

Benthic invertebrate recovery following a rail-car derailment of sodium hydroxide into the Cheakamus River, British Columbia

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OVERVIEW

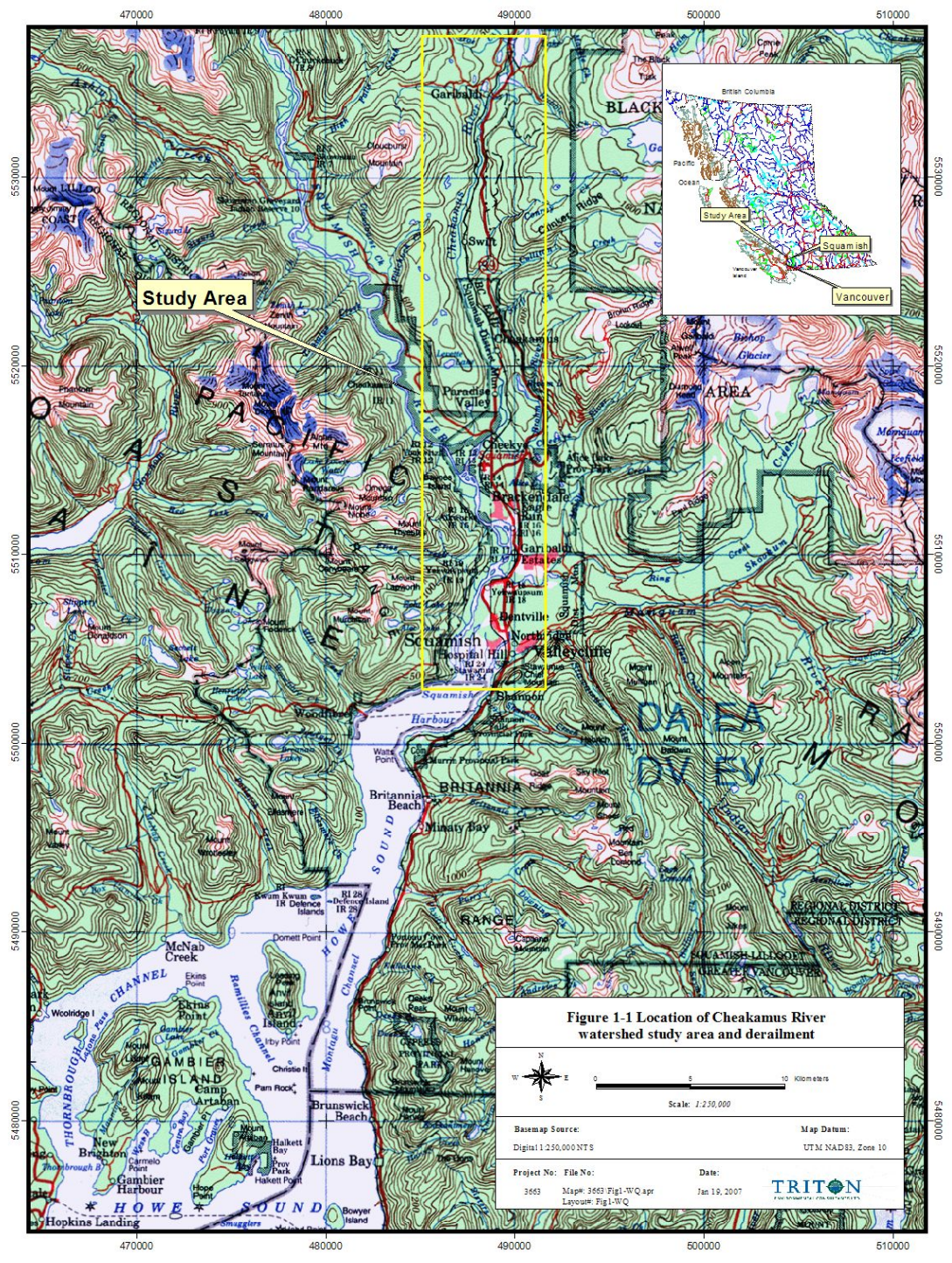
- Setting
- Details on sodium hydroxide spill
- Details on study design and approach
- Results from kick net data
- Results from colonization basket study
- Interpreting results and challenges
- Application of Reference Condition Approach
- Conclusions



SETTING:

CHEAKAMUIS RIVER

- Georgia Basin in Coast Mountain Range
- 70 km from Vancouver
- 1,070 km² watershed area
- Impounded in 1957. Flows for 26 km after Daisy Dam
- Downstream of Whistler WWTP
- Average monthly discharge = 33 m³/s
- Railway built in 1952, connects North Vancouver to Lillooet
- 2003 flood was 1 in 100 year event



CHEAKAMUS RIVER, BC



DERAILMENT





SODIUM HYDROXIDE DERAILMENT

- 0700h PDT, 5 August 2005, train derailed in canyon crossing
- 45,000 L of sodium hydroxide (73%) entered Cheakamus R.
- Estimated 90% of fish impacted in river downstream of spill
- pH 14 recorded in the river, moved through in ~ 6 h
- Water soluble, dissociates into sodium and hydroxyl ions
- Groundwater wells within 100 m not affected
- Drinking water ban lifted after 48 h



STUDY APPROACH

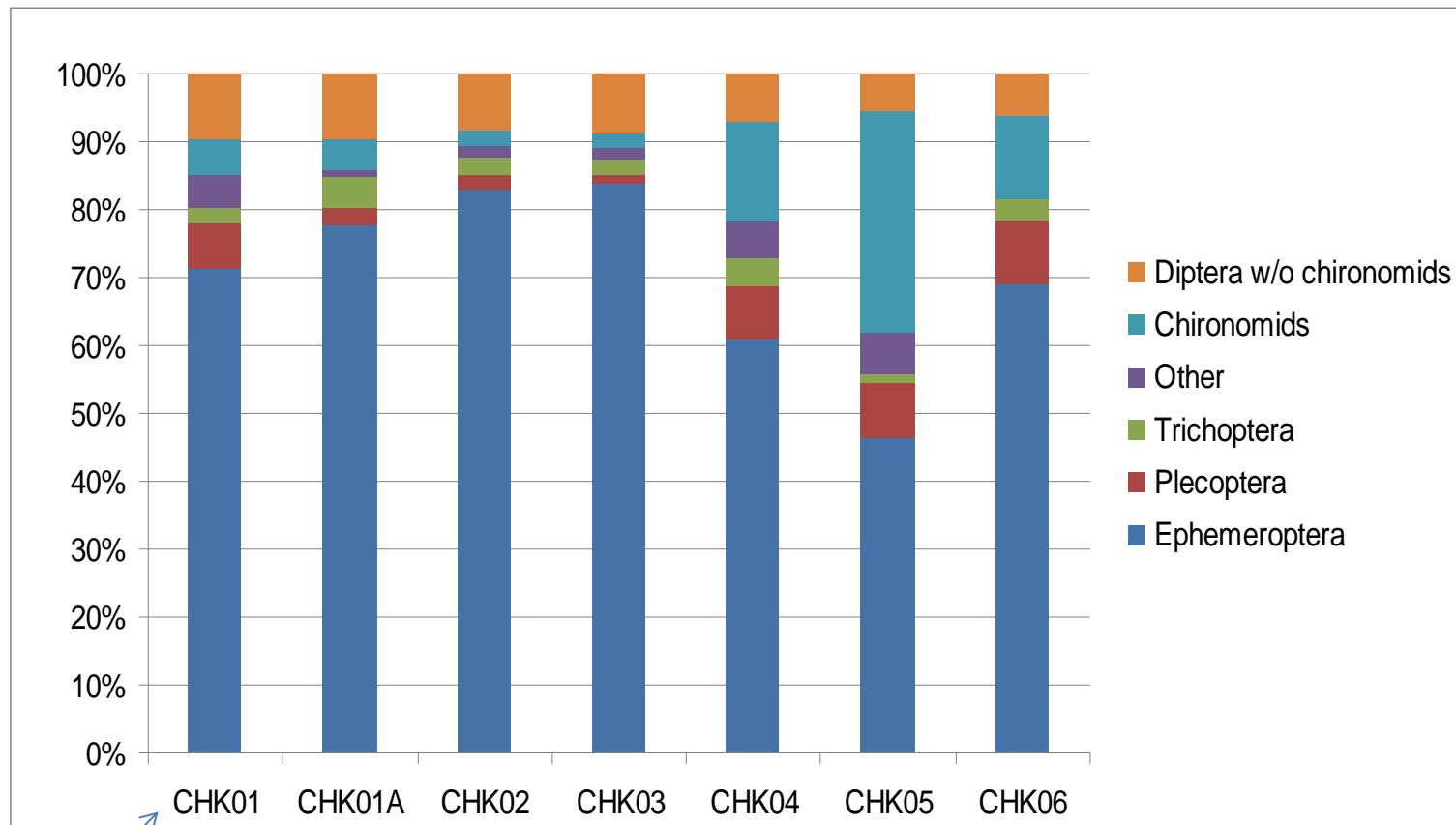
- Resample locations used in pre-spill study to aid in comparisons
- Sites same as week of spill kick sampling by Provincial Gov't
- Sample control site upstream of spill
- Adopt kick sampling protocols used by Canadian Aquatic Biomonitoring Network (CABIN). Allows for comparisons to regional reference condition database
- Collaboration with Environment Canada to resample their sites as well as replicate some of sampling done here



SAMPLING APPROACH

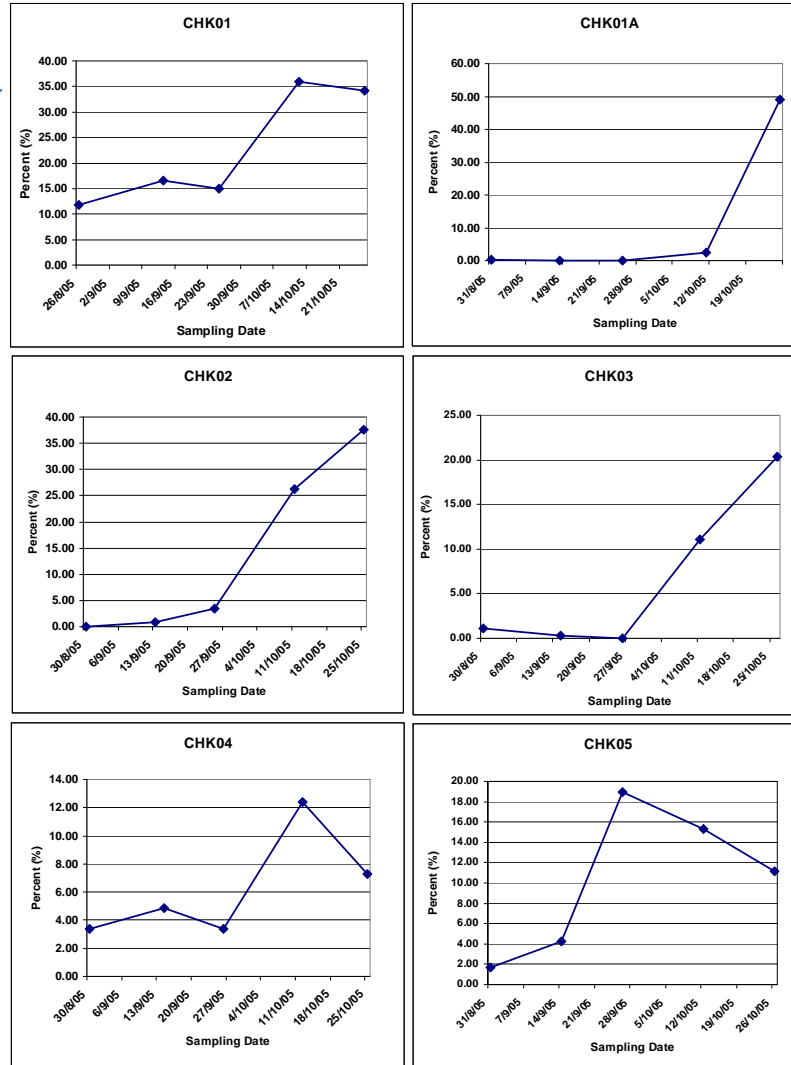
- Spill on August 5, sampling began August 26
- Used a kick net to sample biweekly Aug - Nov, 2005
- Samples collected from 1 control, 6 sites downstream
 - 5 samples per sites (representing weeks: 1, 3, 5, 7, 9)
- Repeated pre-spill study: colonization baskets in river for 41 days in Nov/Dec 2005. Same sites as 1996 and 1999/2000 studies with 4 sites: 2 above and 2 below spill location

KICK NET COMMUNITY COMPOSITION



Control

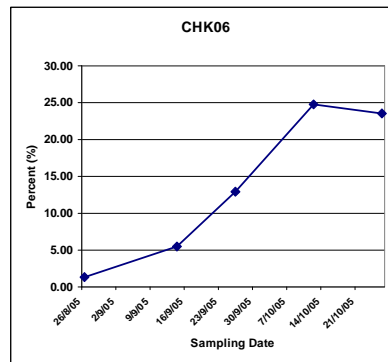
Control



% Mayflies that are Heptageniidae

Y axis: percentage

X axis: Sampling Date

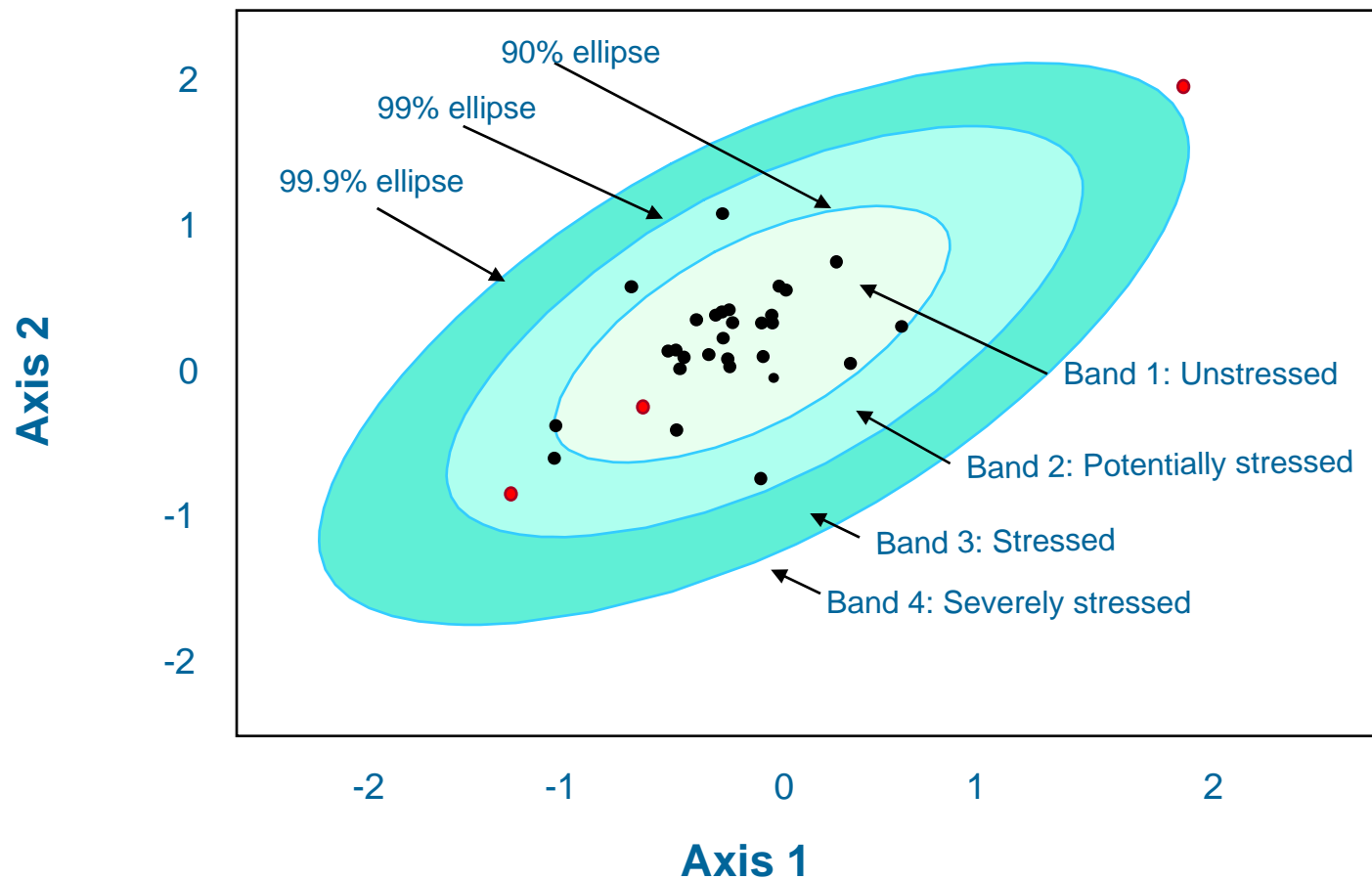




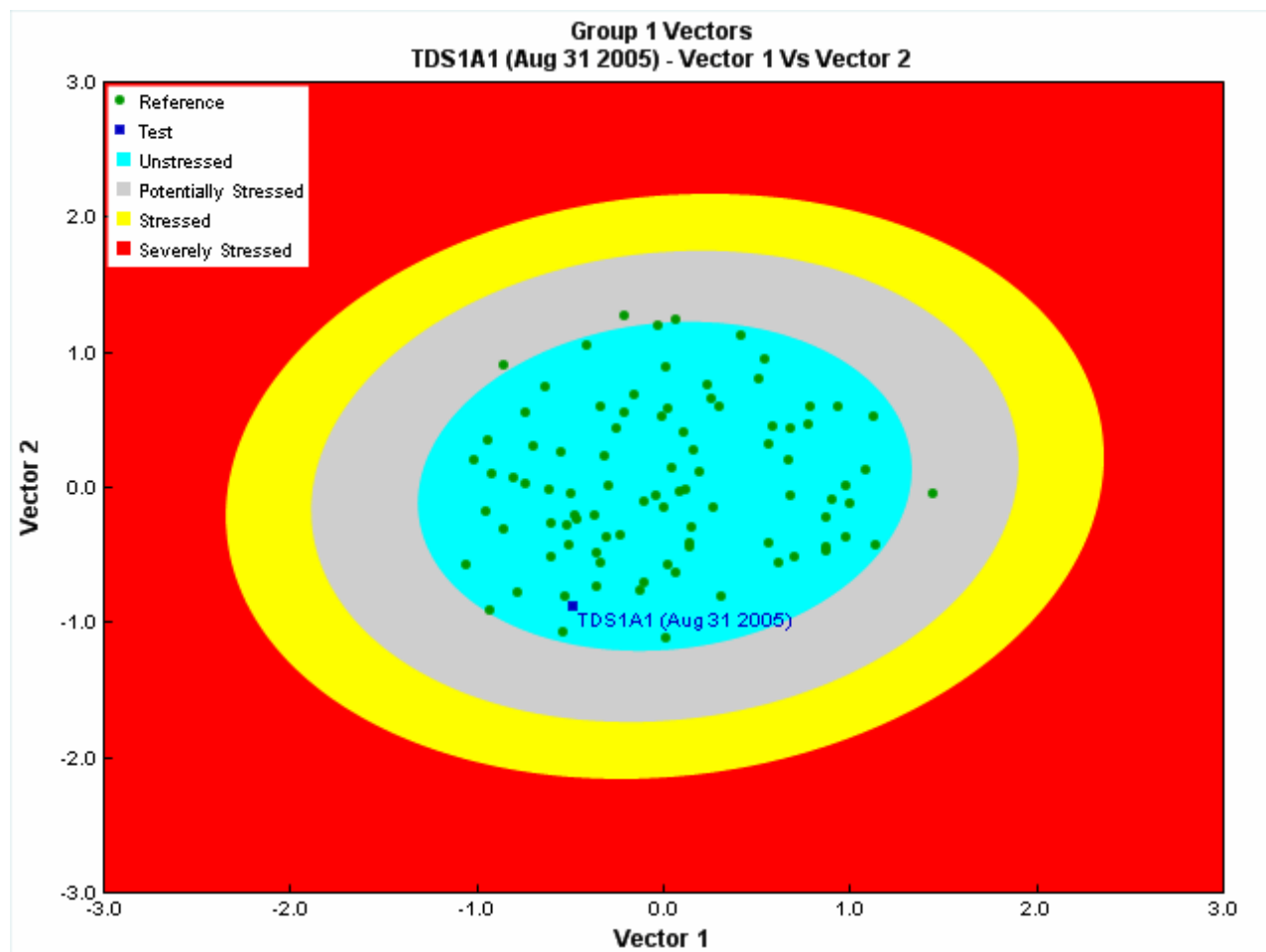
STUDY SITES AND THE REGIONAL REFERENCE CONDITION

- Predictive model covering Georgia Basin tested by Environment Canada and Canadian Aquatic Biomonitoring Network
- Environmental variables predict study sites to one of five subset groups of reference database
- Median “Group 1” membership probability = 0.83 (range 0.63 - 0.99) for study sites
- Benthic community compared to Group 1 sites

BENTHIC ASSESSMENT OF SEDIMENT (BEAST)



POST SPILL TEST SITE VS. REFERENCE CONDITION



POST SPILL KICK NET RESULTS: RCA (BEAST)

Distance from Spill	Week 1	Week 3	Week 5	Week 7	Week 9	Median Score
Upstream Control	1	2	2	2	1	2
3 km	2	3	2	3	3	3
4 km	2	3	3	2	3	3
5.2 km	2	3	4	2	4	3
8.6 km (DS of Culliton Cr.)	2	1	2	2	1	2
13.5 km (DS of Swift Cr.)	2	2	1	1	1	1
17 km (DS of Cheekye R.)	1	1	1	1	1	1
Median for "treatment" Sites	2	2.5	2	2	2	
Control	1	2	2	2	1	

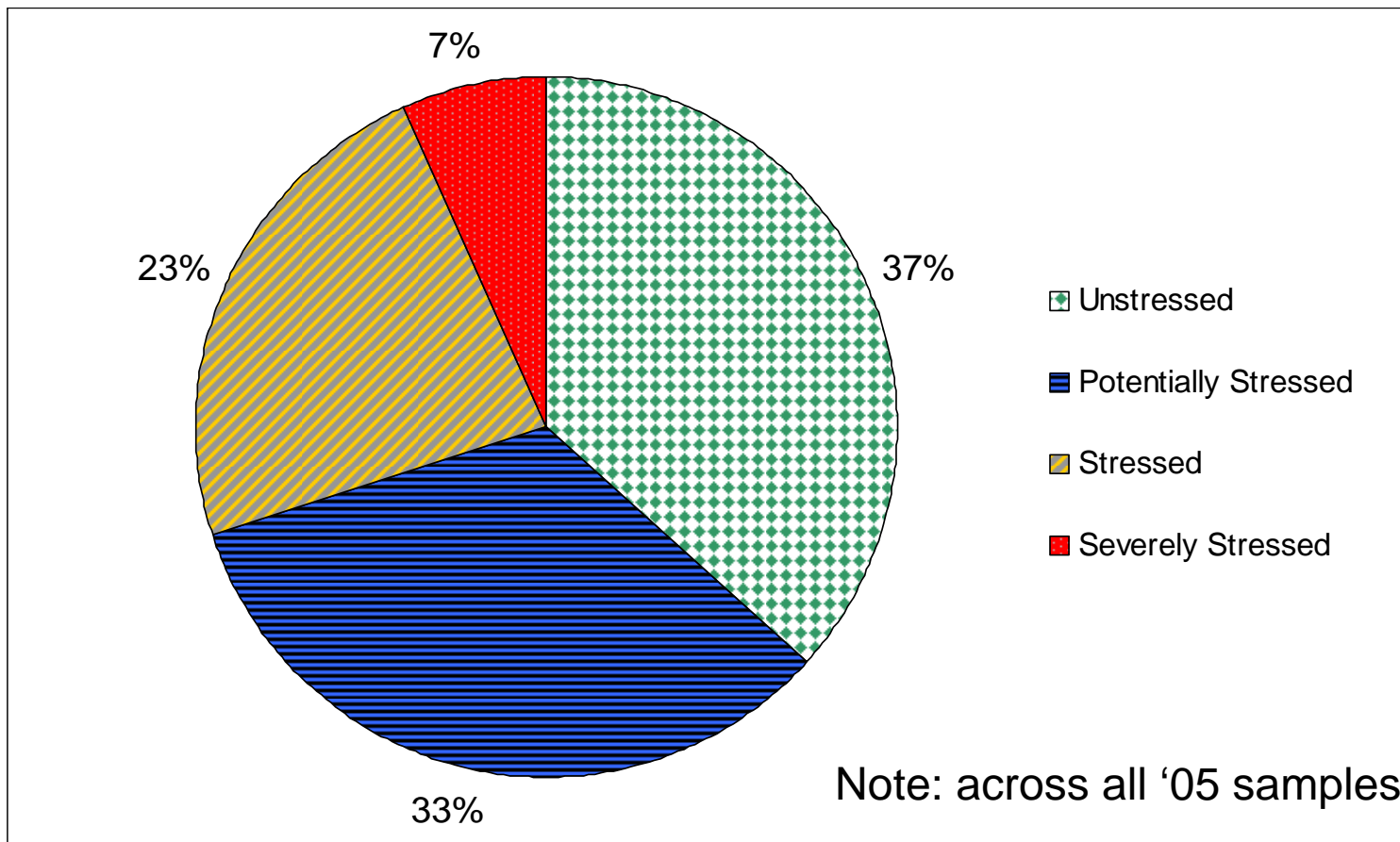
1 = Unstressed

2 = Potentially Stressed

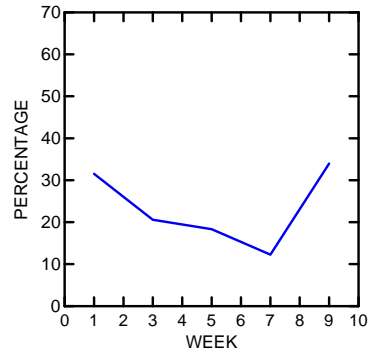
3 = Stressed

4 = Severely Stressed

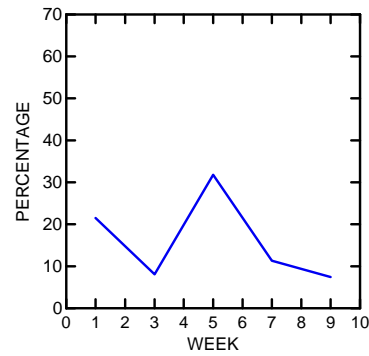
SUMMARY OF SITE STATUS USING RCA



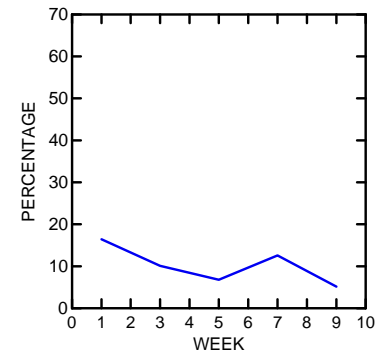
Control 1



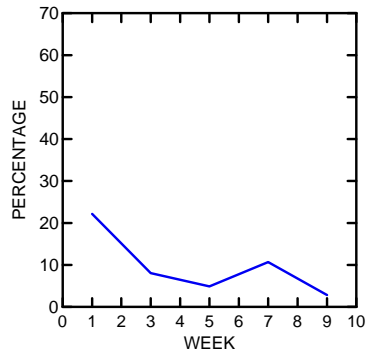
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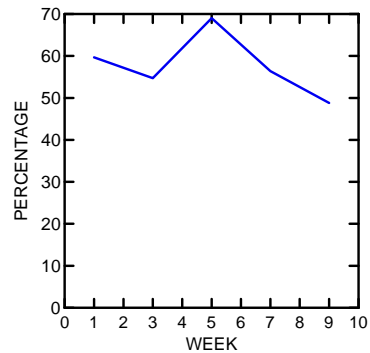
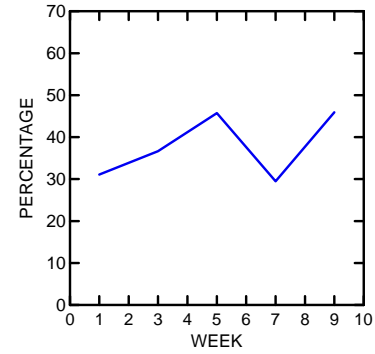
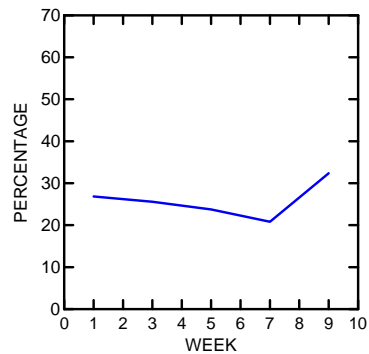
5



6



7



Y axis: % similarity
X axis: Time (week)
100% similarity = reference condition



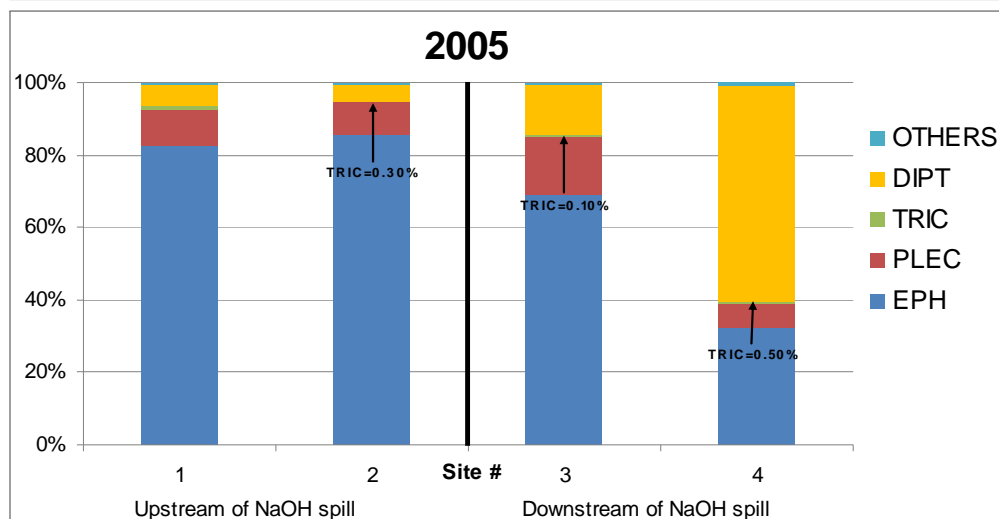
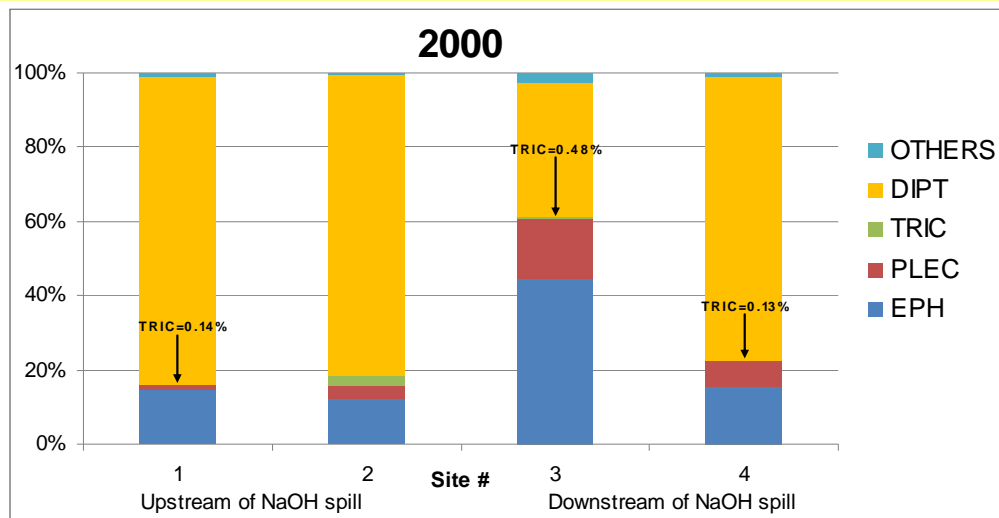
RCA SUMMARY

- 30% of kick net samples in stressed or severely stressed categories as compared to reference condition
- Potential pre-spill effects: control site was “potentially stressed”
- Sites furthest downstream showed least stress
- Median rating for spill affected sites was “potentially stressed”

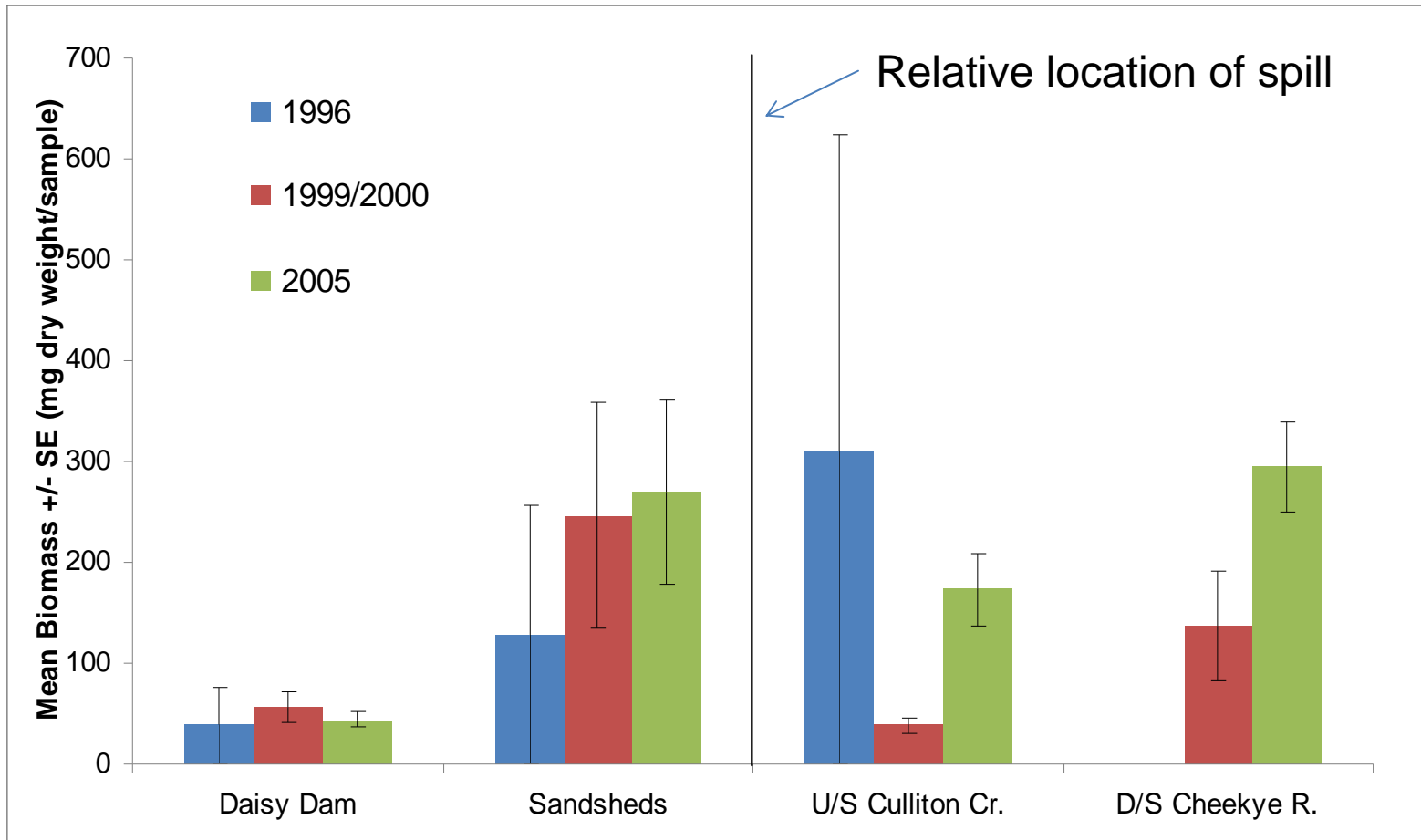
POST-SPILL COLONIZATION BASKET RESULTS



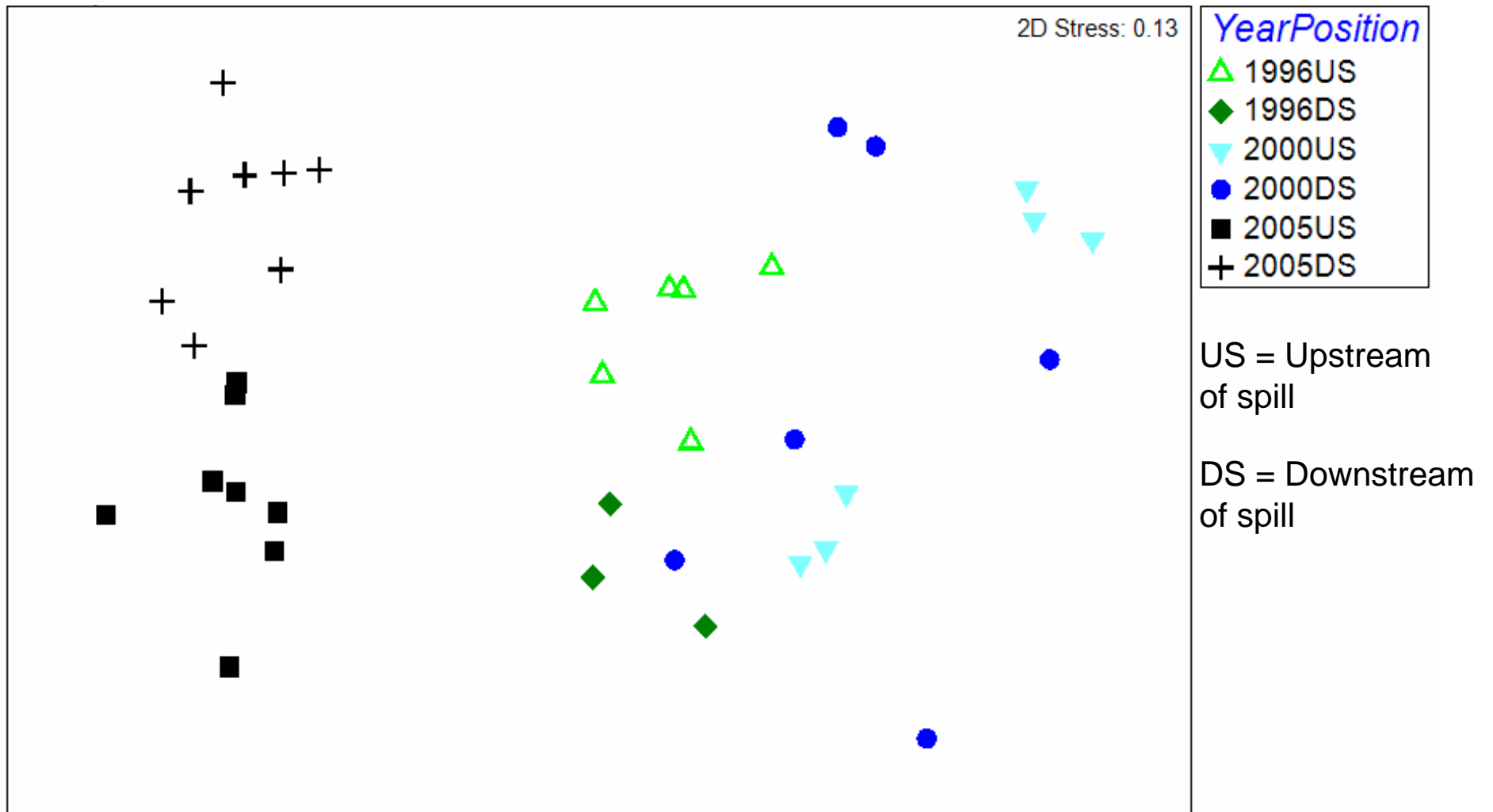
BASKET SAMPLE COMMUNITY COMPOSITION



INVERTEBRATE BIOMASS PER COLONIZATION BASKET SAMPLE 1996, 2000 AND 2005



MDS PLOT OF BENTHOS ABUNDANCE FROM COLONIZATION STUDIES





COLONIZATION BASKET SUMMARY

- Substantial year-to-year variation in community composition and biomass
- Mayflies the dominant group in 2005, except for site furthest downstream
- Downstream site had greatest abundance in 2005
- 2005 samples, including upstream controls, had community structure distinct from 1996 and 2000 samples
- Upstream control site samples more similar to each other than to spill-affected sites from 2005. Similar trend in past years, but to lesser degree
- Effects of 2003 flood are not known



STUDY SUMMARY

- Substantial year-to-year and site-to-site variation in community composition and biomass
- Mayflies, particularly *Baetis* sp., the dominant group in most samples
- Specific taxa, such as Heptagenids, affected to greater degree
- Downstream sites had greater abundance in many cases
- Downstream drift is likely mechanism for recovery
- Recovery was rapid for most taxa and overall abundance



RCA UTILITY FOR PULSE DISTURBANCES?

- Pre-spill data required in a managed watershed
- Multi-year programs should have several control sites to monitor year-to-year changes
- Still needs more consideration for detecting later successional shifts to benthic community
- Careful consideration if physical habitat changed. Landslides and other one-time events can change habitat and the probability of Group membership



CONCLUSIONS

- Stream benthos recovering within weeks of the derailment
- Complimentary results from basket and kick net studies
- Some taxa respond more slowly
- Beware interannual variation when considering reasons behind benthos variation
- Drift likely associated with degree of recovery



Thank-you