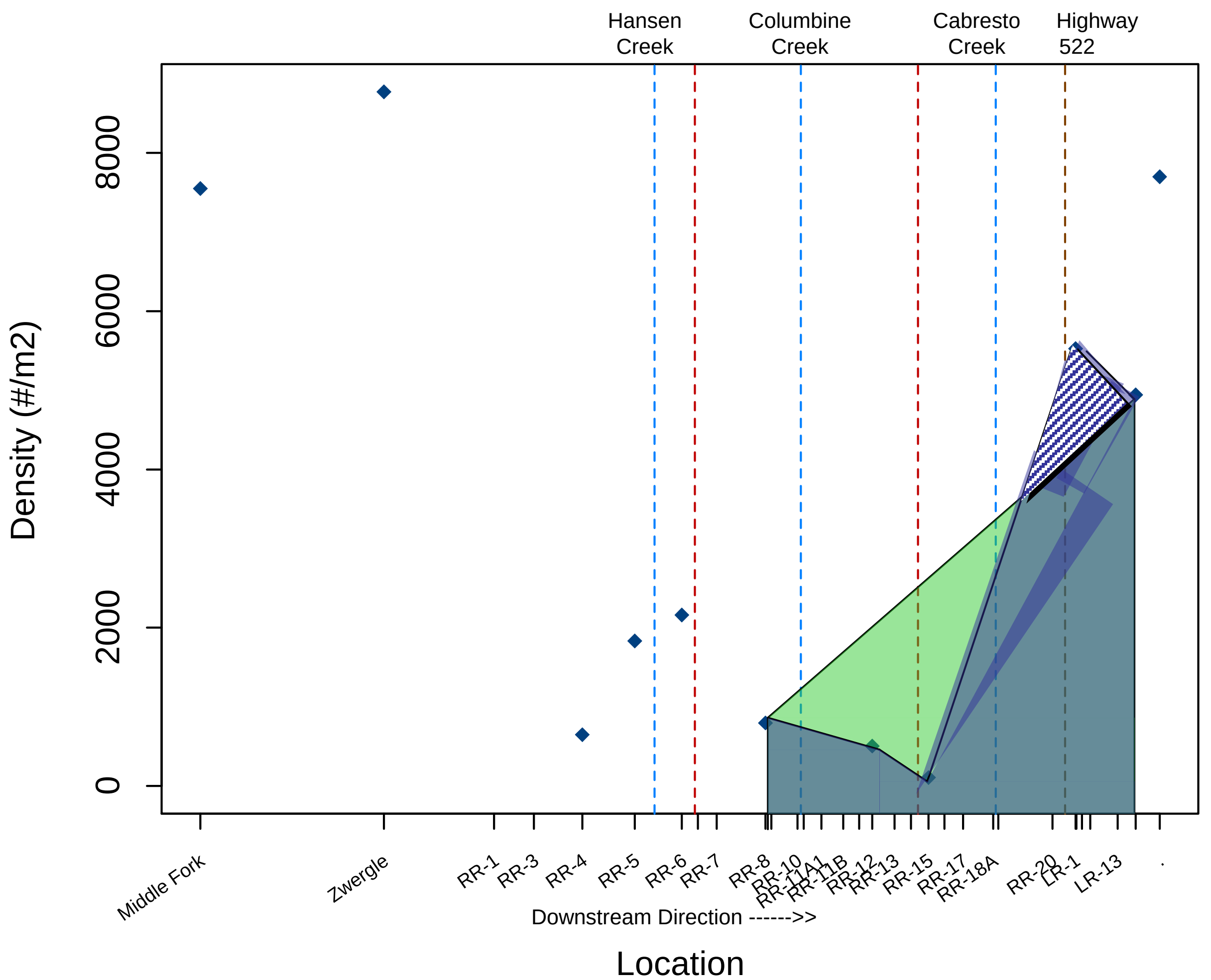
Invertebrate Density (#/m2) in spring of 2002



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Approach (cont.)

Calculating service loss

- *Percent* population reduction = % service loss
- *Difference* in toxicity = % service loss
- Calculated as differential in area under curves

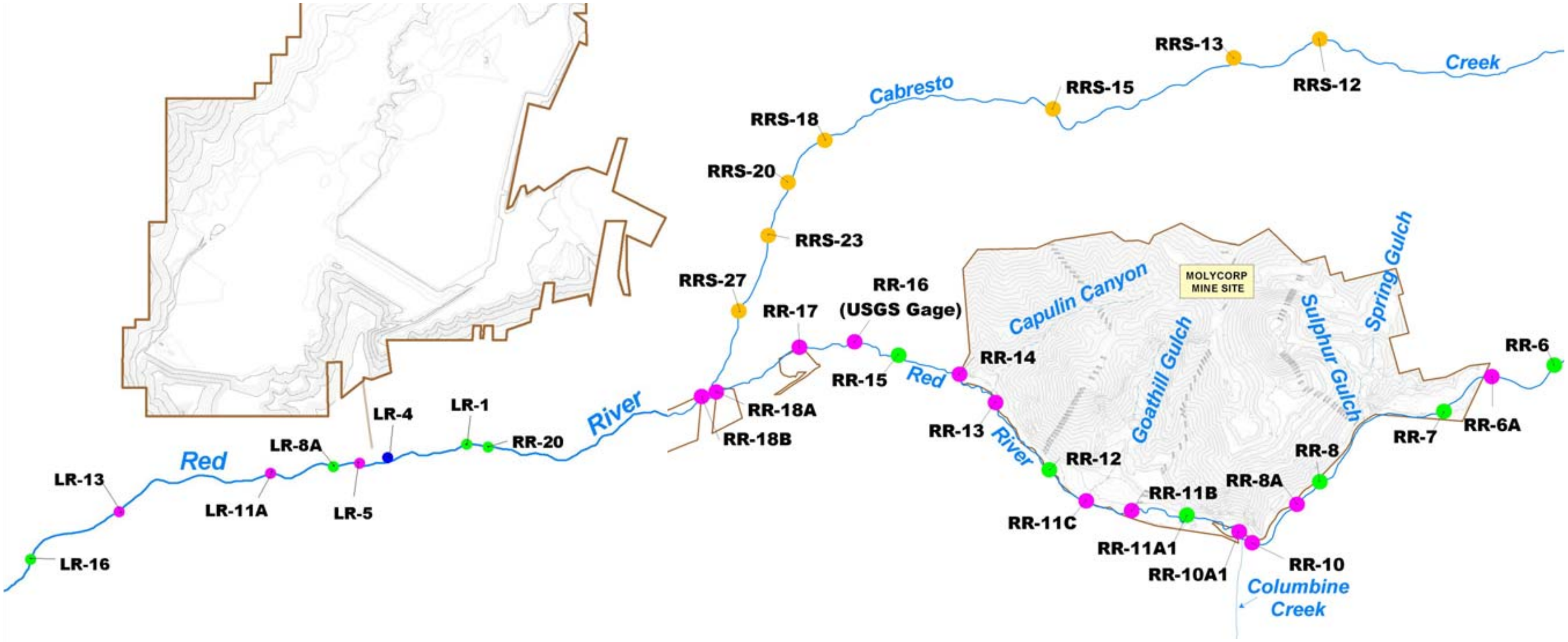
Service Loss Analysis

Sampling locations used in analysis

Data sources and availability

Results

RI/FS Surface Water Sampling Sites



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Locations used in Analysis

Station	Site Name	River Mile
RR-8	Upstream of Columbine	13.55
RR-11A1	Downstream of Cabin Springs	12.15
RR-12	Goathill Campground	10.89
RR-15	Questa Ranger Station	9.49
RR-20	Upstream of Highway 522	6.41
LR-1	Downstream of Highway 522	5.83
LR-8A	Downstream of Outfall 002	5.68
LR-16	Upstream of Hatchery	4.34

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Biological Data Availability

CEC, 1997-2003

1997-Spring 2002

- Only 4 locations available in area of interest
- No data for designated location endpoints (RR-11A1 => LR8A)

Fall 2002-Fall 2003

- Data available for designated location endpoints
- Additional data points between location endpoints

Fall and spring data for invertebrates; fall data only for fish

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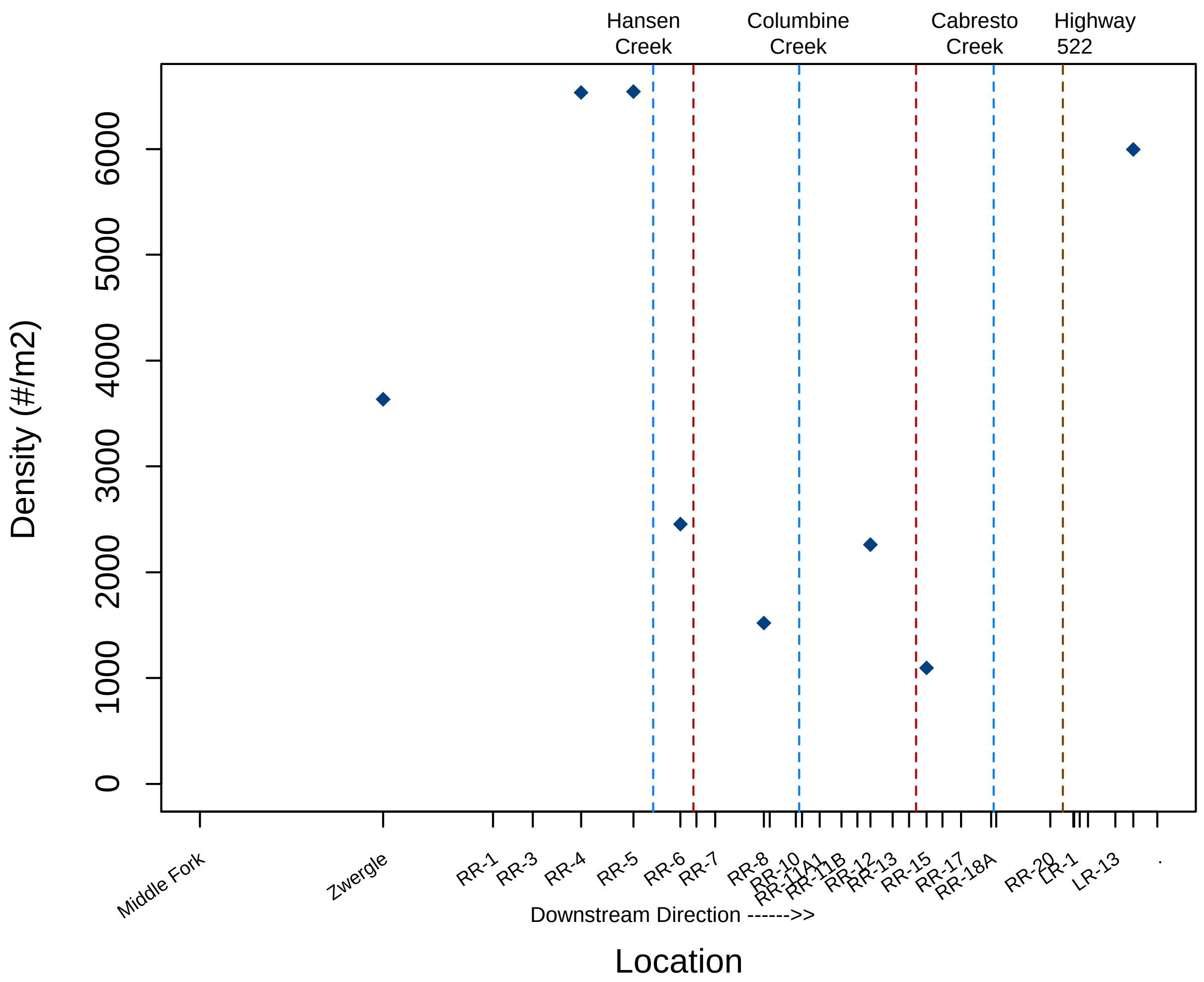
Invertebrate Density (#/m2) in fall of 1998



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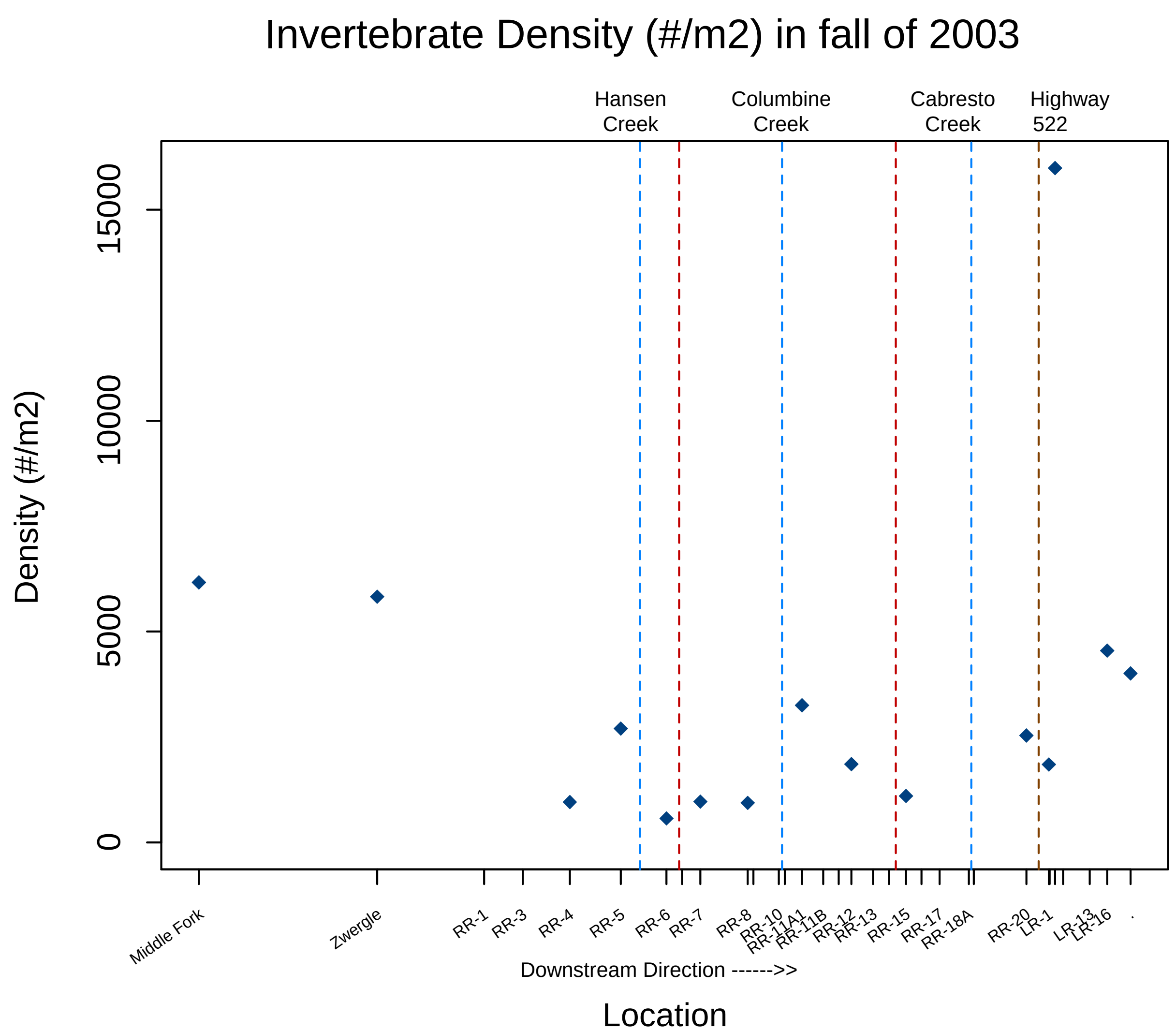

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Potential Analysis Approaches

Option 1: Use agreed-upon location endpoints: RR-11A1 and LR-8A

- Only possible for 2002 and 2003
- Use all available data for each given record

Option 2: Use alternative location endpoints: RR-8 to LR-16

- Option 2a: Use only the four data points that are available for the majority of records
- Option 2b: Use all available data for each given record

Alternative Methods: Example

Fall 2002 Data

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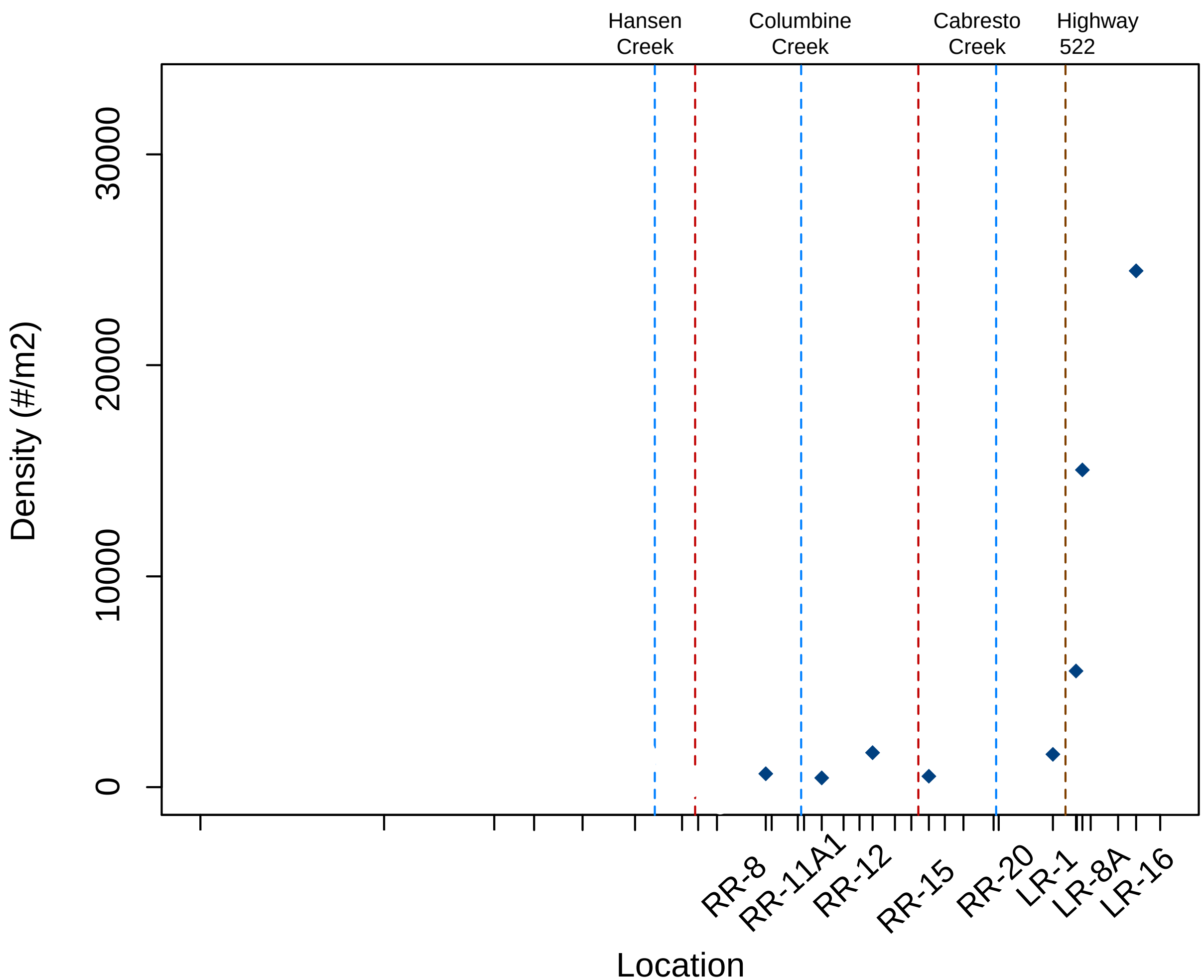
Example Data:

Invertebrate Density (#/m2) in fall of 2002



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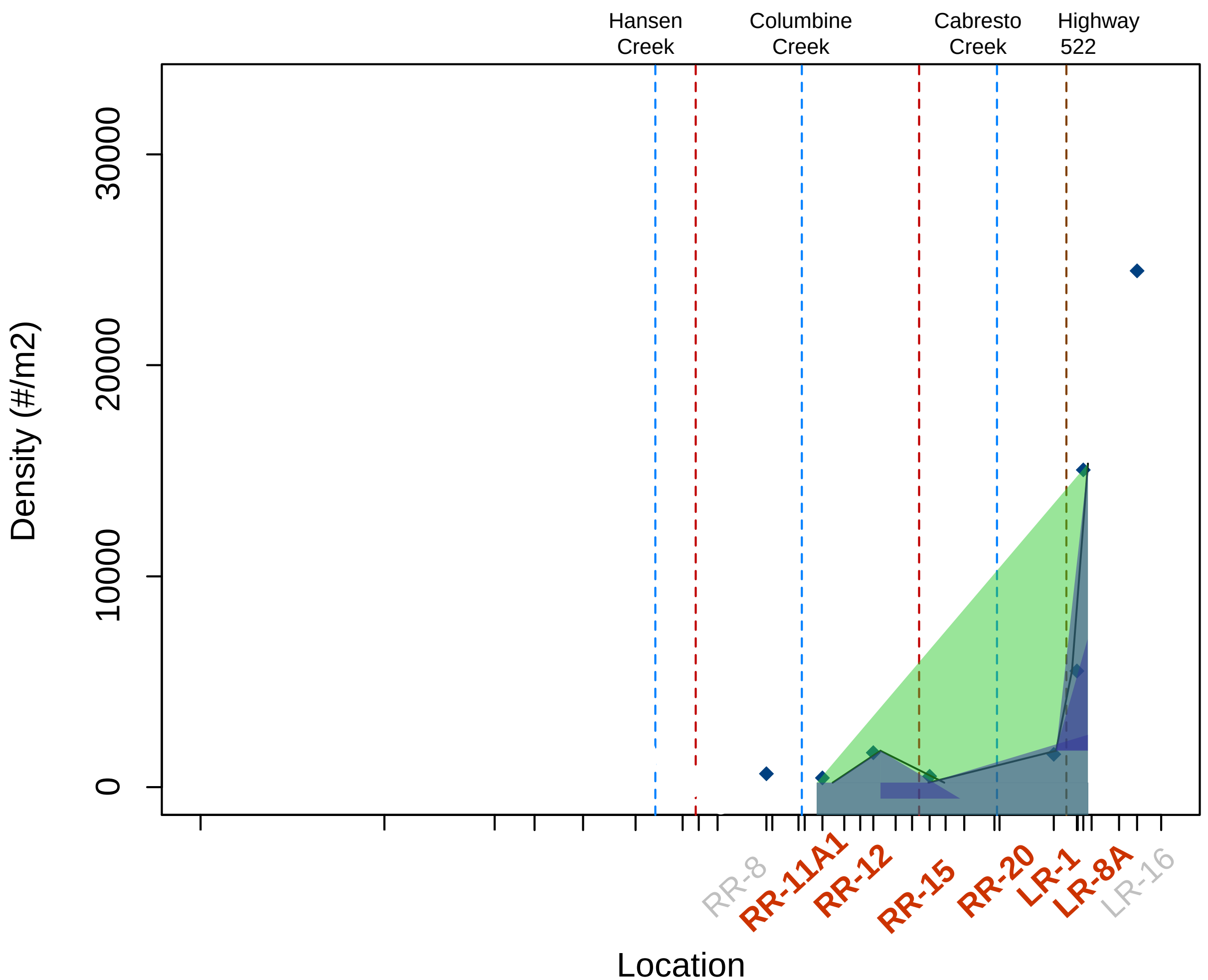
Example Option 1:

Invertebrate Density (#/m2) in fall of 2002



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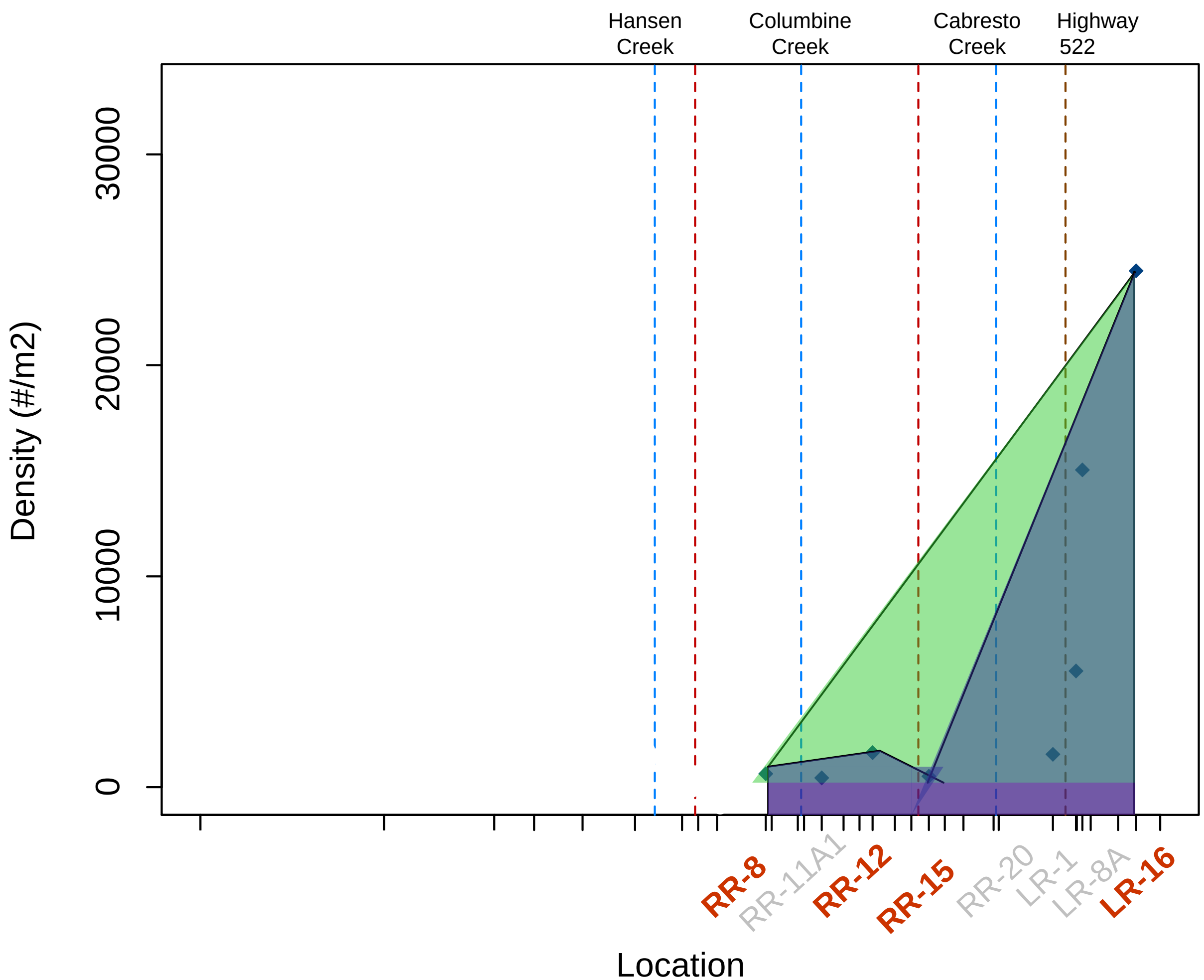
Example Option 2a:

Invertebrate Density (#/m2) in fall of 2002



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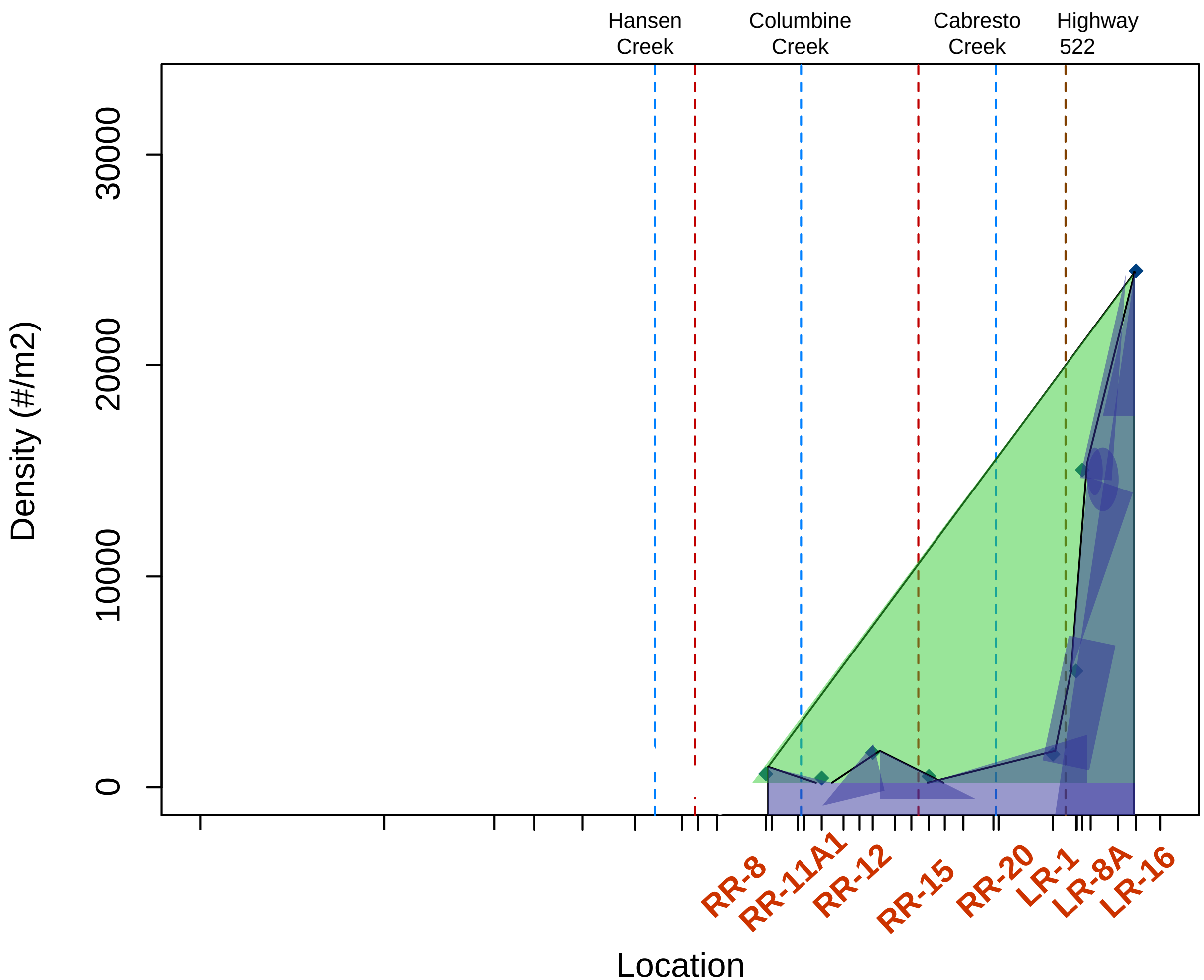
Example Option 2b:

Invertebrate Density (#/m2) in fall of 2002



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Invertebrate Results

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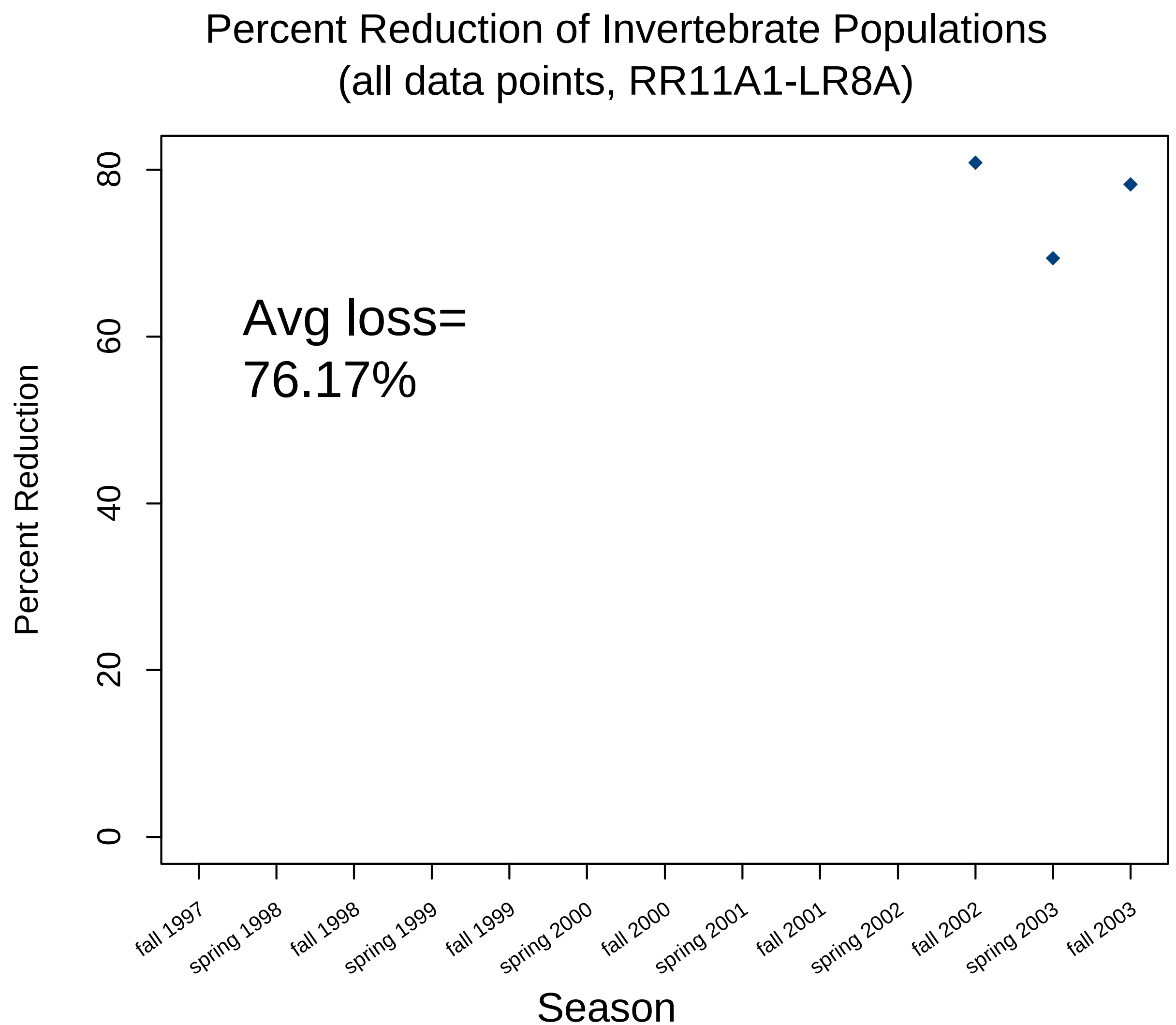
Option 1: Agreed-upon location endpoints



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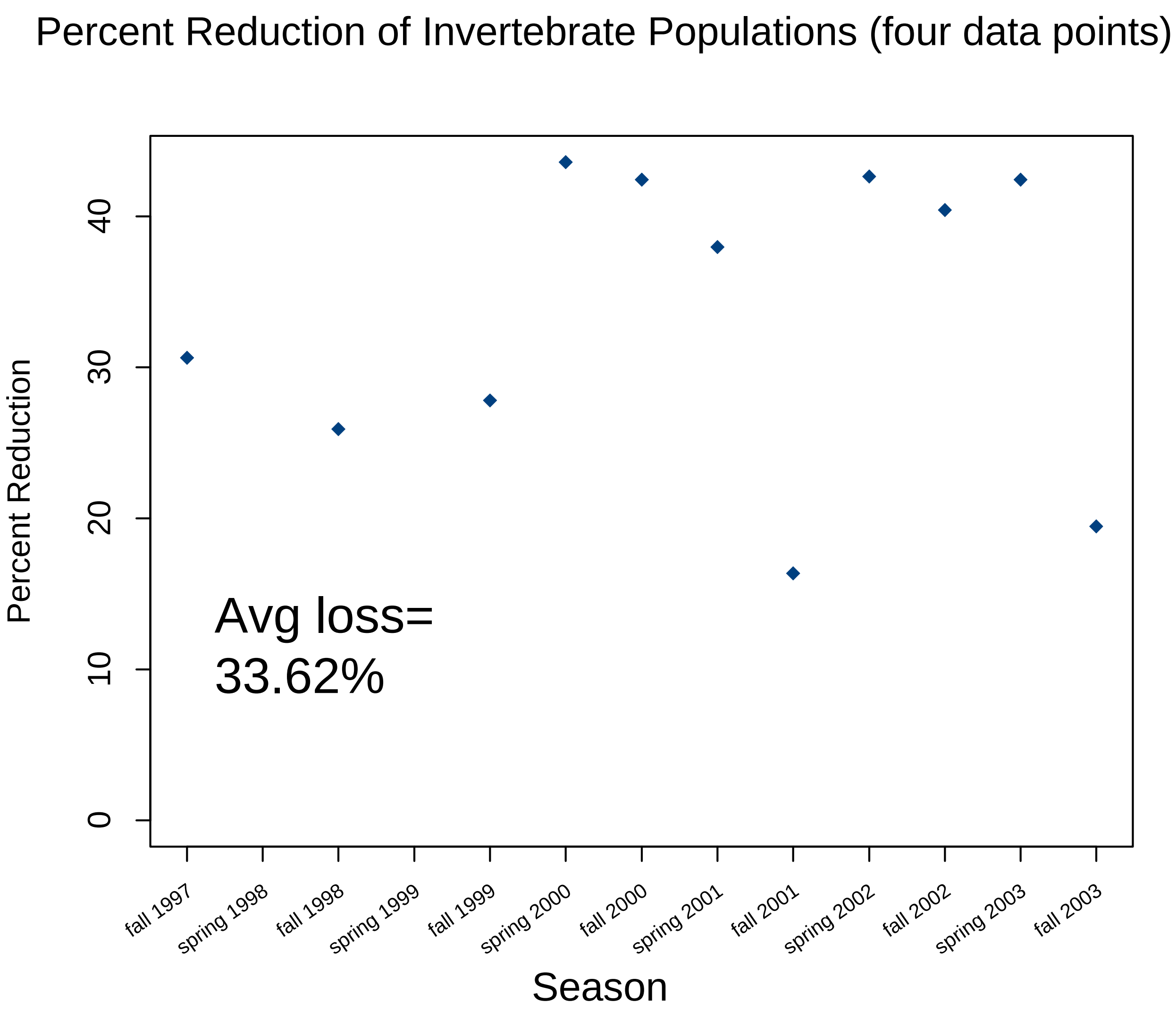
Option 2a: Use of consistent 4 locations



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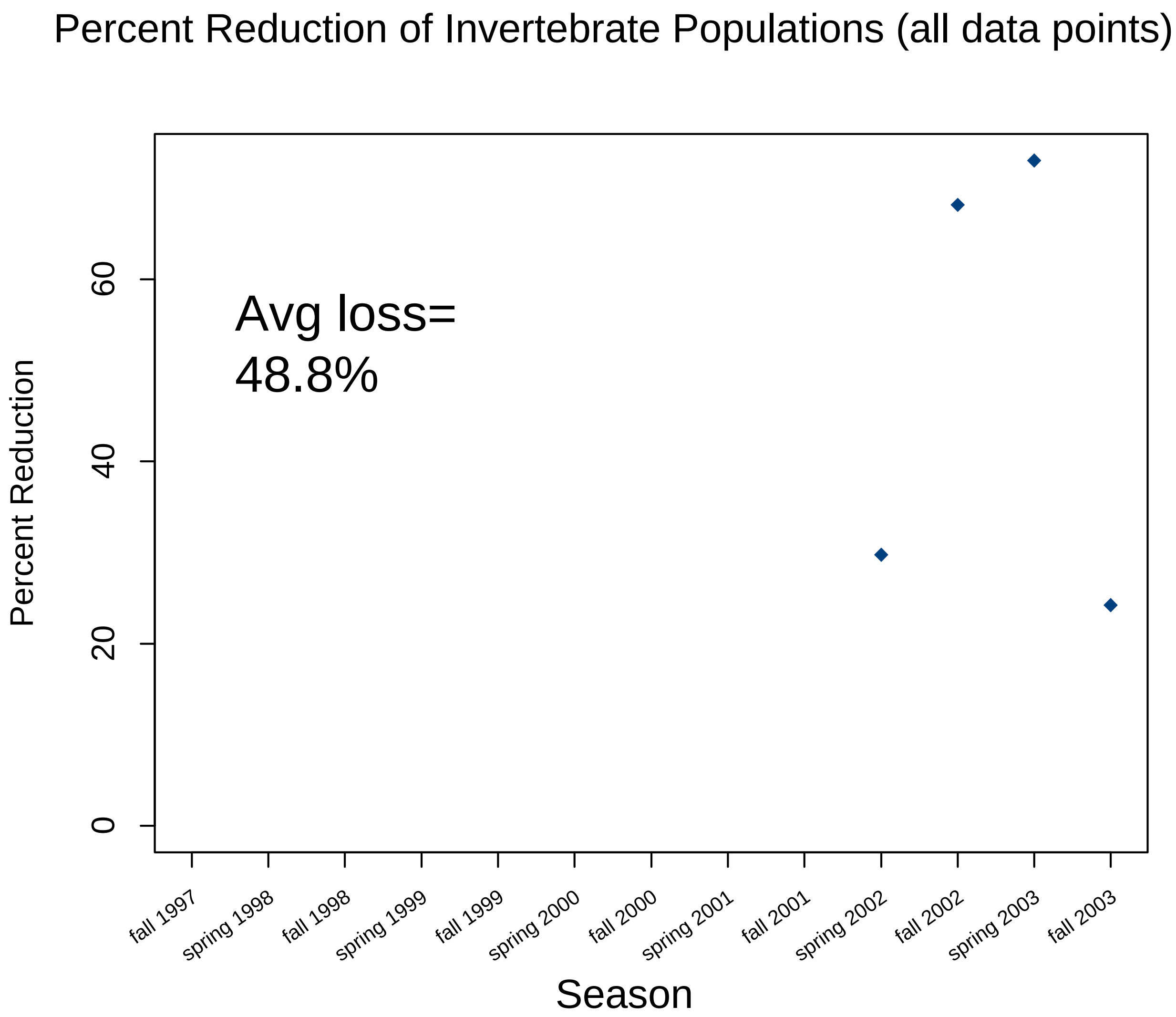
Option 2b: Use of additional intermediary locations in 2002-2003



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Fish Results
(Resident Trout)

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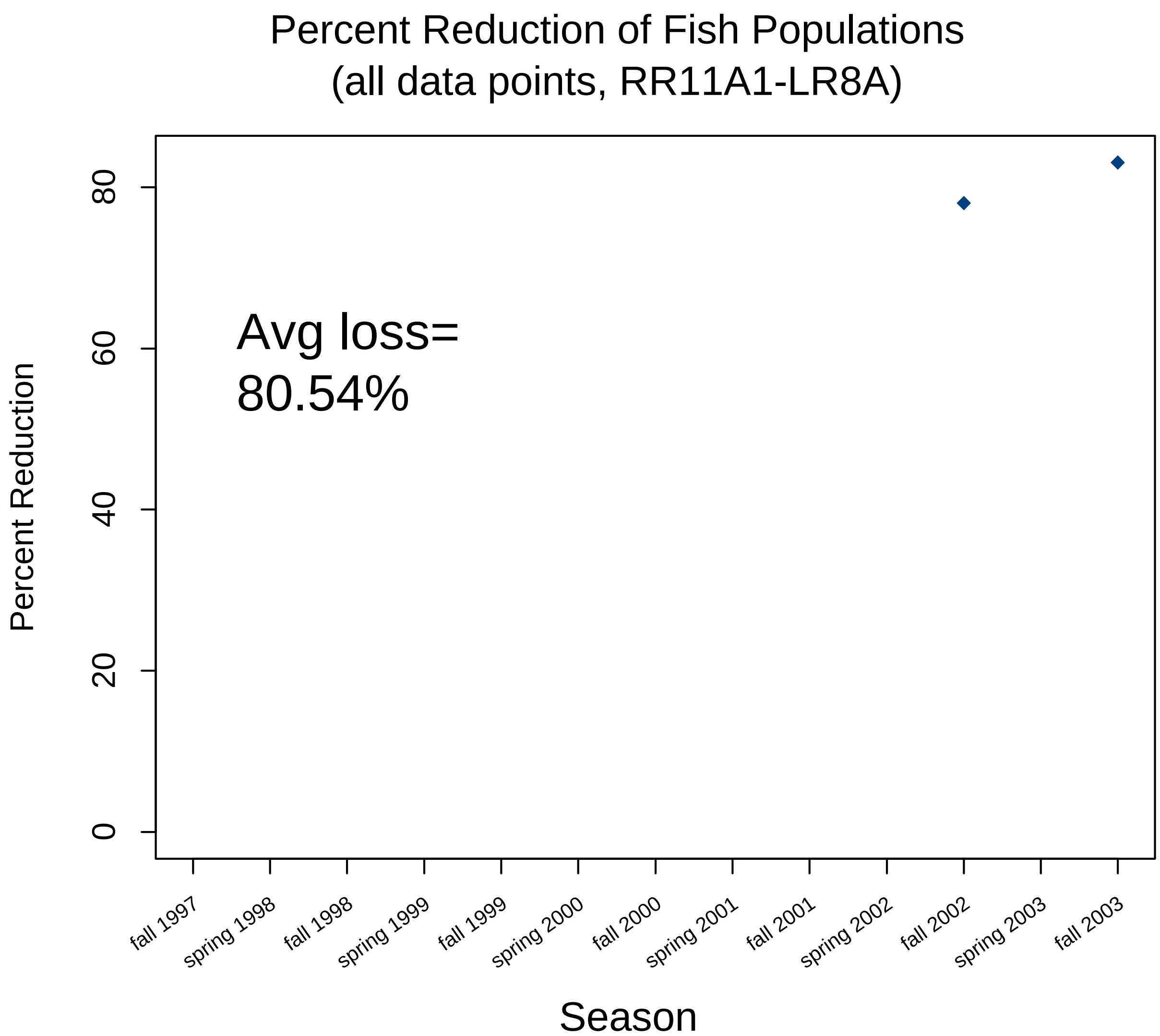
Option 1: Agreed upon location endpoints



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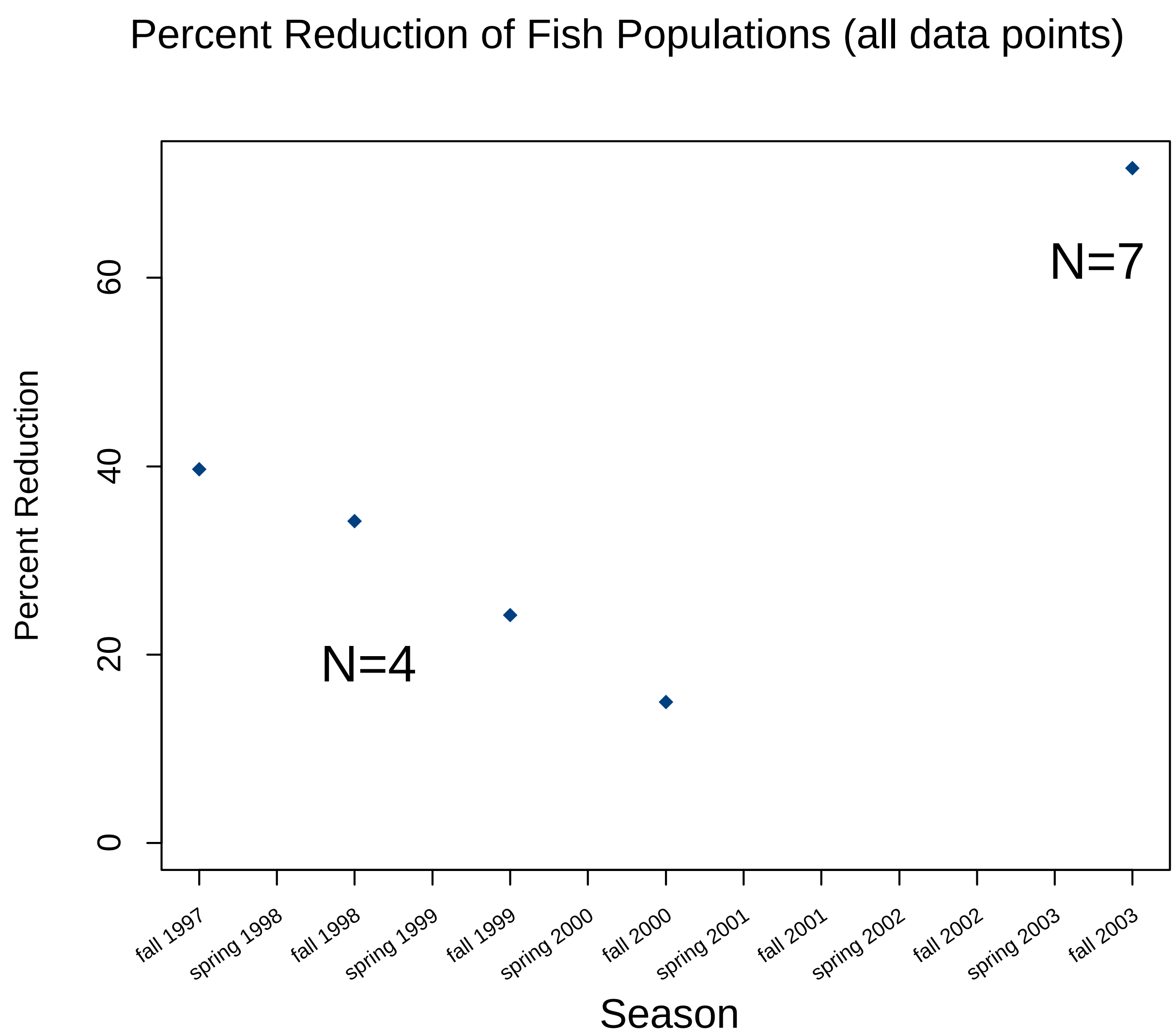
Option 2: Alternative locations based on available data



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Collective Results

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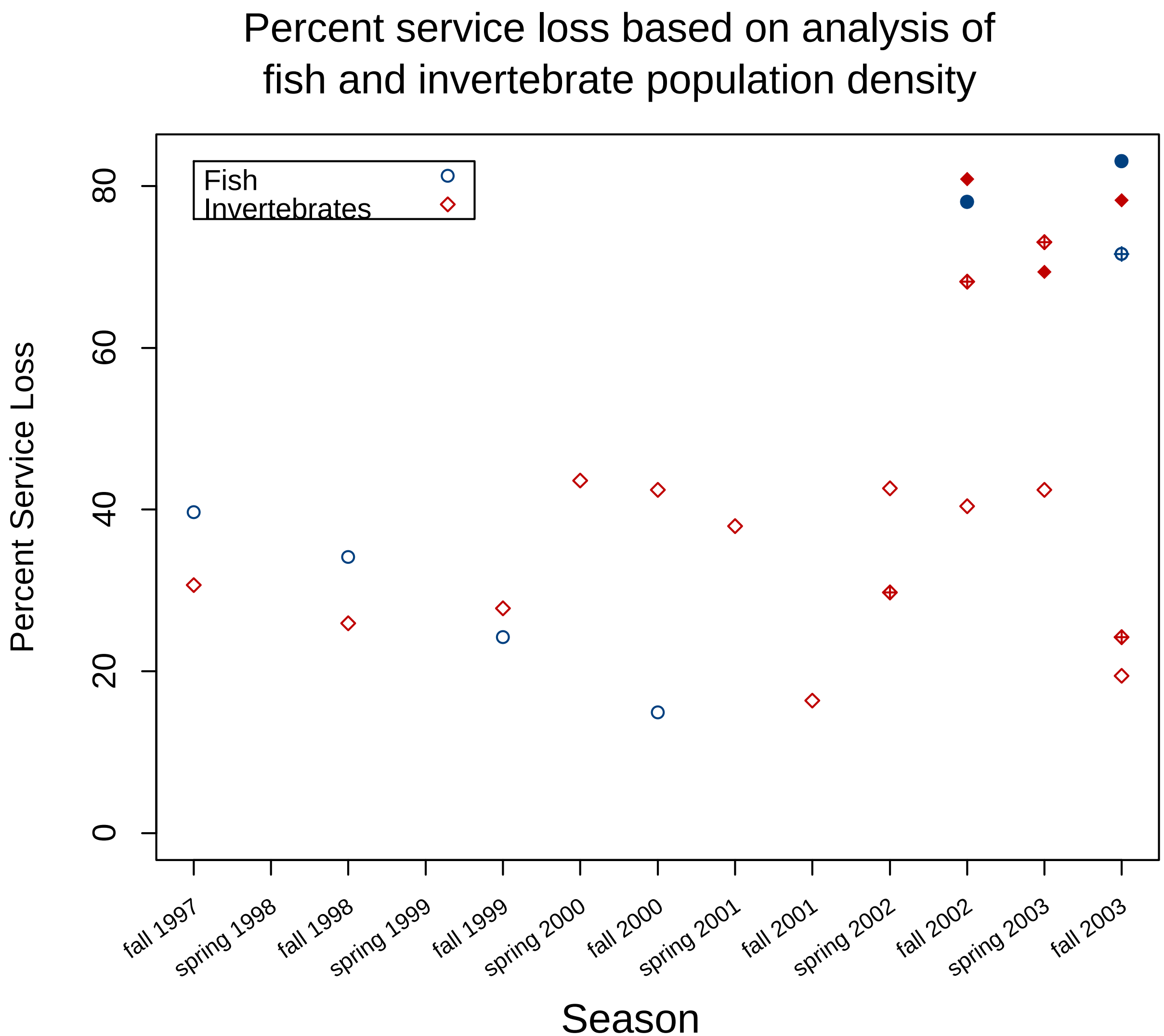
All analysis options



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Conclusions: Biological Approach

Generally similar outcomes for fish v. invertebrates

Results sensitive to selection of analytical approach

- Option 1: service loss approximately 70-80%
- Option 2: service loss approximately 30-40%
- Variability between options a function of degree of impact in lower river reaches for which data availability is more limited

Relatively little temporal variability (1997-2003) when using consistent approach (option 2)

Pre-1997 data of limited usability: assumptions re pre-1997 conditions?

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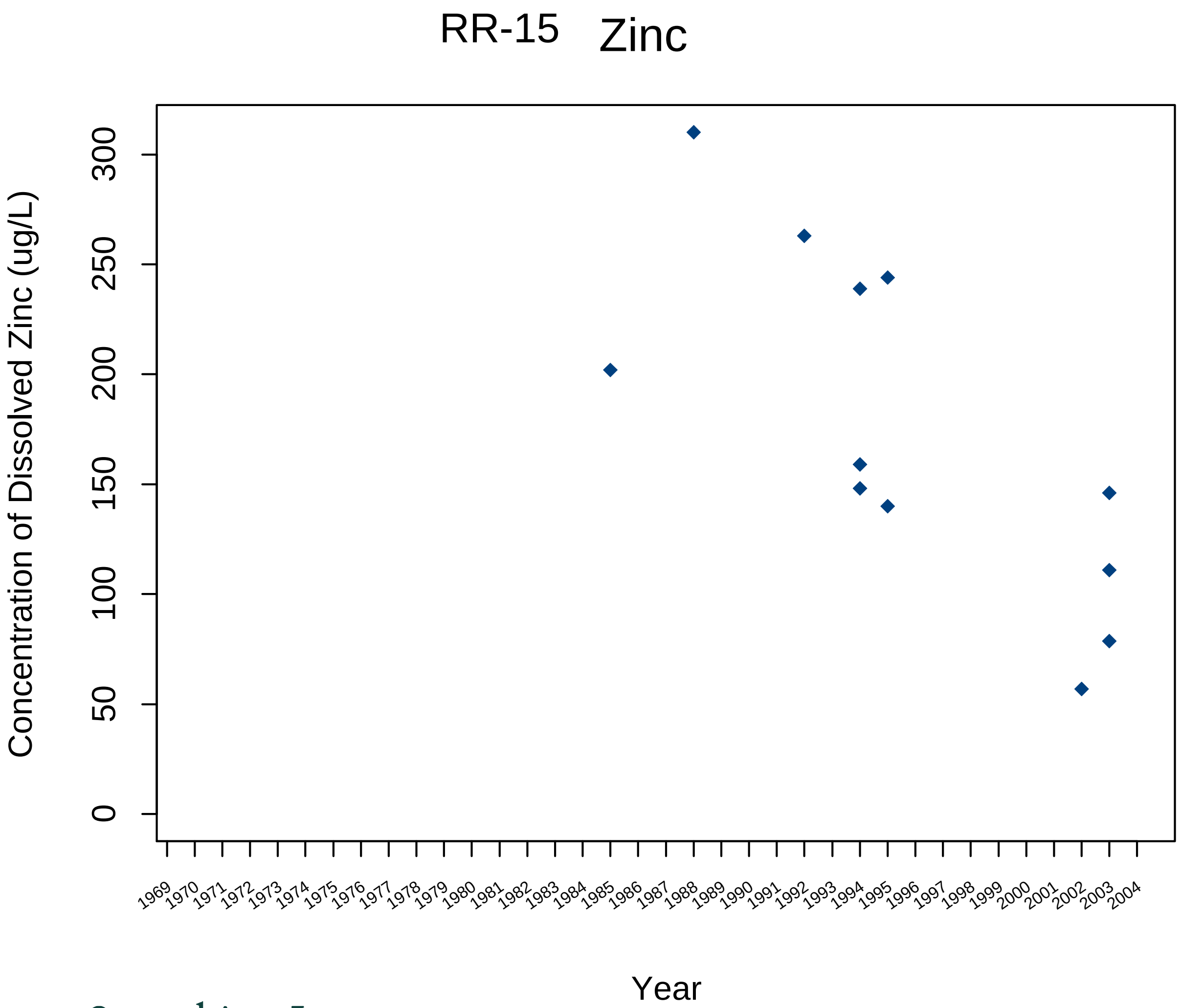
Pre-1997 Conditions?



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Toxicological Approach

Per agreement with Molycorp, evaluated toxicity data as "check" on biological approach

Approach: To estimate trout mortality from Metal Mixtures and quantify service loss

Objectives

Evaluate service loss to fish using a "toxicity approach"; to be contrasted with the "population approach"

General method:

- Calculate metal mixture toxicity to Rainbow trout for Cd, Cu, Pb, and Zn
  - Al not considered
  - Other metals not considered
- Hardness only controlling variable
- Assume additive toxicity
- Estimate percent mortality of trout from metals exposure
- Estimate service loss using "wedge model"

Additive Toxicity Model

- Derive rainbow trout hardness slope equations from most recent ALC data
  - 2001 Cd; 1995 Cu; 1995 Zn; 1984 Pb
- Quantify metals exposure as percent of LC_{50}
- Sum fractional LC_{50}s
- Estimate percent acute mortality from dose response data for Zn derived by Brinkman et al. (2004)

Derivation of rainbow trout LC_{50} equations

Use ALC LC_{50} data for rainbow trout

Use rainbow trout hardness slopes from ALC datasets to derive coefficients for species specific hardness equations

Use rainbow trout equations to quantify each metal exposure as percent of LC_{50}

Equations for Rainbow Trout Metals Toxicity:

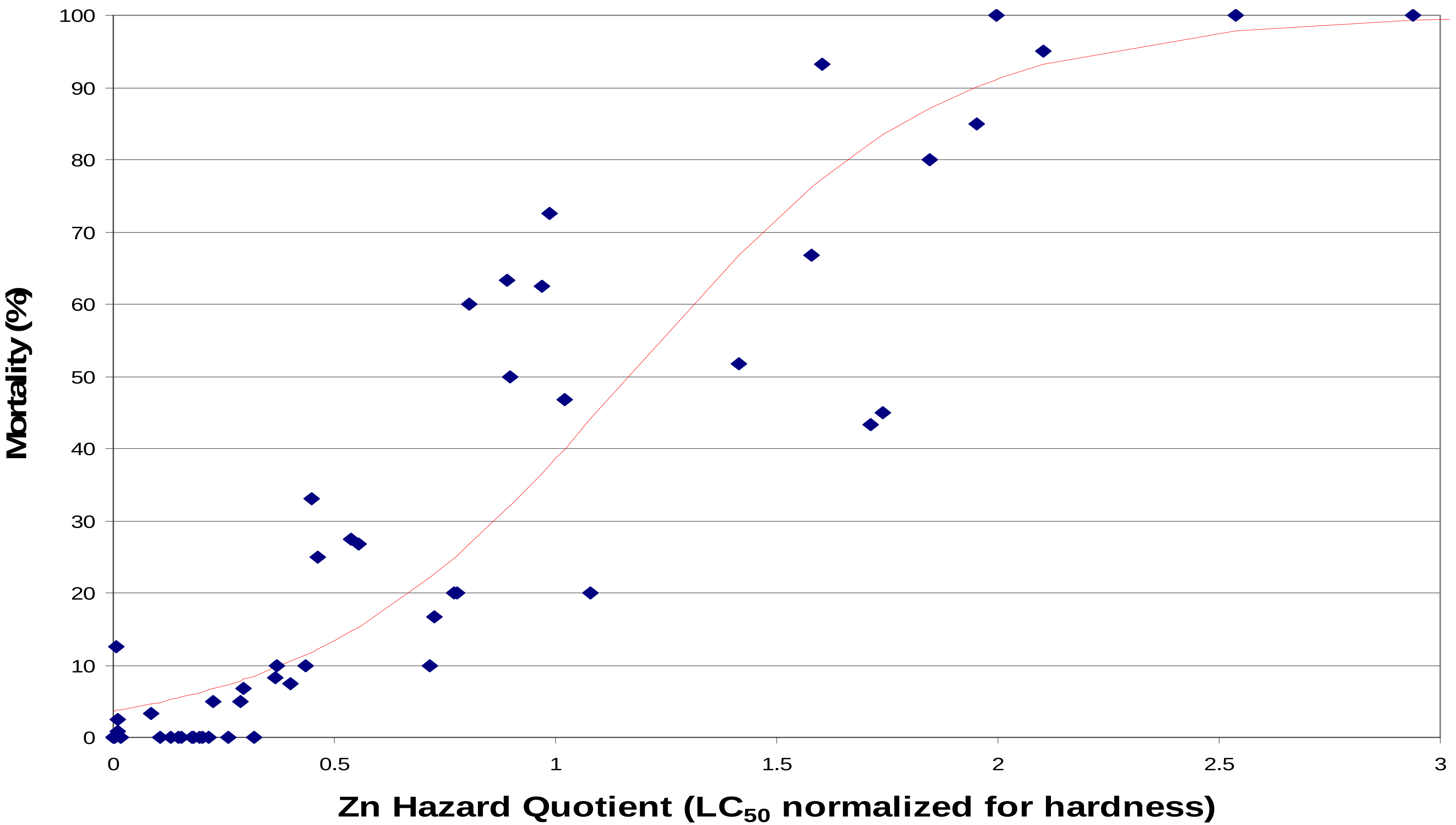
Cu LC_{50} = EXP(0.8889*Ln(hardness) + 0.18334)

Zn LC_{50} = EXP(0.8755*Ln(hardness) + 3.1107)

Pb LC_{50} = EXP(2.475*Ln(hardness) - 2.9355)

Cd: AWQC FAV uses LC_{50} for rainbow trout, and no species hardness slope is given for rainbow trout; therefore Cd FAV equation is used.

Zn Toxicity Model (Brinkman)



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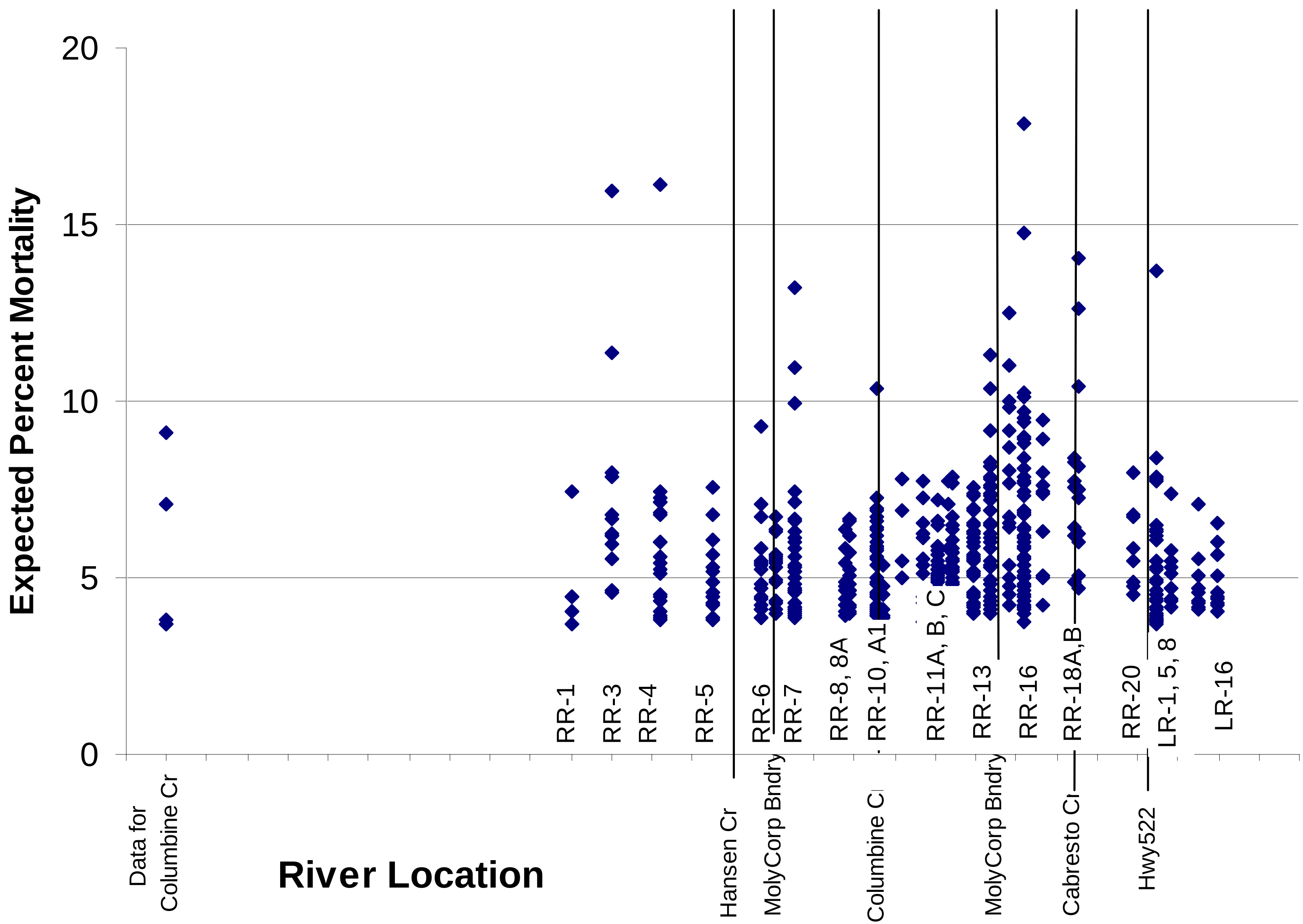
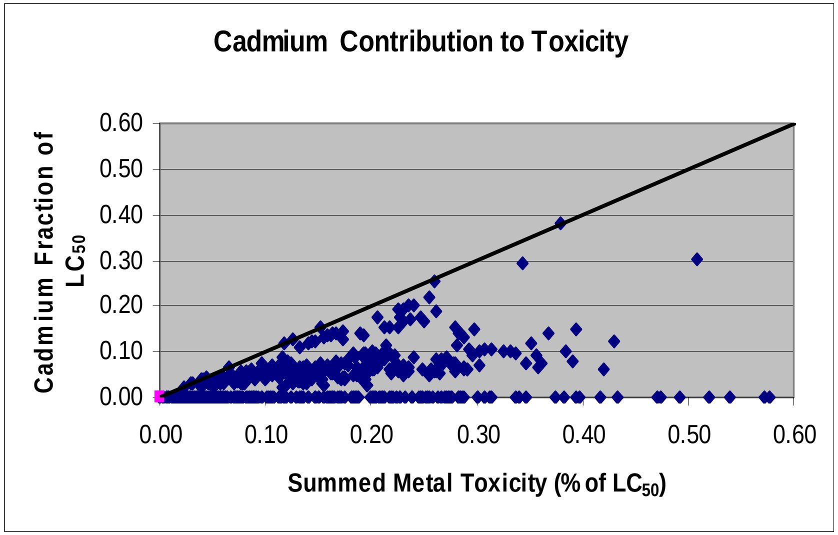
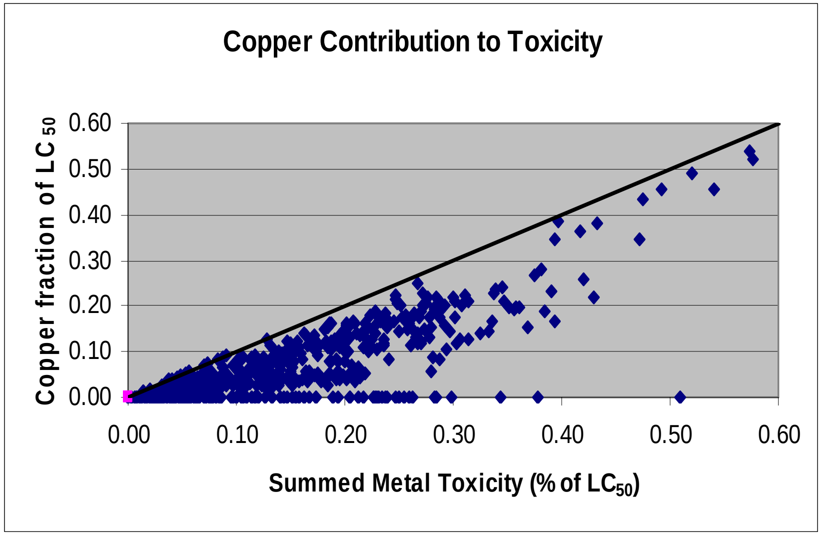
Rainbow Trout Mortality

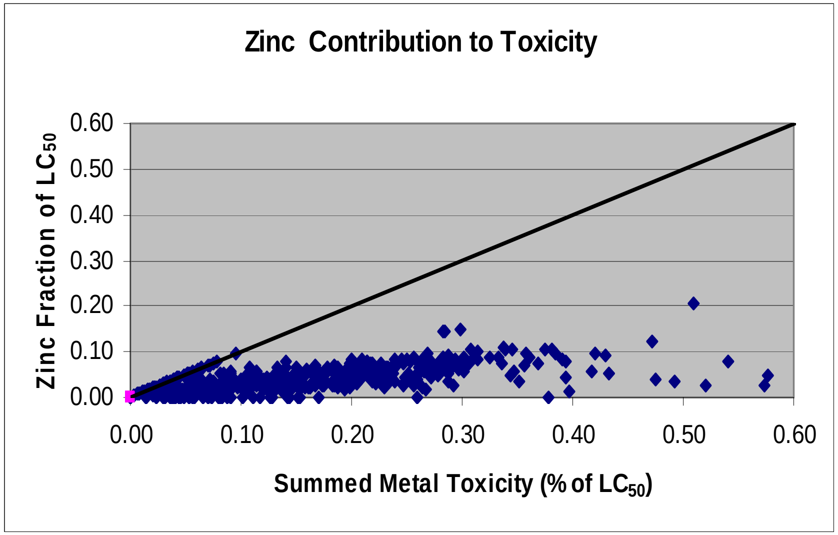
Summed toxicity of Cd, Cu, Pb, and Zn using trout equations

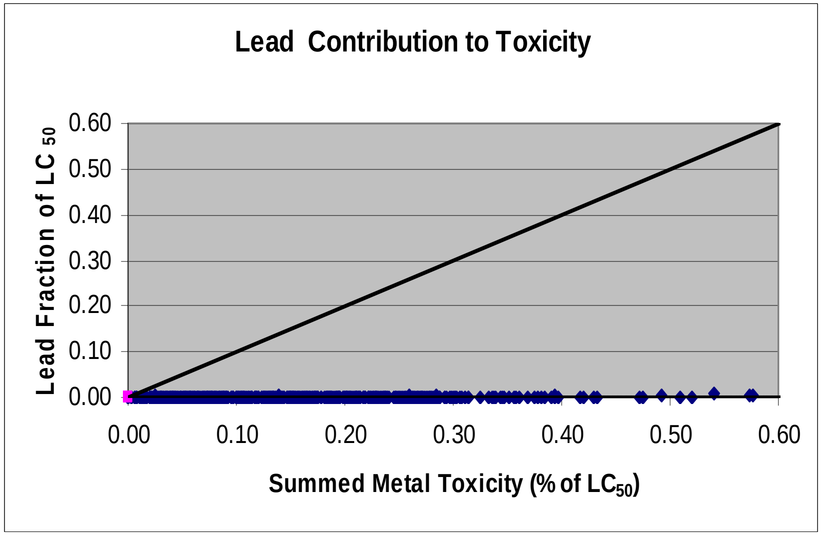


Individual Metal Fractional Contribution to Total Toxicity









Alternative method to estimate mortality

Rather than derive new equations for rainbow trout, it is possible to use the FAV equations (pooled slopes), and the SMAV (LC_{50}) values for rainbow trout, and multiply the FAV by the ratio of the SMAV/FAV, giving a species correction to the hardness derived FAV. This method gives very close results to the rainbow trout derived formulas.

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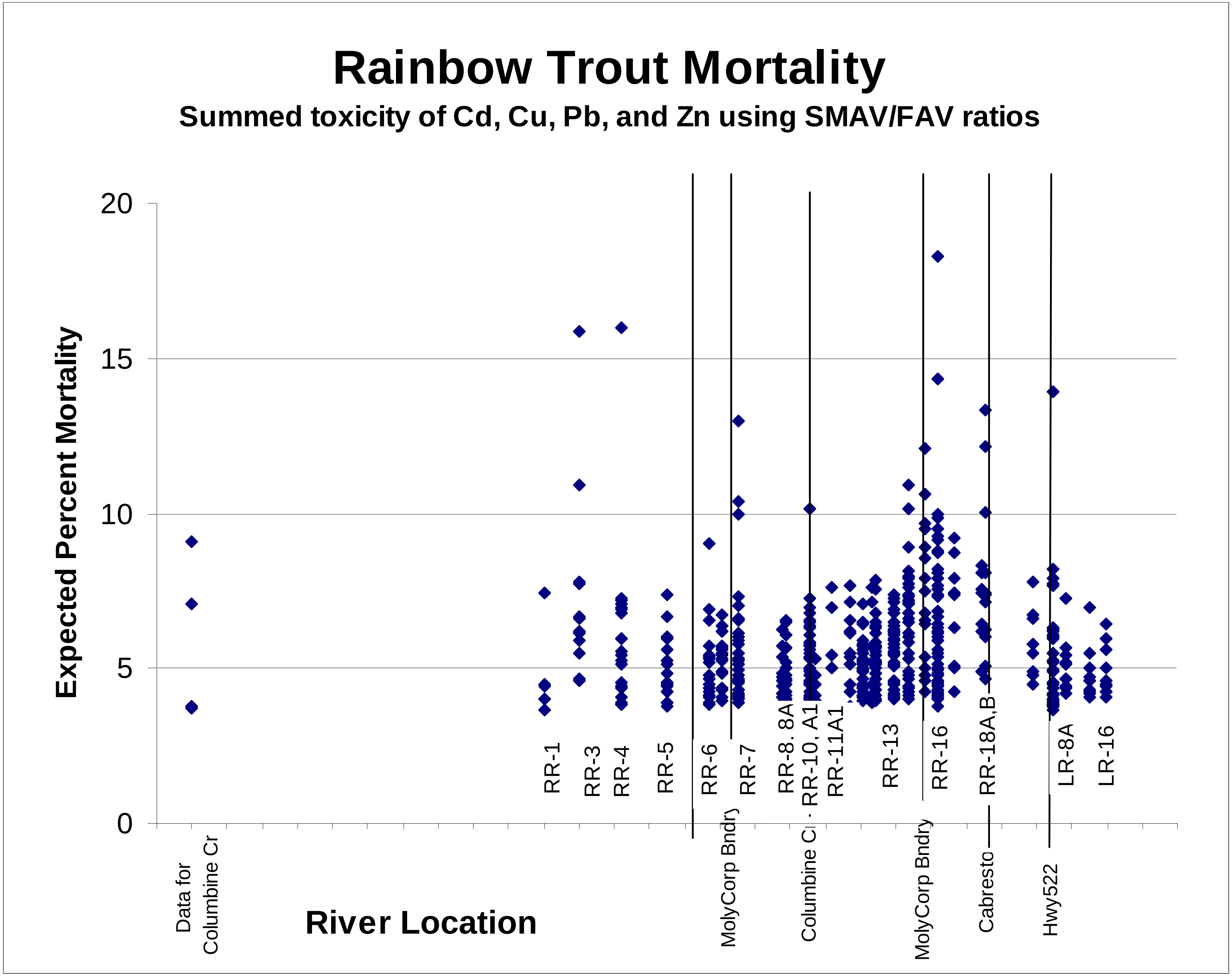
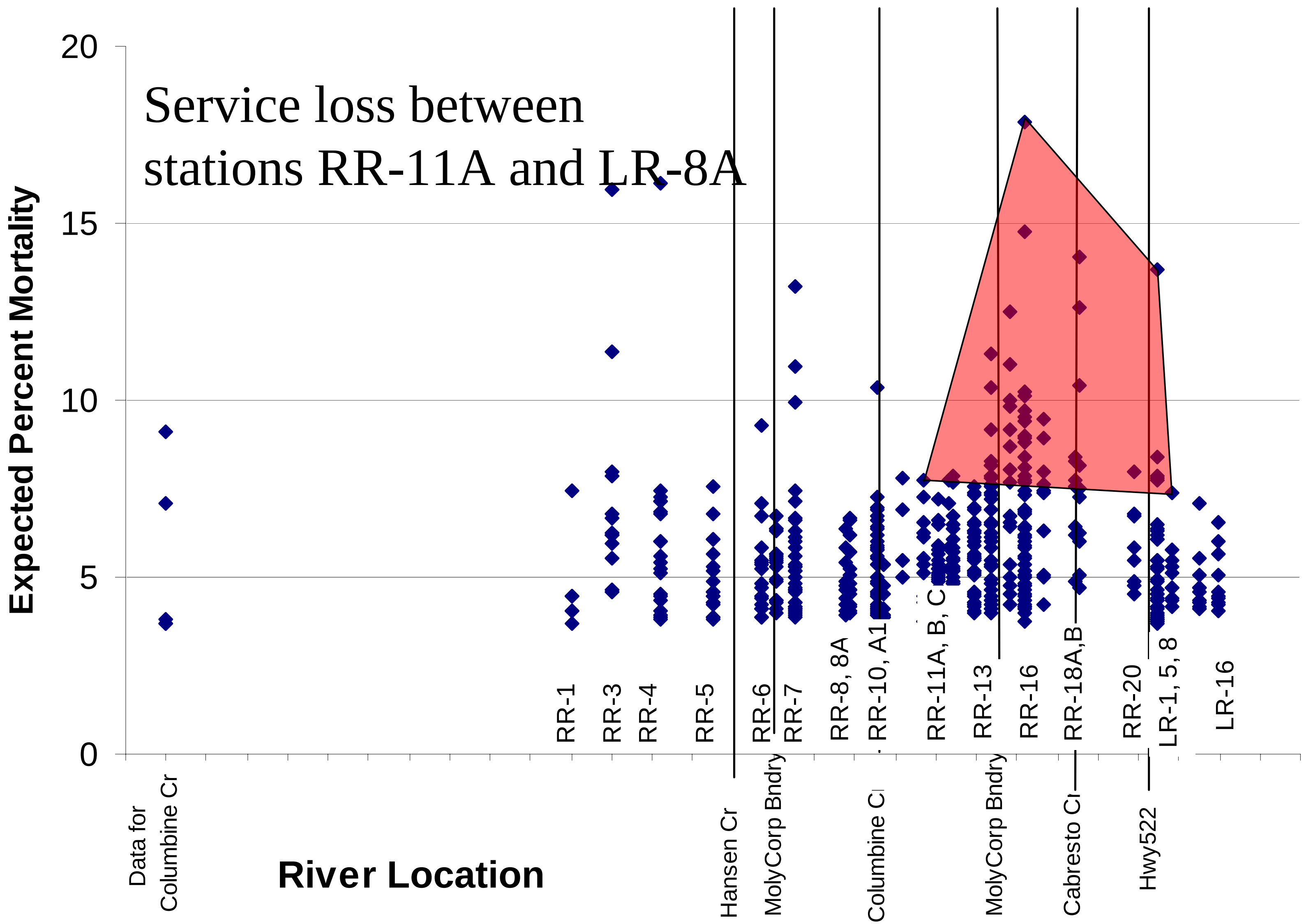
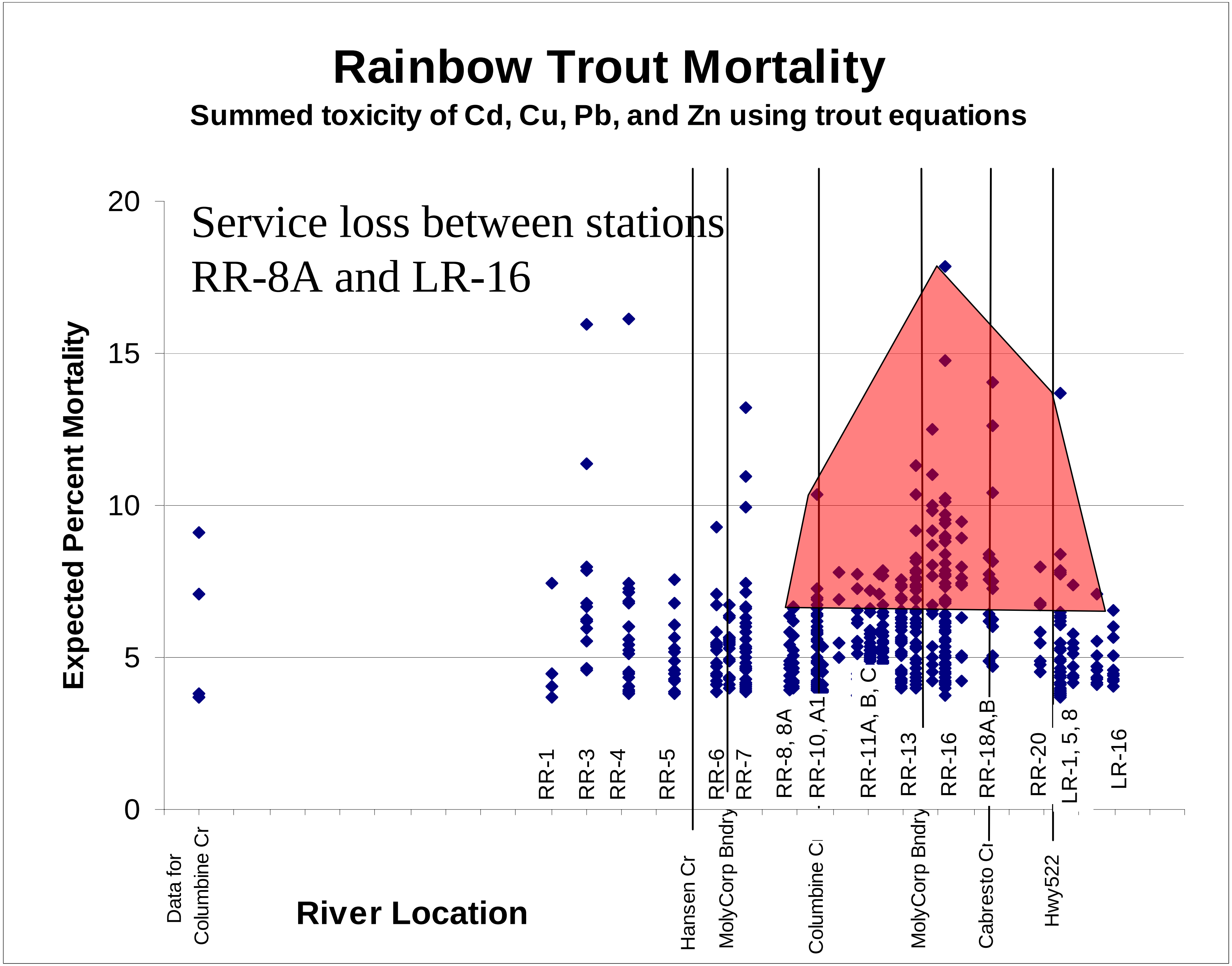


Rainbow Trout Mortality
Summed toxicity of Cd, Cu, Pb, and Zn using SMAV/FAV ratios
Expected Percent Mortality
20
15
10
5
0
River Location
Data for Columbine Cr
RR-1
RR-3
RR-4
RR-5
RR-6
RR-7
RR-8. 8A
RR-10, A1
RR-11A1
RR-13
RR-16
RR-18A,B
LR-8A
LR-16
MolyCorp Bndry
Columbine Cr
MolyCorp Bndry
Cabresto
Hwy522

Rainbow Trout Mortality

Summed toxicity of Cd, Cu, Pb, and Zn using trout equations

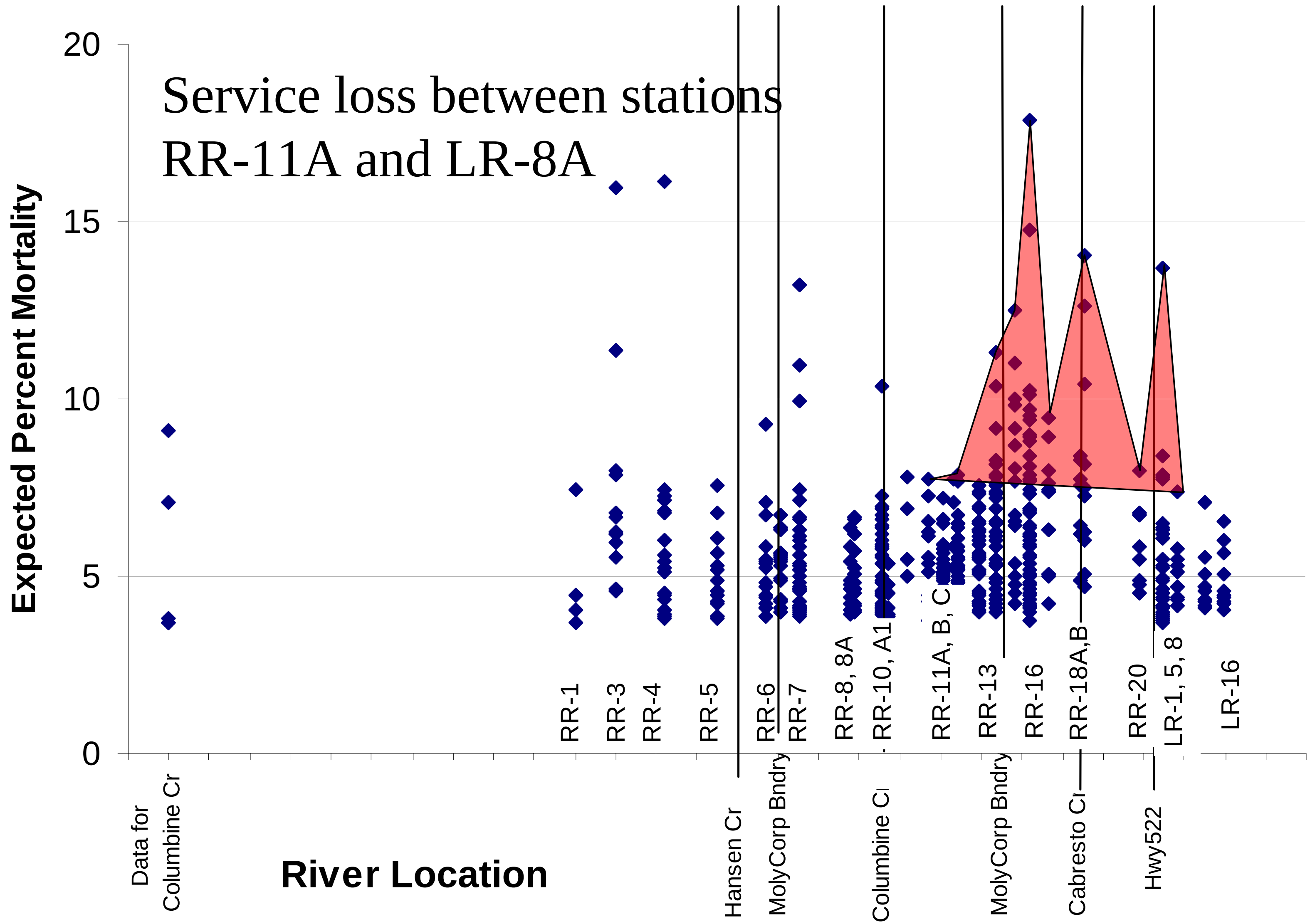


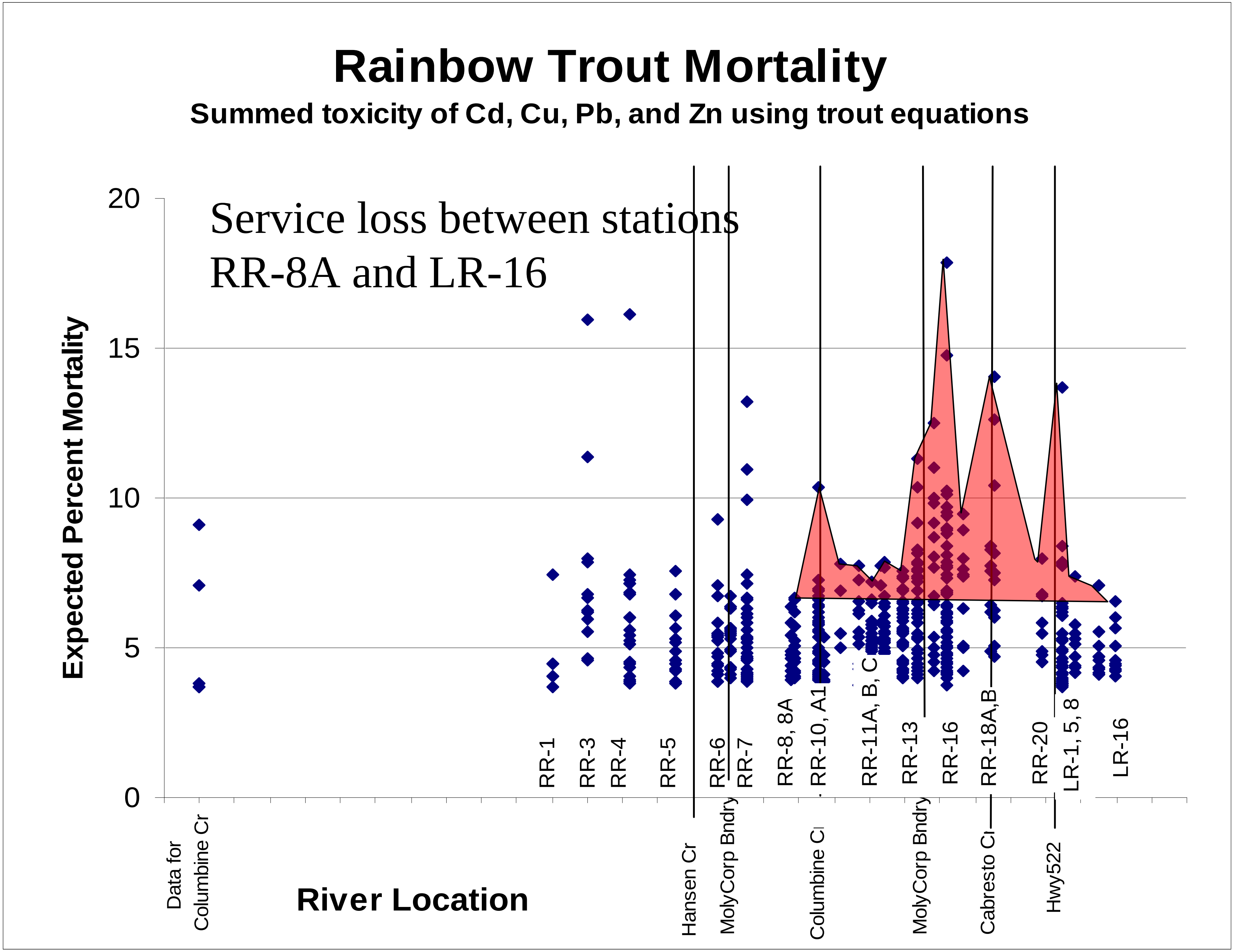


Rainbow Trout Mortality
Summed toxicity of Cd, Cu, Pb, and Zn using trout equations
Service loss between stations
RR-8A and LR-16
Expected Percent Mortality
20
15
10
5
0
RR-1
RR-3
RR-4
RR-5
RR-6
RR-7
RR-8, 8A
RR-10, A1
RR-11A, B, C
RR-13
RR-16
RR-18A,B
RR-20
LR-1, 5, 8
LR-16
Data for
Columbine Cr
River Location
Hansen Cr
MolyCorp Bndry
Columbine Cr
MolyCorp Bndry
Cabresto Cr
Hwy522

Rainbow Trout Mortality

Summed toxicity of Cd, Cu, Pb, and Zn using trout equations





Rainbow Trout Mortality
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Service loss between stations
RR-8A and LR-16
Expected Percent Mortality
0
5
10
15
20
River Location
Data for Columbine Cr
RR-1
RR-3
RR-4
RR-5
RR-6
RR-7
RR-8, 8A
RR-10, A1
RR-11A, B, C
RR-13
RR-16
RR-18A,B
RR-20
LR-1, 5, 8
LR-16
Hansen Cr
MolyCorp Bndry
Columbine Cr
MolyCorp Bndry
Cabresto Cr
Hwy522

Toxicity Model - Conclusions

Joint toxicity model generates service loss of approx. 10-15% (v. 35-80% for population data)

Limitations/uncertainties:

- other metals (e.g., Al)
- other chemical factors (e.g., pH)
- “physical” effects of floc deposition
- localized high concentrations at seeps, banks, etc.
- pulses

Biological approach appears to be reasonable model for Trustee use

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Summary

Service losses to be assigned based on biological approach

- Not strongly sensitive to species endpoint

Magnitude of service loss dependent on:

- Analytical approach
  - Ranges from approx. 35% - 75% service loss
  - "midpoint" = approx. 50% service loss?
- Assumption re pre-1997 conditions
  - Constant model in absence of data?
    - Conservative
    - May enable selection of less "conservative" service loss value?

Implications for HEA

Assumptions for HEA calculations:

- River begins to recover in 2010
- Takes 10 years to fully recover
- Constant injury loss between 1981 and 2010
- Restoration begins in 2010
- Restoration fully functional in 5 years

Two alternative scenarios of length of river impacts evaluated: 6.47 or 9.21 river miles.

Each alternative evaluated for a range of percent service losses and gains

Preliminary HEA results

Scenario 1 — Percent Service Loss

6.47 river miles injured

Percent Service Gain	35%	50%	75%
25%	14.25	20.25	30.5
50%	7	10	15.25
75%	4.75	6.75	10

Scenario 2 — Percent Service Loss

9.21 river miles injured

Percent Service Gain	35%	50%	75%
25%	20.25	29	43.5
50%	10	14.5	21.75
75%	6.75	9.75	14.5